2019

Major General Harold J. "Harry" Greene
Awards *for* Acquisition Writing

A Scholar and an Inspirational Leader

by Lt. Gen. Paul A. Ostrowski

As I was preparing to write this introduction, I took time to reflect on my service with Maj. Gen. Harold J. "Harry" Greene. He was a mentor and a friend to me and, I might add, to many, many others. I recall vividly how Harry cared about people, especially those on his team. He was always interested in what was happening in their lives, what they were working on, how he could help them achieve their professional goals. Harry held daily "walkabouts" where anyone could talk to him about anything. He often started what could become a lengthy discussion with "What have you done for the Army today?"

Harry had great respect for others and it showed. He taught us that we can disagree without being disagreeable. It was not a cliché for him. While most would find it intimidating to engage in a debate with their boss, Harry relished a good, spirited discussion. He often prevailed, but it was another opportunity for his workforce to learn from the master. An engineer by training, he held several graduate degrees and a doctorate in materials science from the University of Southern California. His keen intellect was only matched by his skills in communicating—at all levels. He was a scholar and an inspirational leader.

He was also known for his quick wit. Harry loved a good joke, and his boisterous laugh would echo through the halls. He found humor in daily happenings. While some in meetings might be embarrassed by a mistake on a presentation or a misstatement, Harry would lighten the mood with a quip and the meeting moved on. He empowered his team by seeing the lighter side of life.

Most importantly, Harry took great pride in the success of others. That is why this annual competition—the Major General Harold J. "Harry" Greene Awards for Acquisition Writing—is a fitting tribute to him. Through critical thinking and writing about acquisition in one of the four categories—acquisition reform, future operations, innovation and lessons learned—those who participate are continually improving the acquisition process and obtaining better outcomes. Harry would be pleased to see the reach of the winning submissions, as well as those receiving honorable mention. They influence the dialogue about acquisition, both internally and externally.

In his 34 years of distinguished service, Harry worked tirelessly to make the Army and our nation better. As an Army family, we continue to mourn his loss. It was Aug. 5, 2014, while serving as the deputy commanding general of the Combined Security Transition Command – Afghanistan, that he was killed by an Afghan Soldier during a visit to Marshal Fahim National Defense University in Kabul. As then-Army Chief of Staff Gen. Ray Odierno said at a memorial service in the Pentagon on Aug. 13, 2014, "We can never repay those who raise their right hand and give their lives for our country. What we can do is honor them, remember their sacrifices, and the only thing that I think about is that I know he gave his life doing what he loves, leading Soldiers in service to our Army and the nation."

This special supplement of Army AL&T magazine showcases the 2019 winning and honorable mention authors. I wish to extend my sincere congratulations to each of them and my best wishes to all who participated in the sixth annual Major General Harold J. "Harry" Greene Awards for Acquisition Writing. We are so grateful for your support. Lastly, I want to express my deep appreciation to our distinguished judges who painstakingly reviewed and ranked all of the submissions.

Again, my congratulations and best wishes to all.

The winners and honorable mentions are:

Category: Acquisition Reform

Winner: Accelerating Science to Solutions at the Velocity of Relevance

Authors: **Col. Deydre S. Teyhen, DPT, Ph.D., OCS**, is the commander of Walter Reed Army Institute of Research. Her research portfolio focuses on Soldier health and medical readiness (public health, musculoskeletal medicine, behavioral health, resiliency, imaging, and technology). Prior to assuming command of the Walter Reed Army Institute of Research, Col. Teyhen Commanded the U.S. Army Health Clinic-Schofield Barracks. Prior to that she served as the Assistant Chief of Staff-Public Health at the Army's Office of the Surgeon General, where she led the Army's Performance Triad initiative and oversaw Army Medicine's response to public health diseases, such as the Zika and Ebola viruses.

Col. Robert J. O'Connell, M.D., FACP, is the deputy commander of Walter Reed Army Institute of Research (WRAIR). He is an internal medicine and infectious diseases physician with clinical, research, product development, and leadership experience in medical center, research institute, overseas, and battlefield settings. He currently supervises the execution of infectious diseases and brain/behavior health research at WRAIR

Lt. Col. Vincent F. Capaldi II, M.C., USA, is the chief of the Behavioral Biology Branch and Deputy Center Director, Center for Military Psychiatry and Neuroscience Research, at the Walter Reed Army Institute of Research in Silver Spring, MD. He currently serves as an associate professor in the departments of Internal Medicine and Psychiatry at the Uniformed Services University of the Health Sciences in Bethesda, MD. He is also the program director of the National Capital Consortium combined Internal Medicine and Psychiatry residency training program and chair of the Biomedical Ethics Committee at Walter Reed National Military Medical Center.

Deborah A. Shear, Ph.D., is the director of the Brain Trauma Neuroprotection Research Program within the Center for Military Psychiatry and Neuroscience at Walter Reed Army Institute of Research. The primary mission of her research program is to develop and validate innovative and far-forward therapeutic solutions to improve outcome from traumatic brain injury for the benefit of the injured warfighter.

Col. Matthew G. Clark, Ph.D., PMP, is the director for Medical Systems under the Assistant Secretary of the Army for Acquisition Logistics and Technology at the Pentagon. He is responsible for portfolio management and oversight support of all medically related research, development, acquisition, and joint integration in the U.S. Army involving medical systems.

Abstract: In 2017, the Deputy Secretary of Defense highlighted the reorganization of Defense Acquisition Management structure as required by the National Defense Authorization Act by emphasizing the "speed of relevance," partnerships, and building a comprehensive system that promotes a more lethal force. Building on this concept, the Army Futures Command has successfully demonstrated that combining direction and speed provides the foundation for capabilities to be advanced at the "velocity of relevance." Achieving this velocity requires engagement across the entire spectrum of capa-

bility development, including research within the realm of early science and technology. This paper explores an innovative approach to ensure the science is both relevant and aligned to facilitate the "velocity of relevance" that our warfighters need to meet the objectives of a Multi-Domain Operation (MDO) of the future.

Honorable Mention: Going Too FAR Takes Too Long

Authors: **Joe Novick** is the product manager for the High Mobility Decontamination System and the Next Generation Personnel Decontamination System in the Joint Program Executive Office for Chemical, Biological, Radiological and Nuclear (CBRN) Defense. Mr. Novick holds a Bachelor of Science degree in Biochemistry from the University of Virginia. He is DAWIA certified Level III for Program Management and Systems Engineering.

Ray Gulcynski is a retired Marine CBRN defense officer and provides contract support to the Joint Program Executive Office for Chemical, Biological, Radiological, and Nuclear Defense. Mr. Gulcynski holds a Bachelor of Science degree in Business and a Master of Science degree in Management from Excelsior College in Albany, New York.

Abstract: Rapid contract execution is an oxymoron in defense acquisition. Federal regulations associated with contracting impede defense acquisition programs' ability to use agile management strategies. Other Transaction Authorities (OTA), however, work outside the bounds of the Federal Acquisition Regulation (FAR) to enable industry to deliver iterative and rapid prototypes. Using agile acquisition via the Countering Weapons of Mass Destruction (CWMD) OTA, the High Mobility Decontamination System (HMDS) program delivered the initial set of prototype systems to the U.S. Army within 100 days of project award for testing in an operational environment. The program then upgraded the design based on user feedback from prototype demonstrations and delivered a subsequent set of prototypes less than twelve months later. Through OTAs, program managers can use agile techniques to develop capabilities faster than what is possible in FAR-based approaches.

Category: Future Operations

Winner: On the Limits of "Strong" Artificial Intelligence: Where Don't We Want AI on Tomorrow's Battlefield?

Author: **Lt. Col. Daniel R. Thetford** is the product manager for UH-60V under the Program Executive Office (PEO) Aviation. He previously served as the assistant product manager for the Advanced Threat Infrared Countermeasures (ATIRCM) program; Aviation and Systems Coordinator for the U.S. Army Special Operations Aviation Command (Airborne), G-8; and the Attack Division Chief, TRADOC Capability Manager for Reconnaissance and Attack (TCM-RA). Lt. Col. Thetford was commissioned as an Aviation officer via the Reserve Officers' Training Corps at the University of Dallas, where he earned both a Bachelor of Arts degree in Politics and a Master of Theological Studies degree.

Abstract: Artificial Intelligence (AI) is a rapidly advancing technological field of study with vast implications to DOD Acquisition programs. As the technology advances at a (seemingly) quicker pace than that of policy or Acquisition guidance, questions of AI applicability in DOD Acquisition programs naturally arise for the enterprise as a whole. Specifically, questions regarding where DOD does not desire AI on the battlefield of tomorrow must be asked and addressed in order to avoid wasting limited resources and ensure moral application of emerging technologies. The following paper seeks to offer a general outline of the areas AI should not be pursued by DOD Acquisition programs based on logical conclusions derived from the limits of AI itself.

Honorable Mention: Rare Earth Elements: A Vital Supply Chain at Risk

Author: **Michael J. Ravnitzky** works in the Contracting Division at the Naval Sea Systems Command in Washington. He holds a J.D. (with honors) from Mitchell Hamline School of Law and a B.A. in physics from Cornell University.

Abstract: To achieve a reliable supply chain for Rare Earth Elements, a flexible multi-pronged approach is required. This will ensure access to these vital materials essential to the production of high tech weapons systems. The history of World War II offers lessons and best practices that could be implemented to accelerate the development of assured national supply channels for Rare Earth Elements.

Category: Innovation

Winner: Accelerating Innovation with the SBIR Program

Author: **Kevin Landtroop** is the venture partner for Defense Portfolio and Technologies at Capital Factory in Austin, TX. Working through Capital Factory's Center for Defense Innovation, Kevin connects early-stage companies with future-force technology requirements while helping Army Futures Command, Defense Innovation Unit, AFWERX, and others connect with startups. Prior to joining Capital Factory, Kevin served as managing director of Grayline Defense and co-founded the Texas Defense Innovation Forum. Kevin holds a B.S from West Point, a J.D. from the University of Texas, and an L.L.M. from the Army JAG School.

Abstract: Innovating technology development and acquisition doesn't require the DOD to establish wholly new programs and procedures, at least with respect to prototyping and integrating key enabling technologies. The Small Business Innovation Research (SBIR) program has not worked historically, but AFWERX's recent experiments with directing Phase-I and Phase-II awards at adaptable commercial technologies demonstrates the potential—at least on the front end. Application of commercial accelerator tools could extend this success to Phase-III. This essay describes how an Accelerator-Powered SBIR program can drive hundreds of relevant technology solutions into the Army's innovation pipeline each year, build teams for collaborative lean prototyping, and set the conditions for successful product transition and market commercialization.

Honorable Mention: Intelligent Contracting – A Vision of the Future of Federal Contracting

Author: **Col. (R) Vernon L. Myers** is a contracting officer/branch chief with US Army Contracting Command – Orlando. He is Level III certified in Contracting and Program Management and he has earned the PMP (PMI) certification. He is currently pursuing a Doctor of Business Administration (DBA) with a specialization in Strategy and Innovation at Capella University. He is an avid student and practitioner in the fields of Innovation, Leadership, and Creativity.

Abstract: Procurement organizations across the federal government face similar challenges, to include increasing demand to shorten the procurement acquisition lead time, maintaining adequate resources to execute the contracting mission, and increasing budget constraints, which cause increased strain on the system. Meanwhile, requiring activities are being pushed to obligate money faster and resource managers must reallocate funds more frequently to meet emerging requirements. Assuming the trends listed above continue, what new technology could fundamentally transform or disrupt the procurement domain? Intelligent Contracting represents the convergence of six emerging technologies that may be able to facilitate the entire procurement value chain, from requirements development and solicitation to contract award and performance, and may result in more effective and efficient procurement performance. The primary technologies include cloud computing, artificial intelligence (AI), and big data; while the supporting technologies include intelligent agent technology (IAT), smart contracts, and the blockchain. The intent of this article is to paint a picture of a new vision for the future of procurement based upon the integration of these six emerging technologies by describing the new concept of Intelligent Contracting (IC).

Category: Lessons Learned

Winner: Adaptive Acquisition Lessons: Traditional and Novel Tools for Dynamic Quality Product Development

Authors: **Col. Matthew G. Clark, Ph.D., PMP**, is the director for Medical Systems under the Assistant Secretary of the Army for Acquisition Logistics and Technology at the Pentagon. He is responsible for portfolio management and oversight support of all medically related research, development, acquisition, and joint integration in the U.S. Army involving medical systems.

Kristine Gouveia, M.S., PMP, is a senior consultant for LMI providing support to the Joint Program Executive Office, Chemical Biological Radiological and Nuclear Support Medical Program Management Office. She is responsible for providing program management support to the Rapid Opioid Countermeasures System program.

Saumil Shah, M.S., MBA, PMP, is the assistant product manager at the Joint Program Executive Office for Chemical, Biological, Radiological, and Nuclear Defense. He is responsible for the Rapid Opioid Countermeasures System (ROCS) program.

Abstract: Developing the Rapid Opioid Countermeasure System (ROCS) prototype, the Program Management Office (PMO) continually observed the critical importance of collaboration and communication between government and industry. We sought tools to facilitate dynamic dialogue while moving PMO culture towards dynamic delivery. Three tools in particular helped keep development moving: Concept of Use (CONUSE, an iterative requirement process), early overlapping Knowledge Points (KP), and flexible contracting using Other Transactional Authority (OTA) employing a Statement of Objectives (SOO) first. This essay explains how the PMO used these tools while developing the ROCS prototype for the Joint Force. These tools, in addition to regular engagement with the Test and Evaluation (T&E) community, represented by the Food and Drug Administration (FDA) for this commodity, also helped ensure development of quality products. This essay presents how the PMO overcame challenges with the requirements process, the early need for knowledge to inform and effectively schedule dependent developmental activities, and the need for more flexible contracting that balances government demands with more standard industry practices. Most importantly, these tools and lessons learned have utility for all PMOs.

Honorable Mention: Program Management by Design

Authors: **Lt. Cmdr. Ryan Hilger (USN)** is an Engineering Duty Officer with Navy Strategic Systems Programs in Washington, D.C. He has previously served on USS Springfield (SSN 761) and USS Maine (SSBN 741) (GOLD). He holds a Master of Science in Mechanical Engineering from the Naval Postgraduate School.

Abstract: In an increasingly interconnected acquisition community, legacy methods of communication, program management, and stakeholder alignment have proven unable to keep up with demands and leave acquisition professionals frequently feeling left out of decision making, not empowered to own the solutions, or build high performing, collaborative teams. Human centered design, which is becoming more common in the highest performing organizations, offers a tool set that promotes communication, teamwork, and ownership of the products. Recent experience at one Navy organization shows how design thinking tools can be used to improve program outcomes and employee satisfaction and engagement.

Honorable Mention: Getting Modernization Right with User-Centered Design and Solider Touch Points

Authors: **Pam Savage-Knepshield, Ph.D.**, is a research psychologist and lead for Human Systems Integration and User-Centered Design matrixed to Product Manager Fire Support Command and Control at the Program Executive Office for Command, Control and Communications – Tactical (PEO C3T) from the Combat Capabilities Development Command's Data Analysis Center. A former Distinguished Member of Technical Staff at Lucent Technologies/Bell Laboratories, she has a Ph.D. in Cognitive Psychology from Rutgers University and is a Fellow of the Human Factors and Ergonomics Society.

Lt. Col. (Promotable) Chris Anderson is the former product manager for Fire Support Command and Control at PEO C3T, and is currently serving as the product manager for Command and Control in the Army Hypersonic Project Office. He holds an MBA from the University of Alabama in Huntsville and a B.A. in biology from Ripon College, and is a principle selectee for Senior Service College. He is Level III certified in program management and Level II certified in test and evaluation, and is a member of the Army Acquisition Corps.

Lt. Col. Jason E. Carney is the product manager for Fire Support Command and Control at PEO C3T. He received an M.A. from Webster University and holds bachelor's degrees from the University of South Alabama as well as Boise State University. He is Level III certified in program management and Level II certified in test and evaluation, and is a member of the Army Acquisition Corps.

Angel R. Acevedo is the product support manager for Fire Support Command and Control at PEO C3T. He holds an MBA from the Naval Postgraduate School in Program Management. He is Level III certified in logistic support and Level I certified in program management, and is a member of the Army Acquisition Corps.

James Goon is the deputy product manager for Fire Support Command and Control at PEO C3T. He holds a bachelor's degree in Electrical Engineering from Polytechnic Institute of New York. He is Level III certified in program management and systems planning, research development and engineering, and Level II certified in test and evaluation and program systems engineering, and is a member of the Army Acquisition Corps.

Abstract: User-Centered Design (UCD) is not a new concept. It has been used by commercial industry for over 30 years. However, it has rarely been used during the design and development of military equipment. With the Army's recent emphasis on early experimentation, rapid acquisition, and the use of Soldier Touch Points to drive design decisions, more case studies documenting UCD processes and lessons learned are needed. This case study presents a UCD process that began before contract award. Literature reviews, contextual observation studies, focus groups, online surveys, and design-focused task analyses provided the foundational design intelligence to drive early development decisions. The creation of wireframes (screen mock-ups) and prototype software has enabled the program office to iteratively obtain user feedback and implement course corrections as necessary. Improving the system's usefulness and usability through user-centered design, helps to minimize late stage design changes that increase schedule and cost. Key insights and lessons learned from the application of UCD and their impact on system design are discussed.

Major General Harold J. "Harry" Greene Awards for Acquisition Writing Distinguished Judges

Vincent E. Boles, Maj. Gen. USA (Ret.), Defense Acquisition University (DAU) instructor

Charles A. Cartwright, Maj. Gen. USA (Ret.), DAU faculty member and former program manager, Future Combat Systems

Professor John T. Dillard, senior lecturer, Graduate School of Engineering and Applied Sciences, Naval Postgraduate School

Professor Raymond D. Jones, lecturer and academic associate, Defense Acquisition and Program Management Curriculum, Naval Postgraduate School

Gary Martin, president of GPM Consulting LLC and former Program Executive Officer for Command, Control and Communications – Tactical

Kurt A. McNeely, Col. USA (Ret.), chief, Warfighter Central, U.S. Army Combat Capabilities Development Command

Roger A. Nadeau, Maj. Gen. USA (Ret.), senior vice president, American Business Development Group and former commanding general, U.S. Army Test and Evaluation Command

Kris Osborn, Editor-in-Chief, Warrior Maven

Dana J.H. Pittard, Maj. Gen. USA (Ret.), vice president, Defense Programs, Allison Transmission

Ken Rodgers, Col. USA (Ret.), director, Strategic Defense Systems and C4I, Cypress International

Rickey E. Smith, former deputy chief of staff, G-9, U.S. Army Training and Doctrine Command

Richard G. Trefry, Lt. Gen. USA (Ret.), Association of the United States Army senior fellow and former Army inspector general

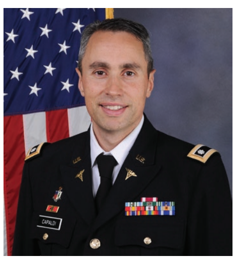
Category: Acquisition Reform

WINNER

Accelerating Science to Solutions at the Velocity of Relevance

By the following authors:


Col. Deydre S. Teyhen **Col. Robert O'Connell**




Lt. Col. Vincent Capaldi II **Deborah Shear, Ph.D.**

Col. Matthew G. Clark

Disclaimer: The opinions or assertions contained herein are the private views of the authors, and are not to be construed as official, or as reflecting true views of the Department of the Army or the Department of Defense.

In 2017, the Deputy Secretary of Defense highlighted the reorganization of Defense Acquisition Management structure as required by the National Defense Authorization Act by emphasizing the "speed of relevance," partnerships, and building a comprehensive system that promotes a more lethal force (Jim Garamone, "DOD Restructures Acquisition, Technology Office to Improve Military Lethality, Speed." DOD News (August 2, 2017)). A limitation with this characterization is that "speed" without direction and purpose is merely aimless motion that may not deliver timely results. Effectively, relevance is lost without a direction. As the Army Futures Command celebrates its first anniversary, it has successfully provided the direction that, when combined with speed, provides the foundation for capability to be developed at the "velocity of relevance." Now that the direction and purpose have been established and communicated, and partnerships are explored and initiated, the system can accelerate action, results, and capability to the "velocity of relevance." Achieving this velocity requires engagement across the entire spectrum of capability development, including research at the early, critical stages of science and technology. This paper explores an innovative approach to ensure the science is both relevant and aligned for the "velocity of relevance" that our warfighters need to meet the objectives of a Multi-Domain Operation (MDO) of the future.

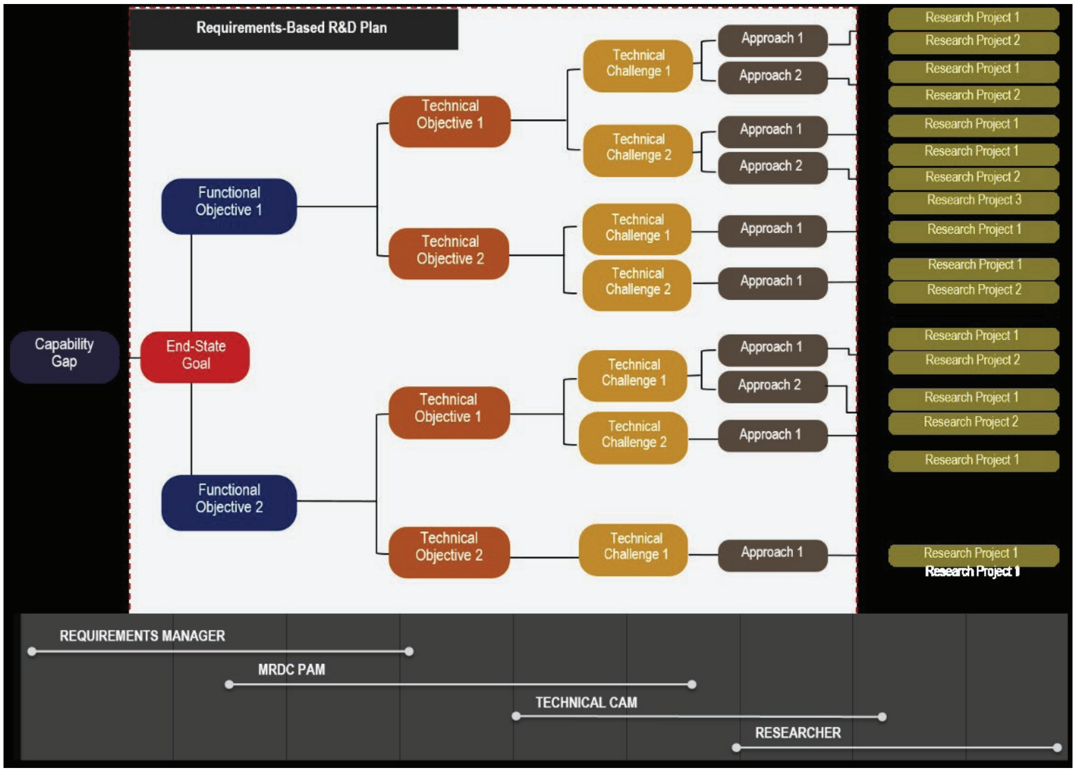
Historically, one visual representation of the scientific approach to address requirements-based research capability gaps has been called a "Waterfall Approach." (Figure 1). Conceptually, once a requirements manager identifies a capability gap and an end-state goal, functional and technical objectives and challenges are identified which lead to a list of research projects for completion to address the identified capability gap. Although this process has served us well in transitioning from investigator-driven to requirements-driven research, this process is often criticized for being slow, antiquated, and stove-piped. To meet the Army's Force Modernization goals, this approach often fails to move at the velocity of relevance, particularly in a volatile, uncertain, complex, and ambiguous environment.

Fundamentally, solution developers need to have both a direction (a vector) and speed for the velocity of relevance. The waterfall approach can fail to address capability gaps because such gaps are often too broad to be useful, leading to a multiplicity of research priorities and efforts that don't necessarily drive forward to solutions. In other words, capability gaps lack a clearly defined vector to facilitate solutions at the velocity of relevance. At the Walter Reed Army Institute of Research (WRAIR), we are adding a step to the Waterfall Approach by having our capability area managers (CAMs) identify the "Wildly Important Question" or WIQ. The answer to the WIQ is the most essential scientific advancement for the creation of a capability gap solution. Fail to answer the WIQ and you will not be able to advance science to a solution. Identifying the WIQ prevents distraction by non-essential questions and creates a highly productive scientific characterized by "focused imagination" for a solution. The WIQ not only provides direction for the research team but it helps ensure the research questions are designed to advance science to a solution of priority for Army Force Modernization.

Sean Covey once stated "focusing on the wildly important requires you to go against your basic wiring as a leader to do more, and instead, focus on less so that your team can achieve more" (McChesney C, Covey S, Huling J. "The 4 Disciplines of Execution." Free Press, (April 2012)). At the U.S. Army Medical Research and Development Command we do medical research in areas 1) that are medically and militarily relevant, 2) have limited academic or industry interest, 3) in need of a rapid solution dictating an intramural approach, and 4) directed by Congress. By focusing on a WIQ, it helps ensure we leverage existing research in academia and industry to help drive the most appropriate solution for a capability gap. Oftentimes, the WIQ identifies a research question that would be too high risk for academia and industry to address based on limited return on investment. By identifying a WIQ that, when successfully answered, could underwrite risk for academia and industry, we can best leverage the limited research dollars available and ultimately facilitate high-value partnerships to accelerate materiel solutions.

Accelerating to the velocity of relevance also requires the right subject matter experts to provide the energy over time to move science to solutions. The concept of "Convergence Science" helps provide WRAIR's research teams with the speed required to move science forward. Bringing the best experts from physical sciences, life sciences, mathematics, engineering, mathematical modeling, and artificial intelligence allows a team to better identify innovative techniques to help drive science to a solution. Stated another way, who across the

FIGURE 1 Waterfall Approach

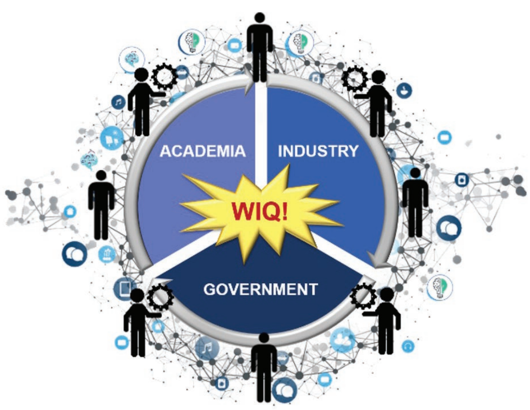


Capability Gap driven research identifies end-state goals, functional objectives, technical objectives and challenges, which ultimately leads to the research projects required to address the capability gaps.
(Created by graphic artists at the Walter Reed Army Institute of Research)

U.S. government, DOD, Army, academia, industry, and international partnerships can help answer the identified WIQ as quickly as possible.

Figure 2 addresses an Army validated capability gap. Who is your A-Team? By focusing on convergence science we can increase agility and innovation within the 6.1 to 6.3 research process. Ultimately, the goal is to bring an activist management process together to solve the WIQ at the velocity of relevance. The partnerships formed around a WIQ facilitate the public-public or public-private partnerships that help to empower research teams with overlapping interest to more efficiently and effectively close a capability gap.

FIGURE 2 WIQ

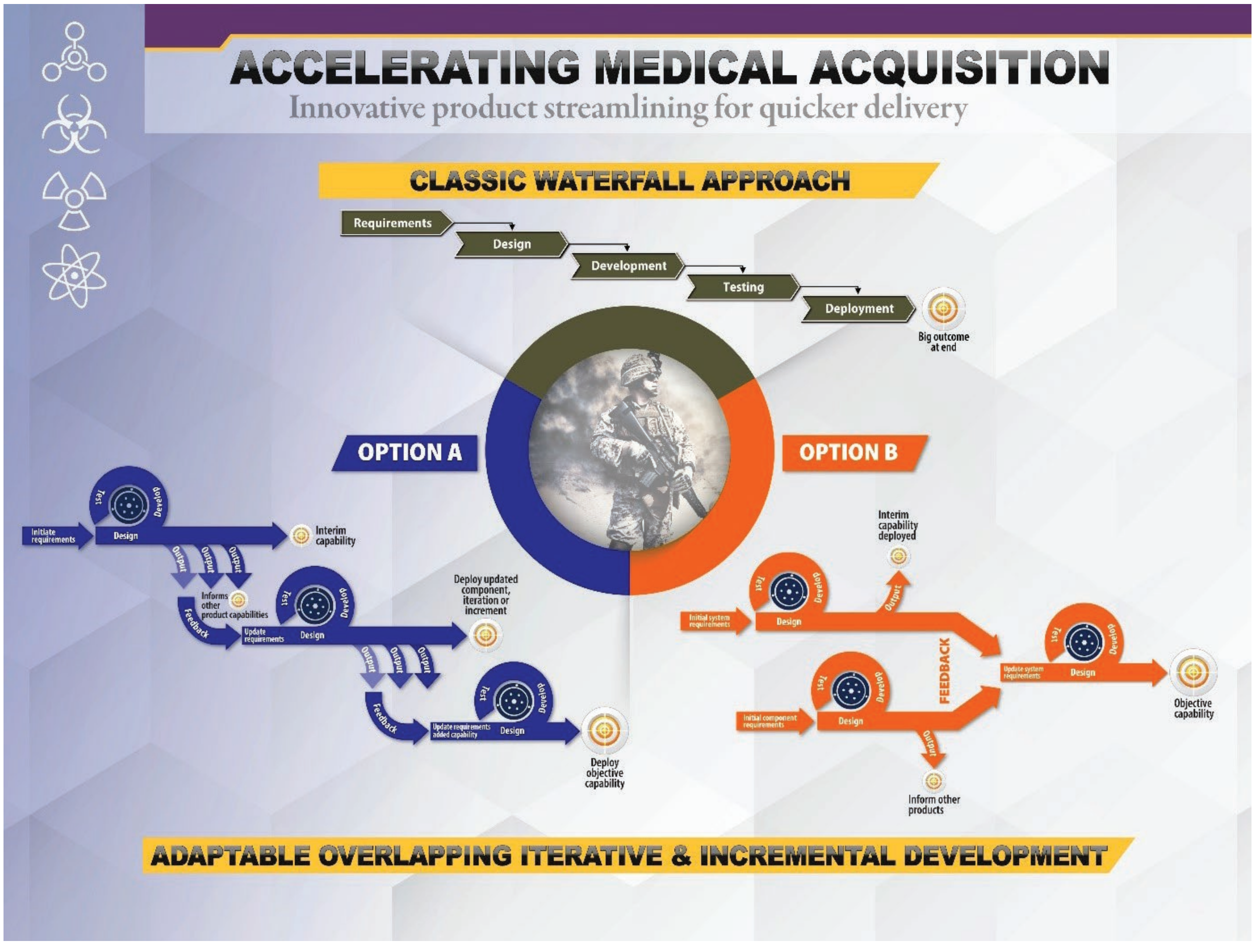


Fail to answer the Wildly Important Question (WIQ) and you will not be able to advance science to a solution. Once the WIQ is identified, you build a team from government, academia, and industry to answer the WIQ at the velocity of relevance. (Created by Dr. Shear at the Walter Reed Army Institute of Research)

How does this look in practice? Traumatic brain injury (TBI) is a major medical concern for MDO. In the past, pharmacological interventions such as progesterone and erythropoietin (EPO) showed significant promise for TBI based on years of research primarily coming from individual laboratories; each progressed to expensive and unproductive clinical trials. For example, there was a $48M non-DOD sponsored trial conducted at 49 trauma centers in the United States and had 882 patients enrolled at the time it was terminated for futility. DOD's requirement to better understand which drugs were effective clearly required a different approach. Army researchers identified the WIQ and leveraged the convergence approach to the scientific process. This resulted in the formation of the WRAIR-sponsored "Operation Brain Trauma Therapy (OBTT)" Consortium as a partnership between academic, industry, and DOD-based centers of excellence. To date, OBTT has screened 12 of the most promising drugs for TBI across multiple TBI models (>1,800 subjects) and has been able to correlate blood-based TBI biomarkers with improved outcomes and reductions in brain injury. The OBTT has been highly productive, having published 23 peer-reviewed papers to date, and having identified two drugs as promising therapies for clinical trials. Importantly, OBTT has also identified drugs, such as EPO, as failing to show preclinical benefit, which would have predicted its failure in some large non-DOD funded trials. This approach was also financially efficient. The overall cost was less than $200,000 per year per institute (or less than $1M per year total). The OBTT has been cited in the New England Journal of Medicine as groundbreaking and provides an outstanding example of how using WIQ and Convergence Science can accelerate the velocity of relevance to identify a drug that will help Soldiers on the battlefield after a blast-related TBI.

Although a WIQ may provide the vector, and convergence science may provide the speed to get to the velocity of relevance, ultimately, to meet the Force Modernization goals, we must add acceleration. Acceleration requires an adaptable overlapping iterative and incremental developmental process (Figure 3) for delivering relevant capability ("Middle Tier Acquisition Using Overlapping, Iterative, and Incremental Development: A Faster Way to Combat Opioid Exposure," Army AL&T (Special supplement to April – June 2019, p. 5)). This is where Science and Technology Managers (STMs) meet Program Managers (PMs)—both are critical for delivering relevant capability. The scientists who drive the STM process tend to focus on highly technical components within the state of the art that compose the systems that are ultimately delivered. Alternatively, PMs focus on delivering systems and capabilities within the state of what is possible and within the time and budget allotted. An iterative and incremental roadmap (Figure 4), agreed upon by the STMs and PMs, provides a unified vision for the foundation of the WIQ and convergence science approach to science and technology innovation.

FIGURE 3 Medical Acquisition



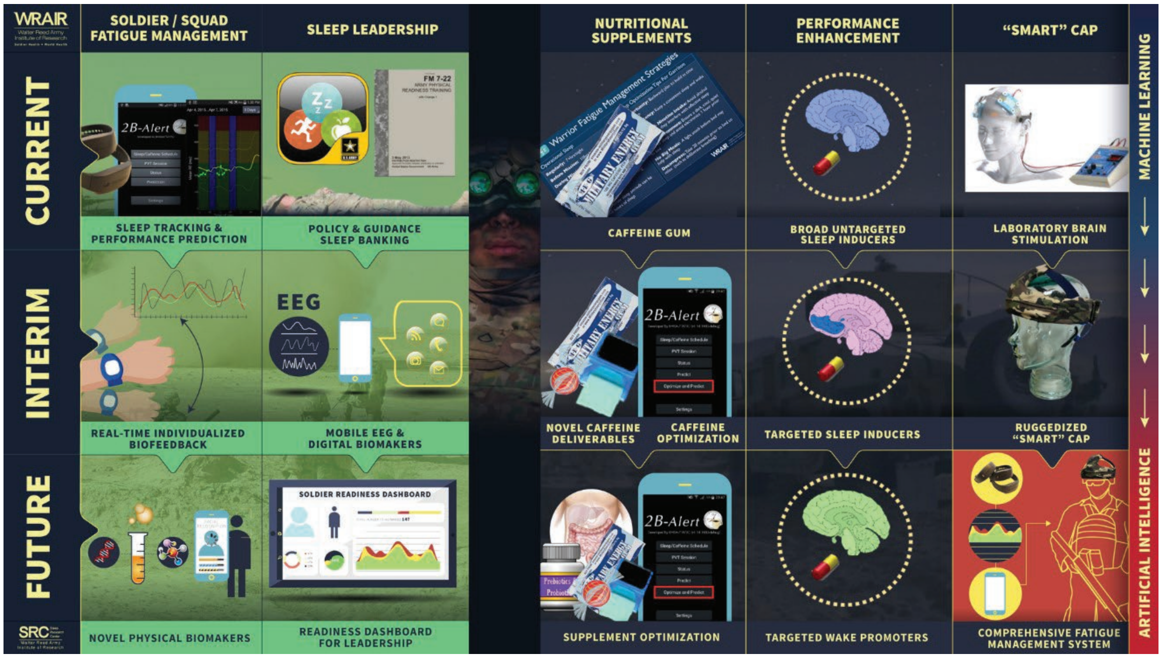
Accelerating Medical Acquisition: Innovative Product Streamlining for Quicker Delivery. Adapted from: "Middle Tier Acquisition Using Overlapping, Iterative, and Incremental Development: A Faster Way to Combat Opioid Exposure," Army AL&T (Special supplement to April – June 2019, p. 5).

Currently the WRAIR and the U.S. Army lead the world in warfighter fatigue management solutions, enabling warfighters to maximize their human potential by maintaining their mental acuity during prolonged battles.

Figure 4 illustrates an incremental and iterative roadmap that leverages machine learning, artificial intelligence, technology, and cutting-edge science to drive research priorities to support Soldier lethality and maximize human potential in an MDO. WIQs and convergence science principles result in improved capabilities, knowledge products, and technology development to address validated capabilities gaps that align to MDOs. Combined, these improved capabilities enable the development of an integrated fatigue management system-of-systems solution (highlighted in red) which enhances warfighter mental and physical lethality on the battlefield. The iterative and incremental roadmaps for a given capability gap serve to unify capability development and deliver iterative and incremental capabilities faster through efforts while allowing for parallel developmental efforts to proceed.

Conceptually, STMs and even individual investigators can use the iterative and incremental roadmap to develop the WIQs required to move from current solutions to interim and future solutions. Alternatively, the PM focuses on what they can deliver that supports the system or objective capability within a given period of time. For both, higher level STMs and PMs need

FIGURE 4 Roadmap



Iterative and Incremental Roadmap for Warfighter Fatigue Management designed to synchronized efforts across the research and development communities to develop iterative and incremental solutions for the warfighter at the velocity of relevance. Created by graphic artists at the Walter Reed Army Institute of Research.

to see both the current state-of-the-art and the future potential that can come from a developmental plan that involves iterative and incremental development. The iterative and incremental roadmap then serves to unify the development and create the conditions for overlapping iterations, either at the component, system, or even system-of-systems level. In short, it provides the "Why" of development and helps planners, programmers, and even oversight organizations see why the U.S. is continuing to invest in capability development that may appear to be seemingly "solved" while also promoting the conditions that allow for true velocity and flexibility within the space of capability development required for force modernization to reach MDO objectives. This approach moves past the limiting waterfall approach employed for teaching acquisition and capability development into a realm where purpose, direction, speed, and relevance can be achieved across STM and PM domains.

Gen. Murray has stated, "I am personally and professionally invested to ensure the future soldiers have the concepts and capabilities they need when and where they need them to fight and win on a future, high-lethal battlefield." At the WRAIR, U.S. Army Medical Research and Development Command, we are leveraging WIQs, Convergence Science, and Iterative and Incremental Roadmaps to move science forward at the velocity of relevance to fill the scientific capability gaps required by our medical portfolio managers to maximize human potential to improve Soldier lethality as defined by the 2028 MDO priorities.

HONORABLE MENTION

Going Too FAR Takes Too Long: Using Other Transaction Authorities and Agile Approaches to Rapid Acquisition

By the following authors:

Joseph Novick **Ray Gulcynski**

Rapid contract execution is an oxymoron in defense acquisition. Federal regulations associated with contracting impede defense acquisition programs' ability to use agile management strategies. Other Transaction Authorities (OTA), however, work outside the bounds of the Federal Acquisition Regulation (FAR) to enable industry to deliver iterative and rapid prototypes. Using agile acquisition via the Countering Weapons of Mass Destruction (CWMD) OTA, the High Mobility Decontamination System (HMDS)1 program delivered the initial set of prototype systems to the U.S. Army within 100 days of project award for testing in an operational environment. The program then upgraded the design based on user feedback from prototype demonstrations and delivered a subsequent set of prototypes less than twelve months later.

OTAs are "legally binding instruments that may be used to engage industry and academia for a broad range of research and prototyping activities.2" The OTA approach provides a responsive solution to meet U.S. Army needs. Capabilities pursued using an OTA are prototyped and provided to users as soon as possible in the development process. Rapid capability delivery increases its relevance and provides an opportunity to mitigate the potential surprises presented by emerging threats. Early user feedback improves operational relevance; informs requirements; and lays the foundation for adjustments to Service Concepts of Employment and Tactics, Techniques, and Procedures. This engagement clarifies trade space and allows programs to fail early, which encourages system modifications driven by user feedback on design and functionality.

Through OTAs, program managers can use agile techniques to develop weapon systems for the U.S. Army. This essay will describe how program managers can use an "other transaction" based strategy to deliver capabilities faster than what is possible in FAR-based approaches.

Agile or Waterfall?

Making the decision to use agile program management requires commitment from all stakeholders as the approach deviates from the "waterfall" model that is typical of DOD programs. The waterfall model is a linear program management process with clearly defined phases. An example of a traditional waterfall model is the process outlined in DOD Instruction 5000.02 (Material Solutions Analysis > Technology Maturation and Risk Reduction > Engineering and Manufacturing Development > Production and Deployment > Sustainment). Once a program formally exits one phase and enters the next, it cannot go back to a previous phase. Think of the waterfall model as a train on preset tracks moving from one station to the next. Any obstacles blocking the tracks bring the train to a screeching halt. The agile process focuses on the prioritization of small, incremental tasks. Agile programs can develop systems despite vague requirements and requirements creep through rapid requirements reprioritization. The agile process is a car on a road that is capable of changing lanes, making turns, and even turning around to avoid obstacles.

The use of agile program management for iterative prototyping also facilitates introduction of capability to users. Operational relevance and functionality improvements continue through the prototyping strategy within cost and schedule constraints. Without strong leadership and regular communication with the user, however, the program can slip into a perpetual modification mode and never realize a final design. Program managers of agile programs can manage costs during iterative prototyping by ensuring that user-defined high priority/high impact requirements receive requisite funding and resources before those of low priority/low impact.

In the case of the HMDS, leadership at the test site was prone to high turnover. This situation meant that the broad-scoped requirements had a high probability of change and requirements creep. These circumstances made agile program management through iterative prototyping the right strategic choice for HMDS.

Agile Contracting

The HMDS team used the CWMD OTA, a consortium based other transaction consisting of 300 companies and academic institutions, to develop the HMDS prototypes vice the traditional FAR-based contracting methods. The OTA provided schedule and requirements flexibility and enabled openness in communications for prototype development that was not available in traditional contracting.

Schedule: Source selection for the CWMD OTA was simpler and more streamlined than typical FAR-based source selections. The process for source selection began with the issuance of a statement of objectives to all members of the consortium. Those that opted to participate submitted a ten-page white paper describing their design vice a large, formal proposal. The selection team determined which design the program would pursue, designs the program could consider later without re-competing the effort, and designs not suitable for this program. The entire process, from the initial request to award, took three months, approximately six to nine months less than typical FAR-based contract awards.

Requirements Flexibility: A high-level statement of work that describes generalized requirements governs the HMDS OTA. This allows for the government and the contractor to make system modifications in a highly efficient manner. The program office can take direct feedback from the user, convey those needs to the vendor, and modify the system design with few bureaucratic actions in contracting.

Openness in Communications: Openness in communications affects the speed to OTA award and modifications to the statement of work. Except for a short period between the white paper submissions and source selection, the program office and the potential performers can have open and frank communication. This includes, but is not limited to, review of draft statements of objectives and statements of work, draft white papers, pricing, details on deliveries, and other such discussions that traditional FAR-based source selection restricts.

Speed, Speed, SPEED!

In agile program management, speed is the name of the game. The program manager's goal ought to be the delivery of the first viable prototype to the user at the earliest possible date. While these first viable prototypes are not perfect, they perform their intended functions and enable feedback loops between the end user and the development team. The HMDS program office demonstrated that the prototypes performed critical functions and were safe before sending them in theater to meet the 100-day delivery deadline.

Direct user feedback ensured the development team focused resources on the most important features to minimize schedule and cost waste on lower priority ones. In the case of HMDS, after the initial prototype fielding, the user allowed the program office to attend an in-theater demonstration. This event provided the program office with a glimpse of the HMDS's concept of employment early in its development. Witnessing the in-theater demonstration enhanced the program office's understanding of the user experience to promote design improvements at the next prototype iteration.

In conjunction with the contractor and the end user, the HMDS program office developed a ledger of prioritized changes to the initial prototypes' design based on user feedback. This action led to a prototype design review hosted by the contractor and attended by the program office and the end user. The resulting dialogue simplified trade space discussions and finalized the prioritization of changes in the ledger. Within three months of the user demonstration, the contractor delivered the next iterative prototype incorporating the highest priority modifications that they could complete within cost and schedule constraints. The program used these newly configured prototypes for follow-on developmental testing.

The ability to make major changes at the last minute in response to requirements creep or test failure was a core benefit of using an agile management strategy. The HMDS experienced a decontaminant compatibility test failure just six weeks prior to system delivery. Using agile management techniques, the program office and the contractor prioritized the redesign of a particular component to improve decontaminant compatibility above all other tasks. Taking advantage of the flexibility of the OTA, the program office and the contractor successfully redesigned the component and tested the system within five weeks of failure. Yet, the overall program schedule only slipped by the two weeks needed to manufacture the redesigned components. Agile management and the OTA allowed the PM to correct a major problem that would have delayed a waterfall program by many months.

Buzzword No More

While upper management may require programs and organizations to be more agile, they likely do not explain how to implement agile strategies. "Be more agile!" "Field faster!" "Implement decisions rapidly!" Agile is the hot buzzword in defense acquisition. This is unfortunate. Telling a traditional waterfall DOD program to "be more agile" is nonsensical. That would be like telling the train to make an immediate hard left. Agile program management requires a paradigm shift in the acquisition community as it uses processes that are not suited for the DOD'S waterfall model. In order to be agile, the right infrastructure and culture must be in place.

The HMDS program office has demonstrated the use of agile program management for iterative prototyping as effective for hardware. Using the OTA and agile program management, the HMDS team delivered an initial capability in less than 100 days, modified the design based on user feedback, and delivered the improved capability in less than fifteen months of OTA award within cost constraints.

While agile is not for every program, the use of agile prototype development improves the speed at which the program office delivers usable capabilities, reduces program risk through iterative prototyping, and reduces costs. The OTA enables U.S. Army Acquisition to use agile management in a waterfall centric DOD Acquisition Framework. OTAs are the right road for agile.

Notes:

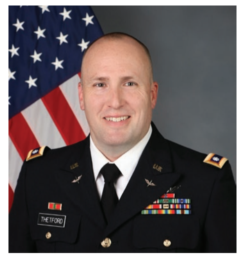
[1] The HMDS is a Chemical, Biological, Radiological, and Nuclear (CBRN) decontamination system for the U.S. Army. Its mission is to decontaminate terrain, military equipment, and fixed sites using DOD approved decontaminants.

[2] "Other Transaction Authority (OTA) Overview." TRANSFORMAL INNOVATION, United States Air Force, April 2016, https://www.transform.af.mil/Portals/18/documents/OSA/OTA_Brief.pdf?ver=2015-09-15-073050-867.

Category: Future Operations

WINNER

On the Limits of 'Strong'[1] Artificial Intelligence: Where *Don't* We Want AI on Tomorrow's Battlefield?



By Lt. Col. Daniel R. Thetford

A rather strange aspect of Artificial Intelligence (AI) application in contemporary DOD Acquisition programs is the noticeable lack of limits. That is to say, no one seems to be discussing where we don't want AI on the future battlefield. Indeed, in almost faith-like adherence, nearly all recent artificial intelligence discussions center on the technical challenges of AI (which are assumed solvable) or the resultant benefits (which are assumed manifold). Apart from occasional deference to human-in-the-loop or some other form of human oversight, the watercooler scuttlebutt concerning AI ostensibly focuses on where it's needed (not where it isn't). This simple observation led to surprising difficulties in specifying potential limits to artificial intelligence. In researching the boundaries of AI application in DOD Acquisition, the issue quickly became complicated both by difficult military application considerations as much as by difficult technical execution considerations. Thus, rather than parroting nebulous clichés of (seemingly) inevitable technical advancement, or pointing longingly to administrative curtailment via ingenious military policy, it is the aim of this paper to investigate the limits of "strong" or "general" Artificial Intelligence with the hopes of specifying practical, actionable considerations for the larger DOD Acquisition Community. With the reader's patience and fortitude, we will first explore Kurt Gödel's incompleteness theorem to introduce the ephemeral connections between calculation and logic; then move to the Three Acts of the Mind in traditional logic to explore the common-sense limits of computer software applications; and finally conclude with practical considerations on implementation of Artificial Intelligence on the Battlefield of tomorrow.

Gödel's Incompleteness Theorem

In 1931, a precocious 25-year-old mathematician named Kurt Gödel shocked the academic world by proving what any ordinary student of math instinctively knew: the mind of the mathematician is greater than the math which they calculate. For as "Gödel's … arguments show … no antecedent limits can be placed on the inventiveness of mathematicians in devising new methods of proof[s]"[2] because the human mind is always able to see beyond the rules of any given calculus; that is, the mathematician is always greater than the math. Such a conclusion may appear obvious on the surface, but in the day of Gödel, the mathematical zeitgeist was a pure form of symbolic logic culminating in "a monumental three-volume work by Bertrand Russell and Alfred North Whitehead called Principia Mathematica" in which it was believed "all mathematics had [been] grounded in … pure logic".[3] Gödel, no doubt to the chagrin of the eminent British mathematician, proved otherwise. Gödel's contribution was to demonstrate how a pure logic construct is always limited due to its own deterministic structure. At the same time, any given mathematician is able to "see beyond the structure," as it were, to new axioms or truths. In other words, contrary to the idealistic hopes of Russell and Whitehead, there appears to be an impassable gulf between a given calculus (no matter the complexity) and the human mind.

The connection to contemporary artificial intelligence is obvious: if logical structures are always limited with respect to the human mind, does strong artificial intelligence suffer the same fate? It would appear so. Artificial Intelligence is nothing more than a given calculus in software coding, and is thus as limited and deterministic as any other created calculus. Even algorithms designed to "learn" beyond their given set of parameters are still limited to that new, deterministic coding. Never can the algorithm expand beyond its programming to new real knowledge the way a human being can.

The Three Acts of the Human Mind: What Traditional Logic Tells Us about AI

Godel's mathematical approach in proving the limitation of any given calculus is complicated and well beyond the scope of this paper. Suffice it here to say the debate has been ongoing in the mathematical community for some time and there is at least solid ground to question the ability of software engineers to build a truly human-like artificial intelligence.

Perhaps a more familiar approach in understanding the insurmountable task of creating "strong" Artificial Intelligence can be illustrated by something close to all of us: human thought itself. Thankfully we need not settle controversial claims about the nature of human consciousness, delve deep into contemporary psychology, or, as mathematician Roger Penrose demonstrated in a recent lecture utilizing Schrodinger's cat example, explain quantum entanglement and superposition prior to waxing theoretical on a non-algorithmic quantum-mechanical location of human thought[4]; instead, we need only rely upon a much older and narrower understanding of human thought—and hopefully much simpler—in order to grasp potential limitations on artificial intelligence.

For generations, the "basis for the science and art of [human] logic [relied upon] two facts: the fact that human beings think, and the fact that thought has a structure."[5] Such structure led to subsequent discovery that human thought follows three main steps: simple apprehension, judging, and reasoning.[6] That is, simple apprehension is the act of the mind understanding terms; judging is the act of the mind making propositions; and reasoning is the act of the mind forming logical arguments. And as any Logic 101 grad knows, terms, propositions, and arguments are the basic building blocks in forming logical syllogisms.

All fine and good, but what does this have to do with AI? Assuming the second and third act of the mind are replicable in a software environment[7], it is the first act of the mind I especially want to highlight as an unsurmountable AI hurtle. The first act of the mind, direct apprehension of a term, includes both something computers can do and something they cannot do. The former is a data point, the latter is a concept[8]: computers can indeed react to new datum within the horizon of their programming, but they cannot universalize any particular data in the form of a concept. Think here of the difference in a child being shown several different types of dogs and learning their basic characteristics, having four legs for example, and the same child seeing an injured dog with only three legs and still correctly categorizing the injured dog as a dog. The difference is one of classification (something an algorithm may be very good at, as in facial recognition software) and generalizing (something even a child does after exposure to only a few examples similar kinds of objects). Unlike the child, the computer never prescinds beyond its programming of a particular input to the concept of similar or like inputs; the child both deduces a particular input and simultaneously induces the universal category of said input (a fancy way of saying the child intellectually understands the characteristics of a particular dog while also understanding the category of universal dog—and at the same time!). Even if the child is wrong in its categorization from time to time, and even if a computer program can more reliably classify a given data input (say at a percentage of reliability greater than the best human being), the fact remains a computer does so under the guise of its deterministic programming while the child is free to see both the particular and universal. Thus the first act of the mind, is, ironically, the most difficult obstacle for a truly "strong" Artificial Intelligence to overcome. The child does naturally what the computer can never do artificially.

Acquisition Implications on the Future Battlefield

If Gödel is correct, the implications to DOD Acquisition are far-reaching. First, if AI is always limited to its programming, then it can never act as a moral agent. Moral agency requires the ability to see both truths in a given situation and truths beyond a given situation. It matters morally both that something is achieved, and how it is achieved. Only a moral actor is capable of such a task (again, even if software can "get the right answer" nearly 100% of the time, it can never be a moral actor in the truest sense). Thus the first implication is human-in-the-loop is not just good legal policy, it is a ubiquitous requirement based on the limits of software engineering. DOD should never allow AI to determine the appropriate action in morally grave situations—events like weapons release, enforcement of international law for non-combatants, determining when to use or avoid certain medical procedures, etc. Final say in these and similar activities must always be determined by an authorized moral agent.

Second, we must be careful of the words used in requirements documents and derived specification documents that request AI on the Battlefield. We must avoid attributing anthropomorphic qualities to AI, even in the vernacular, in order to be clear about what can and cannot be achieved. Artificial Intelligence may be extremely good at data association and complex associative calculation, but is not really capable of "determining", "assessing", or "learning". Use of such terms falsely implies a capability that cannot exist. Therefore our requirements documents must accurately reflect the art of the possible within our technical domain, and materiel developers need to be honest and clear with the Warfighter when developing future requirements.

Finally, knowing the limits of AI allows for concentration in areas in which the technology can be most effective while avoiding inappropriate application elsewhere. This realization on the part of DOD AI developers allows for an optimization of resources, both fiscal and schedule, resulting in the best possible results in the shortest amount of time. Knowing where something ought not be used is sometimes more helpful than knowing where it should be used; and in the uncertain times ahead, clear understanding of the limits of artificial intelligence is not a luxury but a necessity.

Notes:

[1] "Strong" or "general" AI is considered to be equal to (or beyond) human thought and consciousness.

[2] Earnest Nagel and James R. Newman, Gödel's Proof, (New York: New York University Press, 2001), 110.

[3] Ibid., xiii.

[4] Roger Penrose, Youtube, 2015, available at: https://www.youtube.com/watch?v=eJjydSLEVlU

[5] Peter Kreeft, Socratic Logic, (South Bend, Indiana: St. Augustine Press, 2010), 28.

[6] Ibid.

[7] Not a position I maintain at least with respect to the second act of the mind.

[8] Kreeft, 36.

HONORABLE MENTION

Rare Earth Elements: A Vital Supply Chain at Risk

By Michael J. Ravnitzky

Most advanced military technology depends on rare earth elements, or REEs[1]. REEs help Army systems such as night-vision goggles, precision-guided weapons, and communications equipment perform with reduced size, weight, and energy consumption. They also provide greater system efficiency and thermal stability.[2] These features provide portability and field endurance, advantages that are vitally important to the Army and to the other military services. However, assured access to REE materials is currently at risk, placing the entire high-tech military supply chain in jeopardy.

A report issued by the Department of Defense (DOD) Office of Inspector General in 2014 concluded that the office responsible for forecasting for the strategic stockpile lacked a comprehensive and reliable approach to assessing both REE supply and demand.[3] Two years later, a Government Accountability Office (GAO) report expressed concerns regarding REE supply risks, and called for a more comprehensive approach.[4]

The current approach to ensuring the availability of REEs is problematic. DOD's reliance on commercial supply chains for critical procurements has negative consequences. The commercial marketplace has adopted tools including lean manufacturing, vendor-managed inventory, and just-in-time delivery. As a result, the operation of modern outsourced supply chains can conflict with military preparedness. In the case of REEs and other specialty materials with "thin" markets, supply failure can and will occur.

We can look to our nation's experience during World War II to venture beyond single-path solutions and find creative ways to address the present acquisition challenge. By tapping all our national resources and formulating integrated acquisition strategies using our diverse national assets, we can spur the marketplace to provide adequate supplies of REEs for defense and civilian needs.

Rare Earth Elements

A rare earth element is one of 17 chemical elements: the 15 metallic elements with atomic numbers 57 - 71, such as neodymium and dysprosium, plus the chemically similar elements scandium and yttrium. The name, however, is a misnomer—REEs are not rare in the earth's crust, but they are found in low concentrations and are difficult and costly to extract, process, and purify.

REEs are used in missile guidance, lasers, anti-missile defense, satellites, fuel cells, special purpose glass, communications systems, and coatings for jet engines.[5] Commercial products used by the military also require REEs, including automotive catalytic converters, catalysts for oil refining and chemical processing, flat-panel displays, rechargeable batteries, and high-performance permanent magnets. The details of rare earth applications are often proprietary or classified, which muddies the calculation of national needs.

From the 1960s to the 1980s, the United States led the global production of REEs. Eventually, China's labor cost advantages, less demanding environmental rules, and sites with commercially exploitable concentrations of REEs caused world production to shift almost completely to China.[6] This was exacerbated by a "laissez-faire" approach to long-term rare earth procurement strategies.

China now produces 100% of the "heavy" REEs and nearly all of the "light" REEs. Development of known reserves in other countries has been hampered by logistical and investment hurdles, as well as the environmental and technical challenges of mining, extracting, and refining REEs.

The only remaining American REE mining operation now sends its ore to China for processing.[7] In recent years, Chinese firms have purchased key U.S. magnet manufacturers, appropriated their technologies, established production in China, and discontinued the U.S. operations.[8] China has also reduced the sale of its REEs to other nations, not only because of concerns about resource depletion, but also because of its national policy of shifting from the sale of commodities to the sale of higher-value finished goods.

According to a June 2019 Commerce Department report, the United States is heavily dependent on critical mineral imports. If China or Russia were to stop exports to the U.S. and its allies for a prolonged period, similar to

China's rare earth elements embargo of Japan in 2010, it could cause significant shocks throughout U.S. and foreign mineral supply chains.[9]

The passage of the FY2019 National Defense Authorization Act halted the purchase of certain REEs and REE-containing products from China, North Korea, Russia, and Iran. In July 2019, the White House issued five Presidential Determinations that domestic production of specific rare earth elements, alloys, and magnets were essential to national defense.[10]

Those steps, though necessary, are not sufficient.

Lessons From History

During World War II, the U.S. faced strategic material supply constraints due to the voracious demands of war production when many materials from the Pacific regions and Europe were no longer available. Many materials typically sourced overseas such as rubber, silk, chromium, and nickel became unavailable. In 1938, with war on the horizon, the U.S. began stockpiling materials, but isolationist pressures combined with budgeting and purchasing delays hindered their full acquisition.

On the brink of war, substitutes for some scarce materials, e.g., synthetic rubber for latex, and nylon for silk, were developed and deployed with ingenuity, difficulty, and expense.

America learned the hard lesson that sometimes-obscure commodities could be crucial to producing war materials. But the nation developed effective alternative methods of sourcing, such as recruiting widespread civilian participation in mass scrap drives and recycling programs. Sometimes, valuable material was found in unexpected places. For example, a quantity of extremely rich uranium ore from the Belgian Congo was stockpiled in a New York City warehouse and on African docks by a Belgian businessman who kept the uranium out of enemy hands. He sold it to the Manhattan Project in 1942.[11]

When vast amounts of copper was needed for the war effort, the U.S. government invested in opening more than 200 new mines and the expansion of existing ones, but that produced a mere 1.5 percent of what was needed. The remainder came from substituting, scrap, and foreign sources.[12] One source of copper was a secret program that borrowed massive copper electrical components from power plants and factories across the nation, and replaced them for the duration of the war with silver borrowed from the Treasury Department.[13]

The National Strategic Stockpile System

During subsequent decades, a national strategic stockpile system was created to identify key materials and ensure their availability in the event of military conflict. The Defense Logistics Agency's Strategic Materials Division identifies current and potential sources for each designated critical material in the event of specified conflict scenarios. The Agency then quantifies the risk levels for each material and determines whether the projected supply would meet the projected need. This approach, known as "risk-filtering," works well for most strategic materials.

Rare earth elements, however, are quite different from other materials. Their unique and distinctive electronic, magnetic, and optical characteristics makes finding substitutes difficult or impractical. According to one expert, each rare earth element has electronic and magnetic properties that are "exquisitely unique" and can therefore occupy a tiny niche in our technology, as virtually nothing else can.[14] Finding substitutes for REEs can be exceedingly difficult.

Unfortunately, analysts may not be able to accurately gauge present or future demand for REEs using existing methodologies. Since REEs are sometimes elements of a contractor's "secret sauce," manufacturers may be reluctant to share proprietary information on their use, or from their suppliers.[15] Because many REE-containing items are standard commercial products, the extent of their use in those products may not be apparent. Furthermore, given their unique properties, REEs will almost certainly be needed for high-tech military systems that have not yet been fielded or developed.

Recommendations

American defense acquisition should reflect a multi-pronged approach to building reliable supply chains for REEs. First, the US could charter an interdisciplinary panel to study the problem of REE access, including consolidating or coordinating the activity of existing interagency groups working on strategic materials.

Second, the U.S. could task the National Laboratories to develop potential substitutes for REE-containing products. The Labs could develop and disseminate scientific and technical information on REE smelting and extraction techniques, and recycling. They could also offer other forms of technical assistance such as how to reduce the environmental burden and energy intensity of REE processing.

Third, the U.S. could establish an industry working group with appropriate antitrust safeguards to identify REE reprocessing opportunities, such as locating scrap parts and REE-containing materials suitable as feedstock for smelting and extraction.

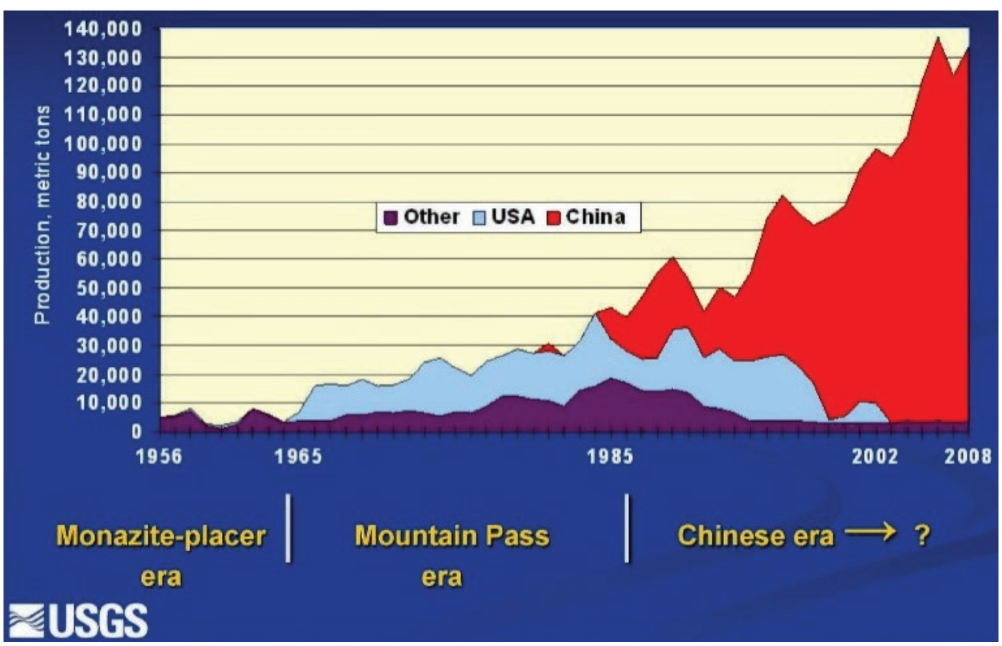
Fourth, the U.S. could build strategic stockpiles in REEs and institute multi-year standing buy orders from domestic REE sources. This would help rebuild domestic production, and could enable establishment of domestic extraction and refining facilities, as well as recycling and reclamation loops. The strengthening of reliable supply chains is more important than procuring at the lowest price.

Besides buying and storing the material, the government could also use "buffering," a leveraging mechanism in which vendors are paid to buy and store material. The government, in effect, purchases a "call" option, giving it the right to purchase material at a future time. A hybrid ("rent-to-own") mechanism is also possible.

Fifth, the U.S. could offer economic and non-economic incentives to encourage the reopening of domestic mines and constructing domestic smelting, refining, and processing operations. Further, the U.S. could tap U.S. Geological Survey resources to identify REE mining resources. Pursuing domestic REE resources and reconstructing the industry would require time, attention, and resources. In particular, the government could offer technical assistance, targeted grants, loan guarantees, and tax credits for REE development. This support could boost extraction efficiencies and help induce industry to operate the mines and refining operations in an environmentally sound manner. In addition, the U.S. should block the international sale of domestic REE producers, and closely scrutinize any proposed sale of REE end-product manufacturers to overseas interests.

Sixth, the U.S. could strengthen cooperation with Canada and America's other trade partners and NATO allies on REE issues, establish joint projects to identify and locate potential REE deposits in those nations, and exchange useful technical data on REE mining, extraction, and recycling.

FIGURE 1 Chinese REE Production



Chinese REE Production (in red). Source: United States Geological Survey

Seventh, the U.S. could find ways to encourage industry to create one or more REE reprocessing facilities to establish recycling loops. In addition, government policy should encourage industry to explore new ways of responsibly extracting REEs from unconventional but promising sources such as scrapped electronics, mine tailings and acid sludge, geothermal brine, coal, and seawater.

Finally, the U.S. could use public prize challenges to highlight and reward innovative technical advances in the production, processing and recycling of REEs.

Our nation is the proud developer of game-changing technologies which depend on rare earth elements. Existing critical materials stockpile management and risk assessment methods create blind spots that do not account for the exceptional nature of REEs and the 21st century tools they make possible. Developing and building an assured supply of all the REEs is essential to our national security. We should not forestall game-changing technological advances due to the inability to obtain these substances.

Notes:

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[14] Professor Andrea Sella, "Insight: Rare-earth metals," Interview on TRT World October 2016. https://www.youtube.com/watch?v=UvQMiqqzcZE

[15] Government Accountability Office, Rare Earth Materials, at 21.

Category: Innovation

WINNER

Accelerating Innovation with the SBIR Program

By Kevin Landtroop

Innovation is the new buzzword throughout not only the Department of Defense (DOD), but the entire US Government (USG). Capital Factory, a startup accelerator in Austin, TX, hosts its share of DOD and USG partners searching for innovation: Defense Innovation Unit (DIU) established a cell at Capital Factory in 2016, AFWERX followed in 2018, and Army Applications Laboratory (AAL) opened their space in Capital Factory's Center for Defense Innovation in 2019. Other defense and government innovation cells conduct tech scouting visits to Capital Factory or are considering permanent presence.

Each of these entities have their own business model, but all face the same three sequential challenges: getting a diverse range of relevant solutions into the innovation funnel, rapidly developing useful prototypes, and transitioning viable solutions to the field. A fourth cross-cutting problem lies in the lack of available contract vehicles and a steady flow of funding that can be deployed just-in-time.

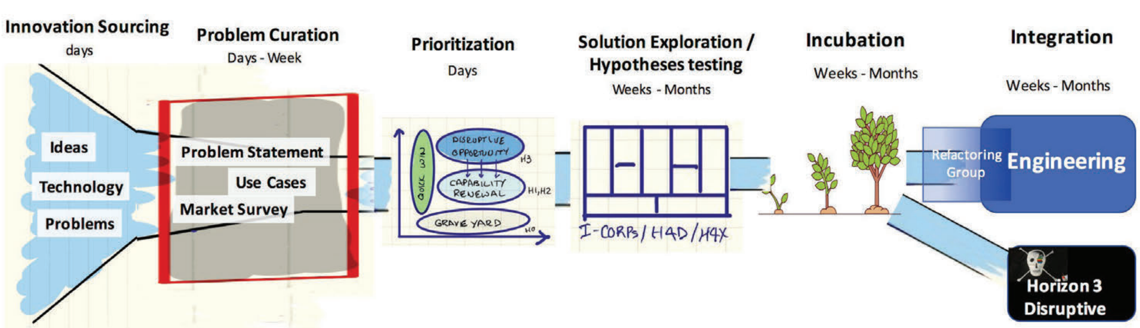
Overlooked by most "innovators" is a steady, predictable flow of dollars in a well-established program: Small Business Innovation Research (SBIR). SBIR is designed to effectively solve the first two sequential challenges, but fails in the third—transitions are rare. With the right business model and partnerships, SBIR can effectively solve all four challenges and evolve into a great model for rapid innovation.

- Phase-I drives hundreds of solutions into the funnel three times per year.
- Phase-II provides opportunity for collaborative lean prototyping.
- Accelerator tools injected early can solve the Phase-III transition problem.
- SBIR is funded, frequent, predictable, and a known (and understood) vehicle.

Let's start by narrowing our view of "innovation," which is itself a misunderstood term. The DOD seeks to advance capabilities through rapid technology innovation by leveraging the commercial marketplace. The "innovation pipeline" developed by Steve Blank and Peter Newell graphically depicts how this innovation happens in the commercial marketplace from conceptual problem to commercial product.[1]

With permission from Pete Newell, I've adapted the pipeline to show how an accelerator (like Capital Factory's) would use accelerator tools to facilitate lean prototyping.[2] This is simply the addition of lean startup or agile development principles to the product development phase of the innovation pipeline. The three phases of an SBIR project fit into this adapted innovation pipeline, as I've depicted in the next figure.[3] We can now readdress the four challenges, and how SBIR, incorporating (and properly executing) accelerator tools into its business model, provides a solution.

FIGURE 1 Innovation Stack



Challenge: How to get a diverse range of relevant solutions into the innovation funnel?

SBIR Phase-I awards are a great way to drive several hundred potential solutions into the funnel each cycle, three times per year. The Air Force awarded more than 350 Phase-I SBIR contracts during the 19.2 cycle, and intends to keep pushing that number higher. All Phase-I awardees are "on contract" and selected through a competitive process. Air Force's effort also responds to the call in the National Security Strategy to expand the defense innovation base! Air Force can justify their Phase-I promiscuity on that basis alone.

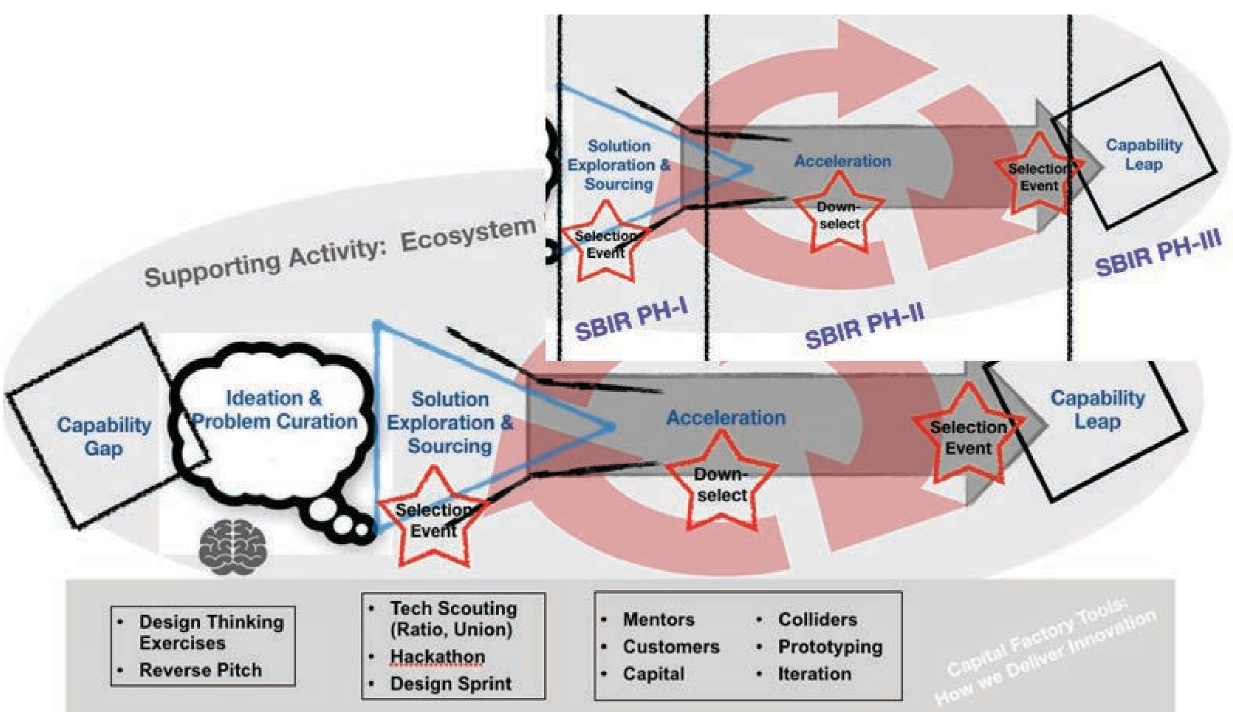
Whether the solutions are relevant is entirely up to the topic writers, but AFWERX has proven that if you write it (and award), the solutions will come. As the Services' SBIR programs evolve in FY20, allowing them to conduct joint Phase-IIs, the number of potential solutions available to each Service will increase not marginally but by multiples. SBIR Phase-I awards could be a great way to drive deal flow into AAL's Army Capabilities Accelerator. For example, as they prepare to launch Field Artillery Autonomous Resupply (FAAR), SBIR topics for the 19.3 cycle could drive solutions in supply-chain automation, robotics, and sensors into AAL's funnel and solve the main problem they've had in FY19: lack of program funding to incentivize companies to engage with them.

Challenge: How to rapidly develop useful prototypes?

Prototyping is the essential function of SBIR Phase-II. Whether the prototype is useful or the effort is rapid depends on the team, the technology readiness level (TRL), customer feedback, and funding. TRL sometimes can't be helped, as not all capability gaps can be overcome by technology within the life cycle of an SBIR project. Choosing wisely during topic selection and Phase-II award can mitigate technology risk. At times, program managers may wish to take a shot on risky tech, test the limits of possibility, or simply invest in the advancement of a particular technology.

The rest are controllable variables within the construct of Phase-II if the "team" consists of more than just the small business building the product. More customers and end users participating in prototype development means better feedback and should result in a better product. Funding should be adequate to complete development and push through obstacles. In both respects, it's important to think more broadly about "team." Opening SBIRs so that other Services can join on a Phase-II

FIGURE 2 Innovation Pipeline



award can be hugely impactful for prototype development. Different customer perspectives and more users providing feedback will drive better product-market fit. Two DOD customers participating in the Phase-II can also double the budget for prototype development and testing, providing much more program flexibility. Bigger budgets also drive speed in entrepreneur-land.

The Phase-II team should not consist only of the awardee company and DOD customers. Product commercialization is a goal of SBIR, and the best Phase-III outcome is when a product transitions into a POR and the commercial marketplace. It makes complete sense then—seems almost obvious, actually—that bringing in big commercial partners to participate in product development will greatly improve the SBIR project and Phase-III outcomes. Big companies (think IBM, Daimler, and BAE Systems) provide commercialization expertise and a marketplace for the first commercial product. They also bring additional development talent, testing capacity, and capital.

Challenge: How do you increase the rate of transition of successful prototypes?

There are three reasons why a Phase-II would not transition: bad product, no customer, or lack of funding. If we assume the product worked and can be scaled, the rest comes down to customers with budget and transition funding.

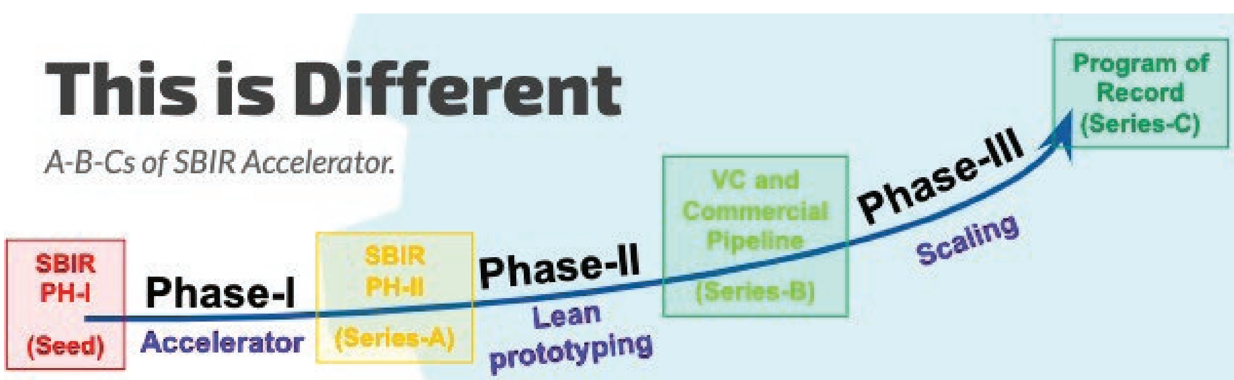
This is the essential problem accelerators were created to solve! A good accelerator knows the team, product, and market, and uses its network of mentors, partners, and investors to connect portfolio companies to customers and capital.[4] Selling to enterprise customers is very difficult for early stage companies. Access to large customers is limited. Companies need capital to sell into enterprise: both to stay alive during extended sales cycles and to scale up production and delivery to a huge customer. Accelerators provide resources to overcome these challenges.

These are the EXACT SAME problems companies face when transitioning an SBIR Phase-III for a government customer. Phase-III "sales" are POR's established and funded through the Program Objective Memorandum (POM). How's that for a long sales cycle—two to three years! Phase-II customers are end-users, but Phase-III customers are Program Executive Offices (PEOs). Accelerators can work exactly the same with these customers, as AFWERX demonstrated recently with their Spark Collider event. Held August 14-15 at Capital Factory, the Spark Collider brought in 120 Phase-I awardees from the 19.2 SBIR cycle with Air Force end users and PMs to form Phase-II teams (teams are established through signing an MOU).

A well-designed and executed SBIR Accelerator would marry Spark Collider with access to commercial customers and investors during Phase-I, forming those teams that will carry the product through to transition. Military customers participate in product development and become Phase-III customers. Commercial customers also participate in product development and bake in a path to commercialization. Investors are already "invested" and standing by to deploy capital to bridge the POM sales cycle (also known as the Valley of Death).

These commercial partners—investors and huge companies—should not be hard to attract. Since AFC's

FIGURE 3 SBIR accelerator



activation, the swell of interest in dual-use technology has become a tidal wave. Once a company has a product development pipeline funded at $2 million (non-dilutive) by multiple government customers, commercial companies will have a strong desire to participate and should be incentivized to do so with a small investment. With a Fortune 100 customer participating in product development, the company will also be very attractive to venture capital.

Challenge: Lack of contract vehicles and predictable funding.

This, fortunately, is one problem SBIR doesn't have. SBIR program funding is appropriated every year and exceeds $1 billion annually across the Services. Funding is deployed in predictable four-month cycles, with incremental funding increases for each phase (similar to venture capital funding rounds).[5] Unlike Other Transaction Agreements, SBIR is a well-used and understood vehicle with established competitive procedures.

This concept is not magic, it's not novel, and it's not complex. Like military plans, the best business ideas are simple and executable.

- Write SBIR topics that address key technology gaps for the Army's 6 modernization priorities. Start with AAL's 15 technology focus areas.
- Use liberal Phase-I awards to drive potential solutions into the funnel. All of these companies are now on contract and selected through a competitive process!
- Accelerator tools add users, product development partners, customers, and venture capital to see the project through to transition.
- The entire project team needs to participate in lean prototyping during Phase-II.
- Commercial customers and venture capital provide experience and incentive to commercialize the product, and resources to bridge the Valley of Death!

I'll finish with speed, and for a reason. It seems that many DOD innovation programs are attempting to go fast simply for the sake of reporting speed to award. The better practice is to identify all necessary components to solve the three sequential challenges, then build a business model that incorporates industry best practices for speed and value. It's also important to remember that for a venture-backed entrepreneur, speed is value: a $2 million raise only lasts so long, and every day the product is delayed is another day without revenue.

Speed is a balance of routinizing a system while tailoring execution, and SBIR provides a great framework. With SBIR cycles occurring at frequent, predictable intervals, entrepreneurs and program managers can count on them and plan accordingly. Using an accelerator, each Phase-II can go as fast as the team, TRL, and funding allow.

Notes:

[1] Steve Blank, The Innovation Stack: How to make innovation programs deliver more than coffee cups, https://steveblank.com/2018/06/05/whats-next-for-getting-stuff-done-in-large-organizations-the-innovation-stack/.

[2] The "down-select" event represents multiple product-market fit techniques during lean prototyping: a true down-select to discard less promising efforts, pivot, or A-B testing. Chart is the author's original work.

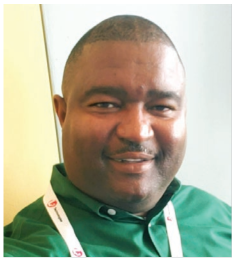
[3] Chart is the author's original work.

[4] Accelerators are helpful during product development as well, providing access to capital and experienced entrepreneurs as mentors.

[5] Chart is the author's original work.

HONORABLE MENTION

Intelligent Contracting – A Vision of the Future of Federal Contracting



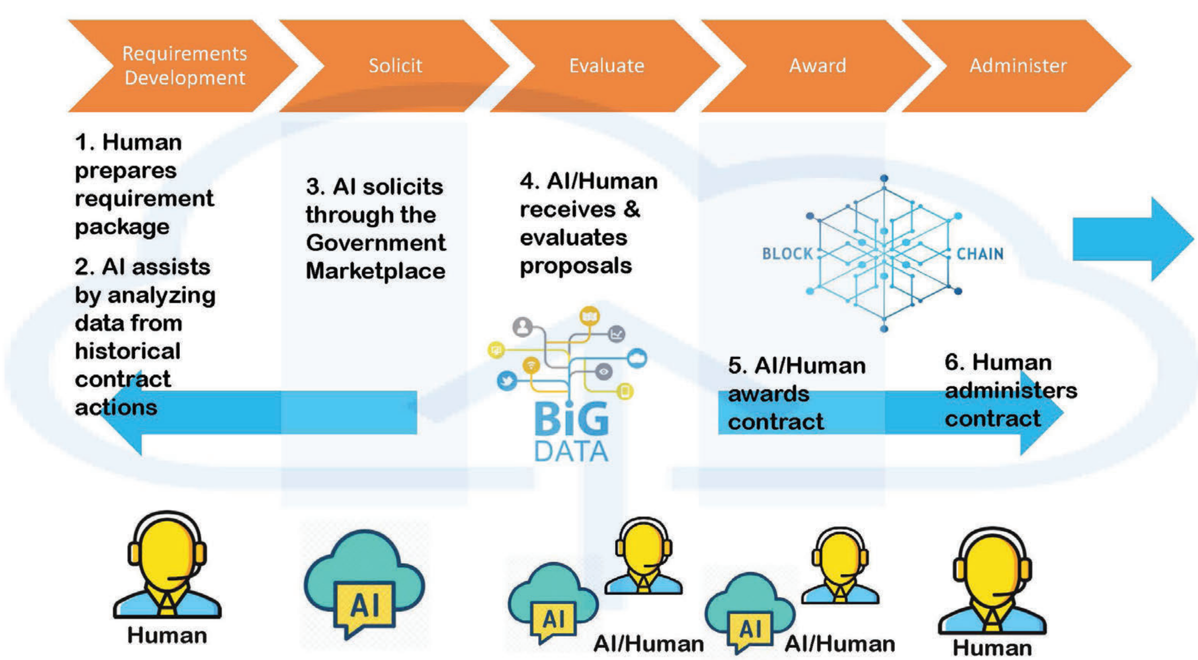
By Col. Vernon Myers, USA (Ret.)

Procurement organizations across the federal government face the same challenges, specifically, maintaining enough resources to execute the mission of contracting for goods and services in support of execution organizations. Additionally, budget constraints, inexperienced personnel, and unstable requirements cause additional strain on the system. Meanwhile, requiring activities are obligating money faster, and resource managers are pulling funds more frequently to meet critical requirements. In 2017, the U.S. Army Contracting Command and its 6,000 civilian and military personnel executed over 165,000 actions valued at more than $62 billion (ACC Fact Sheet, 2019).

Assuming the trends mentioned above continue, what new technology do we have available right now or in the emergent future that could fundamentally transform or disrupt the procurement space? What new innovative business models will shape the way procurement professionals serve customers in the future?

Innovation is the future delivered. In this article, I will describe a future that is within reach in the next few years. Intelligent contracting represents the convergence of six emerging technologies that may be able to facilitate the entire procurement value chain, from requirements development and solicitation, to contract award and performance. Intelligent contracting consists of three primary and three supporting technologies. The primary technologies include cloud computing, artificial intelligence (AI), and big data; while, the supporting technologies include intelligent agent technology (IAT), smart contracts, and the blockchain (See Figure 1). I intend to paint a picture of a new vision for the future of federal procurement based upon the integration of the six emerging technologies that will deliver the innovative intelligent contracting (IC) platform.

FIGURE 1 Intelligent Contracting Primary and Supporting Technologies



Primary Technologies

- Cloud Computing
- Artificial Intelligence
- Big Data

Supporting Technologies

- Intelligent Agent Technology
- Smart Contracts
- Blockchain

Intelligent contracting is an aspirational, high-level vision of what federal procurement could be in 10-20 years. As outlined above, emerging technologies exist now, and four of the six technologies are already being used in diverse federal government applications. I'm advocating that we think bigger by leveraging the capacity and creativity of industry and government to move the procurement business model forward into the 21st century. We are on the cusp of intelligent contracting, and it will take the collective genius of us all to bring this vision to fruition.

Vision

I became interested in intelligent agents a few years ago when I entered an ideation contest and developed an idea called the Federal Multi-Agent System (FEDMAS) (Myers, 2011). FEDMAS is a platform that connects all federal executive agencies in a system where intelligent agents (think … an army of Siri's or Google Assistants) would execute the millions of daily services required by citizens from the government every day, such as applying for a passport, renewing a driver's license, or paying taxes. Citizens would have the ability to deploy personalized intelligent agents anytime, anywhere, and for any legitimate service provided by the government.

I believe that intelligent agents under the direction of AI, operating within a government cloud architecture, using data from millions of historical contract actions, leveraging smart contract technology as the contract instrument, and using the blockchain to secure the transaction, can increase speed and accuracy and decrease the cost of executing contract actions across the federal government. Let's look at how these emerging technologies are currently being used and then apply them to the federal procurement space.

Procurement Now – We Can Do Better!

Federal procurement is a defined market space where the current business model requires customers (requiring activities) to engage market facilitators (contracting agencies) to initiate agreements with suppliers (government contractors) via a transparent and secure marketplace (Federal Business Opportunities) for goods and services to be delivered at specific dates in the future. The current federal procurement business model has served us well over many decades and will continue to do so into the foreseeable future; however, by leveraging the six emerging technologies described in this paper, the method of contract delivery and execution can be made more transparent, more efficient, and more cost-effective. What new technology do we available right now or in the evolving future that could disrupt the current contracting business model? Since the Government is often slow to adopt new technologies, we are most likely a few years away from seeing the convergence of these technologies in the procurement domain; however, it is worth the effort to look at what the art of the possible might be.

Procurement Future – The Art of the Possible

Primary Technologies

Cloud Computing. Cloud computing is the practice of using a network of remote servers hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer (Cloud Computing, 2019). Intelligent contracting would operate within a cloud computing infrastructure similar to the cloud services provided by Amazon Web Services (AWS) to many of the world's largest commercial enterprises (AWS, 2019). The government would need to establish a dedicated cloud architecture that would support AI, big data, intelligent agents, smart contracts, and blockchain capabilities. Cloud computing would provide the Government an opportunity to quickly scale the IC concept, at a reasonable cost, by entering into a contract with a leading cloud provider to host the government cloud infrastructure.

Artificial Intelligence. AI is the analysis, evaluation, and decision-making function within the intelligent contracting concept.AI is an area of computer science that emphasizes the creation of intelligent machines that work and react like humans (Artificial Intelligence, 2019). Some of the activities computers with artificial intelligence are designed for include speech recognition, learning, planning, and problem-solving (Artificial Intelligence, 2019). AI works by combining large amounts of data with fast, iterative processing and intelligent algorithms, allowing the software to learn automatically from patterns or features in the data (SAS, 2019). AI, combined with data from existing government data centers and intelligent agents, will provide an advanced way to automate the procurement process.

Big Data. Big data consists of extremely large data sets that may be analyzed computationally to reveal patterns, trends, and associations, especially relating to human behavior and interactions (Big Data, 2019). The data that would be needed to support the IC concept already exists in databases throughout the federal government. Examples of existing data centers and repositories include the Federal Procurement Data System Next Generation (FPDS-NG), Virtual Contracting Enterprise (VCE), and the Procurement Integrated Enterprise Environment (PIEE). By using data the government is already collecting, IC will be able to feed data to the AI to enable it to, in conjunction with humans, analyze how best to execute each procurement's acquisition strategy. While most of the data needed to launch the IC concept already exists in databases across the federal government, the data will need to be sent through a methodical process to clean, organize, and package it to allow intelligent agents, smart contracts, and the blockchain to efficiently use it to execute the IC concept functions (Miller, 2018).

Supporting Technologies

Intelligent Agents. Intelligent agents are the execution function within the intelligent contracting concept. An agent is defined as one who acts for or in the place of another. Virtual agents have been known by many other names to include bots, personal assistants, software agents, and knowbots (Fingar, 2018). Intelligent agents possess the ability to act on their own to sense, perceive, and communicate with human users, other agents, or objects. Intelligent agents can plan, set goals, reason effectively, and improve their knowledge and performance through learning (Fingar, 2018). Intelligent agents will work in conjunction with humans, AI, and big data to navigate a contract action through the entire procurement process. By using intelligent agents to facilitate the procurement process, productivity will be increased across organizations, and self-service will be provided to customers in an always-on and available mode (Fingar, 2018).

Smart Contracts. Smart contracts are a computer protocol intended to digitally facilitate, verify, or enforce the negotiation or performance of a contract. A smart contract is a computerized transaction protocol that executes the terms of a contract and allows the performance of credible transactions without third parties. A blockchain-based smart contract is visible to all users of the blockchain (Wikipedia contributors, 2019). A smart contract is an output of the intelligent contracting concept that provides a secure contractual instrument that can be used for contract award, performance verification, and payment for services rendered.

Blockchain. A blockchain is a decentralized, distributed, and often public, digital ledger that is used to record transactions across many computers so that any involved record cannot be altered retroactively, without the alteration of all subsequent blocks (Wikipedia contributors, 2019). Blockchain is a relatively new technology that has been most associated with Bitcoin and cryptocurrency; however, it has many more potential applications. The blockchain is the mechanism that would be used to facilitate contract award, payment, and verification of performance or delivery of goods and services. One use case for blockchain is as a tool for awarding and recording transactions, to include smart contract actions. By using the blockchain, contracting professionals can automate the entire process by setting parameters for contract award, payment, and performance verification.

Bridging Strategies – How Do We Get There from Here?

In conclusion, intelligent contracting is an exciting vision of the future of procurement using the six emerging technologies of cloud computing, artificial intelligence, big data, intelligent agents, smart contracts, and the blockchain; however, implementation concerns and other risk considerations still exist. Identifying emerging technologies and developing big ideas is the easy part; on the other hand, figuring out how to integrate the technologies into the intelligent contracting ecosystem will be, admittedly, a tough task. If the Government decided to proceed forward with implementing the intelligent contracting concept, leaders would need to consider pursuing supportive legislation, dedicated funding, prioritizing competing IT projects, and identifying workforce training needs, as preliminary areas of analysis. The Government would also need to conduct a thorough risk analysis before developing this new procurement platform; however, two risks stand out … cybersecurity and finding people with the right expertise to build the intelligent contracting platform. There is much work to be done to integrate emerging technologies into a system that has the required cybersecurity, processes, and protocols necessary for a concept like this to be safe and effective.

Finally, there is a natural fear that technology will hurt people by replacing some with machines and demanding others to develop new skillsets. Innovation and technology are inevitable; however, in this vision of the future of procurement, what is the effect on real people, such as the contracting workforce? What happens to the thousands of federal workers who have spent years learning a trade that can now be completed by AI and intelligent agents? The workforce will need to be retrained to integrate and work with these technologies, but the most important insight is that the contracting workforce will not be replaced. One author stated that even algorithms need to be managed. The bottom line is that there will be a requirement to retrain workers to work in conjunction with technology; however, technology will not replace humans. As many technology experts have stated, change is the only constant when it comes to disruptive technology, and federal procurement will not be excluded. The Government should be proactive and get ahead of the coming changes by harnessing the power of emerging technologies and identifying procurement transformation as a top priority for Government agencies.

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Category: Lessons Learned

WINNER

Adaptive Acquisition Lessons: Traditional and Novel Tools for Dynamic Quality Product Development

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Disclaimer: The views expressed in this article reflect the views of the authors, and do not purport to reflect the official views of the Joint Program Executive Office for Chemical, Biological, Radiological and Nuclear Defense, the U.S. Army, the Department of Defense, or the U.S. government.

Developing the Rapid Opioid Countermeasure System (ROCS) prototype, the Program Management Office (PMO) continually observed the critical importance of collaboration and communication between government and industry. Initially, applying Middle Tier Acquisition and the Edison Award-winning Overlapping Iterative and Incremental development approach we developed unmoored the PMO from linear "check the box" thinking and one-way communication that consistently hinders quality rapid product development in the Department of Defense (DOD). We sought tools to facilitate dynamic dialogue while moving PMO culture towards dynamic delivery. Three tools in particular helped keep development moving: Concept of Use (CONUSE), early overlapping Knowledge Points (KP), and flexible contracting using Other Transactional Authority (OTA) employing a Statement of Objectives (SOO) first.

This essay explains how the PMO used these tools while developing the ROCS prototype for Joint Forces. These tools, in addition to regular engagement with the Test and Evaluation (T&E) community represented by the Food and Drug Administration (FDA), also helped ensure development of quality products. This essay presents how the PMO overcame challenges with the requirements process, the early need for knowledge to inform and effectively schedule dependent developmental activities, and the need for more flexible contracting that balances government demands with more standard industry practices.

Iterative Requirement Development: Employ CONUSE First

In "Tailorable Traditional" acquisitions, DODI 5000.02 dictates that a Concept of Operations (CONOPS) is required before Milestone A. CONOPS are a Component approved acquisition document that describes the "operational tasks, events, durations, frequency, and environment in which the material solution is expected to perform each mission and each phase of the mission" (emphasis added). The problem is the typical CONOPS scope is too broad, which is compounded for Joint capabilities. Army requirement generators further demand a basis of issue plan (BOIP), which compounds the issue.

For ROCS, the CONOPS conundrum hindered development of a validated Capability Development Document (CDD) despite shared understanding about the need. To move forward quickly while facilitating dialogue amongst stakeholders and industry, the PMO employed a product-focused CONUSE to manage the problem.

A CONUSE simply describes the purpose of the capability in terms of the intended users and how the product was to be used. The product-focused CONUSE process helped set conditions for a future CONOPS, and more importantly, provided the methodology for asking necessary questions supporting knowledge-based acquisition and productive early conversations with the T&E community.

FIGURE 1 CONOPS Communication Tool for Iterative Requirement Development

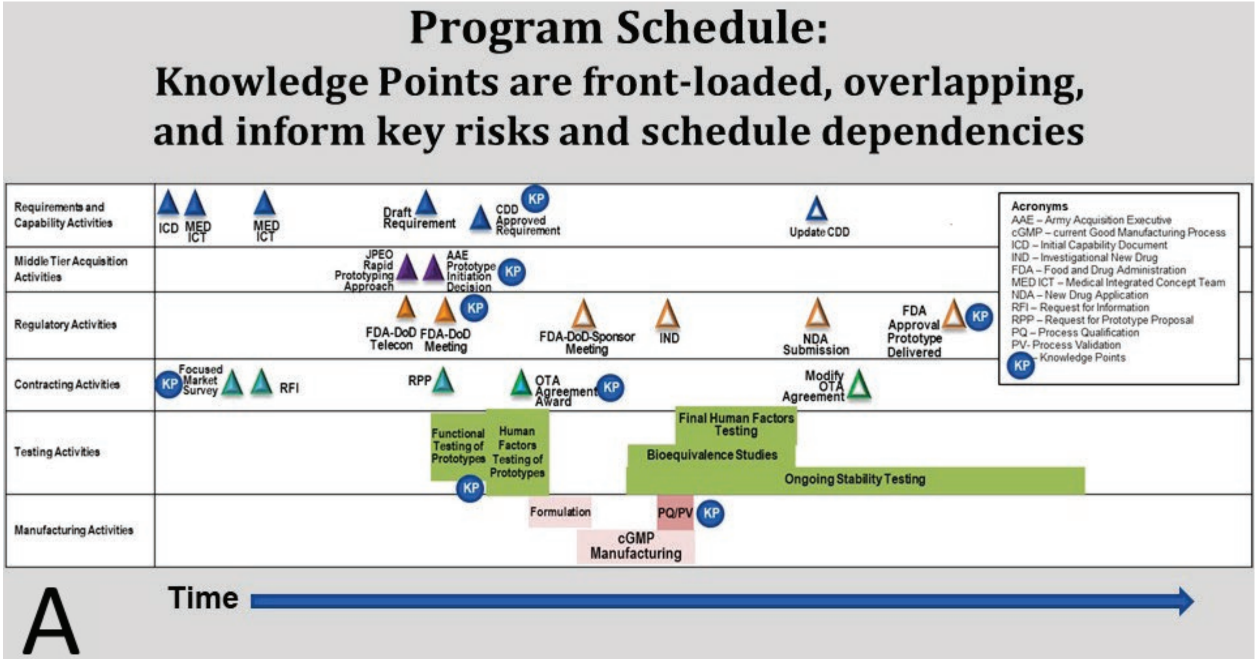
A graphical representation of the key questions required for the ROCS CONUSE is presented in Figure 1. The four main questions included:

1. What is the primary purpose of the capability or product?
2. What are the most likely (not all) scenarios where the product will be used?
3. In what environment and location (e.g., role of care) would casualties be treated?
4. How would the drug/product be delivered to a casualty?

Answering these questions, the Services concluded a rescue therapeutic was the best CONUSE for this capability. Consequently, they prioritized the product for the most likely units and users and not all possible units in all phases of conflict. A product- focused CONUSE subsequently facilitated dialogue with industry regarding the product requirements, without distraction from broader elements of CONOPS (which did not matter to the companies interested in developing this capability).

In time, a full CONOPS should be considered. However, for now, the CONUSE supported quick development of an approved draft CDD that allowed the program to move forward. CONUSE does not currently exist in DOD processes, but it should because it promotes iterative requirements development that supports efficient product development. Consequently, for tasks with varying complexity, different groups can work different aspects in parallel promoting process speed. Logistics staff under the Joint Chiefs of Staff reported to Congressional staff in April 2019 that the typical process to a draft capability document takes 8-22.5 months to complete. For ROCS, the CONUSE process resulted in an acceptable approved requirement in under 4 months.

FIGURES 2A and 2B Knowledge-Based Acqusition



Product Development Knowledge Points

B

KP #	Task	Purpose	Event	Desired Outcome	Action/Re-Action
1	Receive approved requirement	Requirements will ensure that the acquired product is what the user wants and needs	MCS-CDP receives approved requirements document from JRO-CBRND	Approved requirements document received within 6 months of AAE approval for Rapid Prototyping	Users receive product meeting their requirements
2	Market Research	Market research assists in identifying companies that may have FDA approved products which will shorten the development timeline	Market Survey and RFIs	Identification of a manufacturing base with FDA approved products	Capability will be fielded to users in a shorter time period
3	Seek AAE approval for Rapid Prototyping approach	Rapid prototyping will assist in streamlining the program by reducing the amount of documentation currently required by the JCIDS process	AAE Middle Tier Brief	Approval by AAE	Capability will be fielded to users in a shorter period of time vice JCIDS process
4	Seek FDA concurrence on regulatory strategy	Meeting with the FDA early and often provides for understanding of what information the FDA needs in order to approve this product	FDA-DoD Meeting using PL 115-92	FDA concurs no additional safety or efficacy data required beyond a bioequivalency study	Data will support FDA approval
5	Determine if additional autoinjector development is required	Early testing of products enables identification of potential delays to schedule due to additional development work	Performance/Functional Testing at MRMC Test Branch	No significant development effort required for autoinjector	Performance/functional data will shorten development time
6	Award Agreement (OTA)	Successful source selection and agreement negotiations will identify performer that can deliver the product that can meet the user's requirements	Source selection/Agreement negotiations	Agreement through OTA awarded to performer that can deliver product that can meet the user's requirements	Users receive product meeting their requirements
7	Determine product is manufacturable	Process qualification and process validation will data to indicate the manufacturing process and product meets quality standards	Perform Process Qualification (PQ) and Process Validation (PV)	Manufacturing process and products meeting acceptable quality limits	Data will support FDA approval
8	Obtain FDA approval	To assure users that product is safe and effective for use.	Submit NDA to initiate FDA review	Obtain FDA approval	FDA approval will support fielding of capability

Knowledge-Based Acquisition using Knowledge Points (KP) informs schedule, mitigates development risks, and engages relevant stakeholders

Early KPs Inform Schedule, Mitigate Risk and Involve Relevant Players

The PMO focused on knowledge-based acquisition to obtain the right information, at the right time, from multiple competitive (e.g., industry) and collaborative (e.g., other governmental agencies and international partner) sources. This included asking what information was needed to develop this capability. The PMO front-loaded KPs in the timeline to inform schedule development and mitigate risk early. As shown in Figures 2A and 2B, five of the eight KPs occurred prior to issuing a contract.

The first KP was "Receive Approved Requirement." That KP's purpose was to ensure that the PMO developed a capability that the user wanted and needed. This drove the PMO's decision to use a CONUSE process with stakeholders. Knowledge of product-specific capability requirements greatly assisted the PMO when conducting market research and speaking with potential performers.

"Market Research" was the second KP. The PMO needed to know if there were companies that were already producing FDA-approved products that could meet stringent T&E and quality requirements. Having to seek FDA approval for a new drug would require costly studies that would also dramatically increase the developmental schedule. The PMO conducted research online and also contacted potential performers using a Request for Information on FedBizOps and through the Medical CBRN Defense Consortium (MCDC), an OTA consortium. This also allowed the PMO to identify general manufacturing capabilities and limitations that might hinder rapid development of quality products, which was particularly useful when discussing the regulatory strategy with the FDA.

Market research knowledge enabled the PMO to consider a Middle Tier Acquisition strategy. This approach reduced the documentation required by the JCIDS process. This led to the third KP, "Seek Army Acquisition Executive (AAE) Approval for Rapid Prototyping Approach." The PMO was able to prove to the AAE that a performer could be identified that could meet the Rapid Prototyping requirements.

The PMO also had discussions with the FDA, which is the fourth KP, "Seek FDA Concurrence on Regulatory Strategy." The PMO was fortunate to have legal authority that supported early communication with the FDA under Public Law 115-92. The PMO also tested commercially available technologies as part of the fifth KP, "Determine If Additional Product Development Is Required," to determine whether they could meet military standards and learn about design variation.

Front-loading KPs gave the PMO confidence that a quality product could be developed in an accelerated manner and meet T&E (FDA) requirements. This also led the PMO through a successful source selection and agreement negotiations resulting in an award.

Flexible Contracting: Using OTAs with SOOs

In order to accelerate product development, the PMO needed a flexible contracting mechanism that was mutually beneficial to both the government and industry; such a mechanism would attract companies with proven FDA experience and products.

The OTA promoted increased competition by attracting non-traditional companies that might not ordinarily navigate difficult Federal Acquisition Regulations (FAR). OTAs allow for discussion and collaborations with and between companies during certain parts of the agreement process. The PMO also established Cooperative Research and Development Agreements (CRADAs) with companies before releasing the Request for Prototype Proposal. This allowed for commercially available product testing, as previously mentioned. Under FAR-based contracting, while technically feasible, a risk of protest can increase when testing candidate products.

Product testing and open dialogue with the companies allowed the PMO to make performance assessments of the types of product technology during appropriate parts of the contracting process. This knowledge helped with risk management and promoted robust knowledge-informed programmatic decisions.

In addition to using an OTA, the PMO employed a SOO first instead of a Statement of Work (SOW). A SOW is supposed to effectively tell the contractor the work requirements and metrics needed to successfully complete the project. Yet, SOWs are one of the most common areas for mistakes, and more importantly they effectively only provide one-way communication. Therefore, starting with a SOW is not the best approach for complex developmental technologies requiring T&E approval.

Using a SOO allows the PMO to state the overall objectives of the project. Developing a SOW is more time consuming for the PMO to clearly define all performance requirements and metrics for success. The SOO provides potential offerors with maximum flexibility to propose the most innovative solutions to meet project objectives. That is, SOOs promote cooperation between the government and the selected company.

For example, one performance objective was that the "autoinjector shall allow a warfighter (wearing MOPP Level 4 Personal Protective Equipment and Battle Dress Uniform), to accurately identify this device from other current/developmental autoinjectors in use by the military, and self-administer during periods of reduced visibility/dexterity, while minimizing the risk of inadvertent administration." The PMO did not specify what the autoinjector should look like in terms of shape, color, or tactility of the device. Companies were allowed to freely propose how they could best meet objectives while quickly delivering the product.

Another key objective in the SOO was to "Establish and execute a regulatory strategy and plan that supports FDA approval." The PMO did not specify a specific regulatory strategy that the company should use to obtain approval, but FDA review is important to ensure quality products. The PMO understood what the regulatory strategy should be used based on meetings with the FDA (see KPs). However, the PMO did not want that information to hamper companies from developing internal regulatory strategies for their product. In addition, the PMO used the knowledge to determine if the company was proposing an achievable regulatory strategy that would be acceptable to the FDA.

In the end, the company the PMO selected for award under the OTA was a pharmaceutical company with an FDA-approved product. The use of the OTA proved beneficial to both the government and the company, since the company had no previous experience in Government contracting and was not interested in expanding its business to include FAR-based contracts. This company said FAR requirements would have been too significant a burden. Under the OTA, the company did not have to abandon successful business practices to work with the government. The OTA allowed the government to contract a successful pharmaceutical company that will allow the PMO to meet timeline and product performance requirements for a quality accelerated product development.

Feedback, Knowledge and Flexible Contracting Mechanisms Promote Accelerated Development

This essay outlined three mechanisms PMOs should consider that will support both traditional and rapid product development. The main lesson is that feedback is the key for success for innovation and delivery. This essay presented three tools or mechanisms for feedback and communication with relevant stakeholders. Initially, choosing a CONUSE prior to a CONOPS is an incremental way to drive the requirements development process forward. This approach was particularly useful given that accelerated delivery was required and key elements of the product were quickly defined through the CONUSE.

KPs were discussed as a way to help steer programs towards making sound decisions that help reduce the risk associated with developing a complex capability. KPs allow for quick decisions and can create a method for communicating critical points in the schedule so that movement through development is the objective.

Finally, the OTAs and SOOs are the tools that can be critical for setting the conditions for an accelerated prototype development. These tools, versus FAR-based contracts and a detailed first-pass SOW, provide the ability to attract companies that may not want to work with the government due to the perceived onerous nature of FAR contracts. A SOO facilitates meaningful dynamic dialogue towards product development and delivery.

Collectively, these tools can give PMOs confidence that a capability can be rapidly developed in a collaborative manner. These three efforts resulted in a signed agreement nearly two months faster than a comparable product that did not employ them in the same PMO. When added to time saved approving the requirement, the approach used for ROCS has saved between 6 and 20 months in product development schedule to date.

More broadly, there are numerous tools like these available to PMOs. Greater experimentation will hopefully further change DOD Acquisition culture allowing quality capability delivery to drive the acquisition process rather than being driven by burdensome oversight as seems ubiquitous today.

Notes:

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HONORABLE MENTION

Program Management by Design

By Lt. Cmdr. Ryan Hilger, USN

Meaningful acquisition reform will not occur with quick, one-time fixes. Instead, it must be part of an ongoing effort to create sustainable and continuous improvement. That continuous improvement must come from a body capable of objectively examining the system while being guided by the experience of working with the system.[1]

The Section 809 Panel, chartered by Congress to examine defense acquisition reform, made the above remark in their final report. For all the emphasis in the training of the Defense Acquisition Workforce with respect to continuous improvement, why would the Section 809 Panel make that statement? Anecdotally, the acquisition workforce complains endlessly that the regulations are too restrictive to be as innovative as leadership exhorts us to be. Yet nearly all of the Panel's recommendations focused on items within the control of the Department of Defense, not reforms requiring action from Congress. Secretary Mattis stated the root cause bluntly: "[the] current bureaucratic approach, centered on exacting thoroughness and minimizing risk above all else, is proving to be increasingly unresponsive."[2] The solution, in Secretary Mattis' view, is to "continuously [deliver] performance with unmatched affordability and speed as we change Departmental mindset, culture, and management systems."[3] Program managers can rightly feel overwhelmed with this diagnosis, caught between the vice grip of needing to deliver on the current cost, schedule, and performance expectations, the needs of the warfighter, and the increasingly loud siren call to reform our acquisition and management practices. We wait for guidance from on high to tell us how to reform our practices to achieve this mythical innovation, but it always seems just beyond the horizon. Design thinking, or human centered design as it is also known, offers the potential to significantly assist the acquisition workforce in answering Secretary Mattis' mandate to change the mindset and culture. It is not the answer, but gives leaders and the workforce the means to make small changes in how we do business—the ingredients for culture change. This article provides some lessons learned on using design thinking in a Navy program office, which are easily translated to help any program manager develop plans and change our daily operations.

FIGURE 1 Section 809 Panel

Warfighter-Centered Design

Design thinking is not a process to follow like Lean Six Sigma or the systems engineering process, but a set of tools that program managers can employ in almost all situations to improve outcomes in program management and development activities. IDEO, the unofficial founder of the design thinking methodology, defines design thinking as "a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success."[4] Unlike the sterile systems engineering process, human centered design acknowledges that people, with all their biases, flaws, and beliefs, are a fundamental part of every system and process, whether an Army private or a systems engineer in charge of configuration management. It is a messy process filled with sticky notes, permanent markers, and a diverse group of people.

FIGURE 2 Warfighter-centered design

Across the Department of Defense, design thinking is slowly gaining a following of believers. Secretary James "Hondo" Geurts, the Assistant Secretary of the Navy for Research, Development, and Acquisition, has charged his staff to help spread innovative ideas like design thinking practices more rapidly and horizontally across the Navy, and even the joint force. His NavalX Agility Cell recently released a playbook for design thinking to give anyone the tools necessary to get started with it.[5] Design thinking is not a panacea for defense acquisition reform, but it does provide individuals in program offices with the tools to slowly change the culture and return to a fanatical focus on the warfighter. Design thinking practitioners across the joint force have reported that use of the tools has lead to a more engaged and energized program office. In the author's Navy program office, other employees are starting to request design thinking tools as a way to tackle the toughest problems, question status quo processes, and simply change the way we do business. Their renewed motivation and enthusiasm will drive defense acquisition reform at the grassroots level and deliver better outcomes for the warfighters.

Outcomes Not Requirements

In the daily struggle with life in a program office, design thinking offers a way to better capture and define requirements in less time than the traditional processes. Every service has a painful requirements story. The Navy's beleaguered Littoral Combat Ship program, in its initial haste to get the first two ships into the water, constructed the vessels while simultaneously changing the designs.[6] The USS Freedom's (LCS 1) first commanding officer reported that the ship went through seven different installed bow designs in four years before the ship commissioned in 2008.[7] The Pentagon Wars told of the storied development of the Army's Bradley Fighting Vehicle and its ever-changing requirements over 16 years of development, with still more requirements changes after initial deployment.[8] In both cases, greater involvement of the actual warfighter, not the O-6s in program offices or in the Pentagon or the many years-retired service members employed by contractors, would have solidified what the warfighter actually needed on the battlefield or on the high seas. These people have experience and knowledge to bring to bear, but often their experience as senior O-6s and retired service members is vastly different from life experience, outlook, and military experience of the junior personnel, the E-4s and O-2s, that will operate these new systems.

In a classic example, the Navy's Submarine Force installed Xbox controllers on Virginia-class submarines, a technology that junior personnel are intimately familiar with and thus require little to no training—the system brilliantly meets the needs of the warfighters.[9] It is highly unlikely that those in the Pentagon would have advocated for such a common sense solution. Design thinking is fundamentally about empathy with the end user. In the case of the military, the Soldier, Sailor, Airman, or Marine. Design thinking brings the warfighter into the requirements process because they are critical stakeholders in the outcome of the program; their lives depend on it.

Design thinking activities are best conducted in short sprints, generally in several-hour to day-long workshops, and are more related to a recipe card than a typical meeting agenda. A facilitator, working with the host to identify the desired outcomes, will build a sequence of several design thinking tools to draw out the objectives from the group. It is a very egalitarian way to do problem solving.[10] In the author's Navy program office, a sprint to develop requirements will start with a planning session with several key personnel with the aim of developing the sprint objectives and the stakeholder map. This scales from new working groups to develop internal processes to senior leaders looking to undertake strategic transformations. One of the keys to any successful sprint is to ensure that you have the right people in the room. The more diverse the group, the better, and many sprints are excellent opportunities to get more participation and team building with non-core members of the program office like your lawyers, the contracting officer, intelligence and counterintelligence professionals, trusted consultants, and more.

FIGURE 3 A sprint to develop requirements

A sprint to develop requirements—anything from minor specifications to system requirements to the government's priorities for incentivizing contractors—will follow generally the same path: ideation, clustering, and prioritizing. In a flurry of sticky notes and permanent markers, all the members will generate as many ideas, requirements, features, desired outcomes, etc. as possible. Duplicates are encouraged. Following that, the group will cluster like ideas and concepts together to see what new patterns emerge. Lastly, the group will work together to develop a relative prioritization of the items through an Importance/Difficulty Matrix or a PICK Chart (Possible, Implement Now, Challenging, and Kill it) to identify the most important things to do first. This sequence works well across a wide variety of needs in a program office and takes about 2-3 hours to facilitate, including time to reload on coffee and donuts. It leverages everyone at the same time, and all participants come out feeling greater ownership of the solution and more energized

FIGURE 4 Changing the Daily Grind

and engaged to tackle the problems in front of them.

Changing the Daily Grind

Does a program office exist solely to hold meetings? Most days it certainly seems like it. Meetings have a purpose though: to problem solve, exchange information, make decisions, hotwash events, or develop plans. Frequently, we approach all of these functions with the standard military tool: the BOGSAT—Bunch of Guys/Girls Sitting Around Talking. Researchers have found that the humble BOGSAT is actually one of the worst forms of collaboration and decision making out there. The consensus stifles creative problem solving and usually trends to the highest paid person's opinion.

The design thinking toolkit offers a multitude of tools that can help improve the quality, participation, outcomes, and satisfaction with meetings. Want to quickly hotwash an event? A tool called Rose, Bud, Thorn allows all participants to easily and semi-anonymously offer what was positive, what was negative, and what had potential about the event.[11] All it requires is three different colors of sticky notes, permanent markers, and a bit of your time. Participants simply write their thoughts along those three categories and stick the notes to the wall. Everyone gets their thoughts heard and the group leader has a wide variety of documented feedback and recommendations to work from. Need to get your team centered on a problem or plan for an event? The same sequence of tools used for requirements development can be used in a half-day session to develop and sequence a list of things that need to be done to define a new project, develop timelines, and assign the items to people—all by moving sticky notes around on the wall. Participants in the author's Navy program office have started requesting to use design thinking tools more frequently to do the work of the program and replace traditional meeting and planning activities. The satisfaction and engagement rates of employees has been steadily marching up as a result, and employees are embracing the tools as a way to continually improve processes through more rapid iteration. Meetings will never be the same again.

Human centered design is not a panacea to fix all problems in defense acquisition, but it offers immense potential to change the culture of the acquisition workforce by changing how program offices conduct their business on a daily basis. Each use of Rose, Bud, Thorn to hotwash an activity or a small sprint to achieve some limited contracting objective will slowly install the values of continuous process improvement and creative problem solving in our workforce. Those small, incremental changes will slowly turn the Defense Acquisition System into the agile and effective force needed for the 21st century warfighter—their lives and the outcome of our future wars depends on it.

FIGURE 5 Human-centered design

Notes:

[1] "Report of the Advisory Panel on Streamlining and Codifying Acquisition Regulations, Volume 3 of 3." Section 809 Panel. January 2019. https://section809panel.org/wp-content/uploads/2019/01/Sec809Panel_Vol3-Report_JAN19_part-1_01-28.pdf

[2] James N. Mattis. Summary of the 2018 National Defense Strategy of the United States of America. Department of Defense. https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf

[3] Ibid., p. 4.

[4] "Design Thinking Defined." IDEO.org. https://designthinking.ideo.com/

[5] Ryan Hilger. "Design Thinking" Intellipedia. (CAC required for access) https://intellipedia.intelink.gov/wiki/NavalX_Playbook_-_Human-Centered_Design

[6] Philip Taubman. "Lesson on How Not to Build a Navy Ship." New York Times. April 25, 2008. https://www.nytimes.com/2008/04/25/us/25ship.html?ref=washington/

[7] Source not disclosed. Personal interview with the author, December 2013.

[8] Mark Austin. "The Bradley Fighting Vehicle." Course Content for ENES 489P: Hands On Systems Engineering Projects. University of Maryland University College. August 2012. https://user.eng.umd.edu/~austin/enes489p/lecture-resources/BradleyFightingVehicle-Scenario.pdf

[9] Chris Matyszczyk. "US Navy launches submarine maneuvered by Xbox controller." cnet. March 17, 2018. https://www.cnet.com/news/us-navy-launches-submarine-maneuvered-by-xbox-controller/

[10] For two excellent sources of design thinking tools, see http://www.designkit.org/ and https://spin.atomicobject.com/2017/05/18/what-is-design-thinking/

[11] Kimberly Crawford. "Design Thinking Toolkit, Activity 9: Rose, Bud, Thorn." Atomic Object, April 3, 2018, https://spin.atomicobject.com/2018/04/03/design-thinking-rose-bud-thorn/

HONORABLE MENTION

Getting Modernization Right with User-Centered Design and Soldier Touch Points

By the following authors:

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The Army is modernizing on many fronts—from how it conducts training, to how it is organized, to how it develops and procures new capabilities. Providing Soldiers with capabilities that are useful, usable and fill critical gaps is the goal for near-term modernization efforts designed to deter and defeat potential adversaries.

Coupled with this goal is an emphasis to include Soldiers in the development process through Soldier Touch Points (STPs). Recent press has reported the success of STPs conducted by Program Executive Office (PEO) Soldier for enhanced night vision goggles, the Combat Capabilities Development Command (CCDC) for exoskeleton technology, and the Assured Positioning Navigation and Timing (PNT) Cross Functional Team's PNT assessment exercise.

The Program Executive Office for Command, Control, Communications-Tactical (PEO C3T) has also incorporated STPs as it modernizes tactical radios, network equipment, and command and control systems.

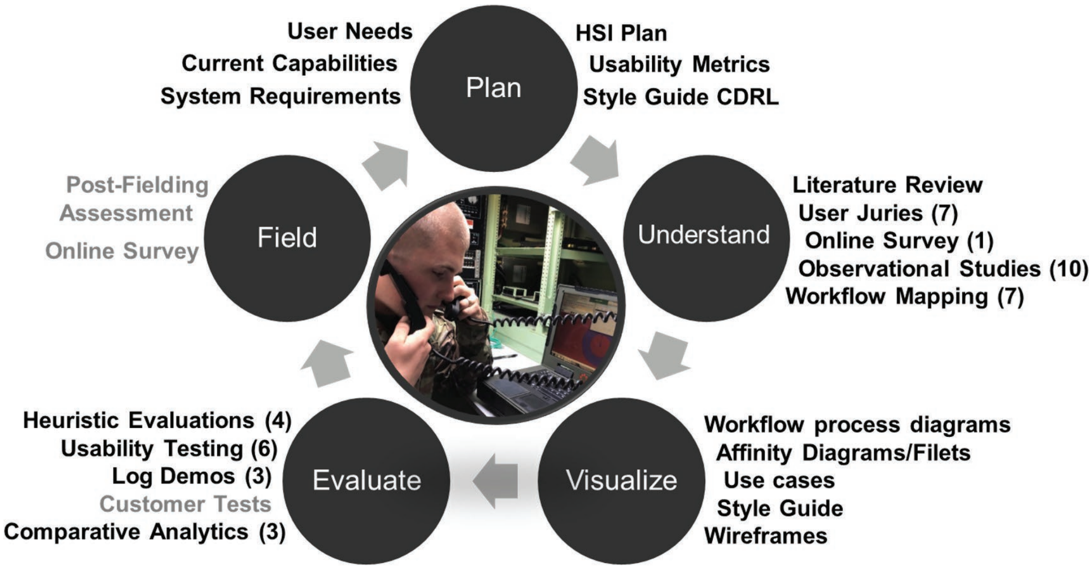
In this article, we describe the User-Centered Design (UCD) process conducted in accordance with the Army Human Systems Integration (HSI) Program by PEO C3T, Project Manager Mission Command, Product Manager (PdM) Fire Support Command and Control (FSC2) during its modernization of the Advanced Field Artillery Tactical Data System (AFATDS). Also discussed are lessons learned during implementation of industry-standard UCD activities to collect STP data during agile development.

Driving Motivators for Fires Software Modernization

The Field Artillery (FA) branch was one of the earliest adopters of militarized digital systems in the U.S. Army, with a legacy dating back to the late-1940s. These early computers performed basic ballistic calculations and reduced the time to process a fire mission. Over the course of seven subsequent decades of "stovepiped" acquisition, digital fires systems became orders of magnitude more capable, but also more complex. In 2014, the Army reinvested in digital Fires to gain efficiencies by collapsing into common computing environments using non-developmental hardware. Based on feedback from the field, it was clear the user interfaces for these systems that required hundreds of hours of training and reliance on field service representatives were no longer adequate.

In collaboration with the Fires Center of Excellence at Fort Sill, the Fires capabilities proponent, PdM FSC2 devised a strategy to combine Fires capabilities into two hardware-agnostic baselines drastically reducing the number of programs of record. All Fire Support functions will be performed using Android-based tablets and smartphones on Precision Fires-Dismounted and Mounted systems. All technical and tactical fire direction, fire control, targeting, meteorology, etc., will be performed using the Mission Command-Fires app hosted on a range of tablets, laptops, and servers.

FIGURE 1 AFATDS UCD Process



AFATDS UCD Process

There are a number of technical and programmatic challenges associated with this collapse strategy. Combining complex systems and using architecture and hardware not directly controlled by a single project manager is difficult. However, the reduction in the overall training and long-term sustainment burden makes the investment more than worthwhile. Just as importantly, it gives the FA community an opportunity to provide direct feedback into system design and development, which was not always done effectively in the past, if at all.

A transformative strategy would be necessary to achieve this.

User-Centered Design: A Human Systems Integration Transformative Strategy

The 2011 Decker-Wager Report[1] recommended increasing requirements analysis—understanding user needs—and incorporating HSI metrics earlier in the acquisition process to address equipment interface and design issues when their mitigation is less costly and less likely to impact schedule.

HSI is the Army's Program to ensure Soldier and unit needs are systematically integrated throughout the system acquisition process ensuring systems can be operated, maintained, and sustained cost-effectively with available manpower, personnel aptitudes/skills and training. One of its seven domains, Human Factors Engineering, focuses on integration of human characteristics into system definition, design, development and evaluation to make equipment easier to operate and maintain, and to reduce the time to accomplish tasks, the chance for operator error and accidents, the amount of training required and the need for operators with specialized skills. One tool to ensure these goals are met is User-Centered Design (UCD).

UCD, widely used in commercial industry, puts intended users of a system squarely in the center of the development process to ensure their needs are the foremost consideration when making design decisions and trade-offs. It focuses on STPs through early, iterative, and consistent application of human factors, ergonomics, and usability engineering activities drawn from these disciplines.

PdM FSC2 forged forward executing an HSI Plan with UCD and STPs at its core and matrixed support from the CCDC Data Analysis Center (DAC).

Leveraging Industry-Standard User-Centered Design Activities

Common UCD activities include field studies (observational studies, contextual inquiry), focus groups (commonly referred to as User Juries in the Army), participatory software design techniques (card sorting, tree testing), heuristic evaluation, and usability testing. Choosing the right activity at the right time depends on the design information needed by developers and the insertion point of UCD in the development process—is it early, late or somewhere in-between?

HSI Plan. We began "early" by developing an HSI Plan documenting UCD activities we would conduct and usability measures to assess the design's efficiency, effectiveness, and user satisfaction.

Usability Measurement. Usability measurement and metrics are critical for assessing a system's ease of use and for tracking design progress. Our goal to reduce training through design of an intuitive interface compelled us to develop usability targets that would enable us to achieve our goal. There are no industry-wide best practices for establishing usability targets, although there is a recognized need for them. Over the course of 15 years, the CCDC DAC C5ISR Field Element has worked to establish a standardized set of usability measures. Although a goal of 100% task completion on the first attempt of a task is the ultimate goal; a more realistic goal of 85% completion has been used successfully during design and evaluation of numerous C5ISR systems. A few examples of usability targets follow:

- Effectiveness. Users who have completed MOS training complete a defined set of critical tasks on the first attempt 85% of the time upon first exposure to the system using contextual help provided by the system.
- Efficiency. Task completion time is calculated by subtracting task start time from end time. Results are compared against objective/threshold standards for each critical task.
- User Satisfaction. Task performance is judged by 85% of the users to be "easy" or "very easy" using 4-point forced-choice rating scale. A group mean score of 80 is obtained using the industry-standard System Usability Scale.

Early STPs. The AFATDS UCD process began early—18 months prior to contract award. Early STPs focused on understanding users' design requirements at the user interface and gathering data to establish usability baselines for future comparative analysis with the modernized system.

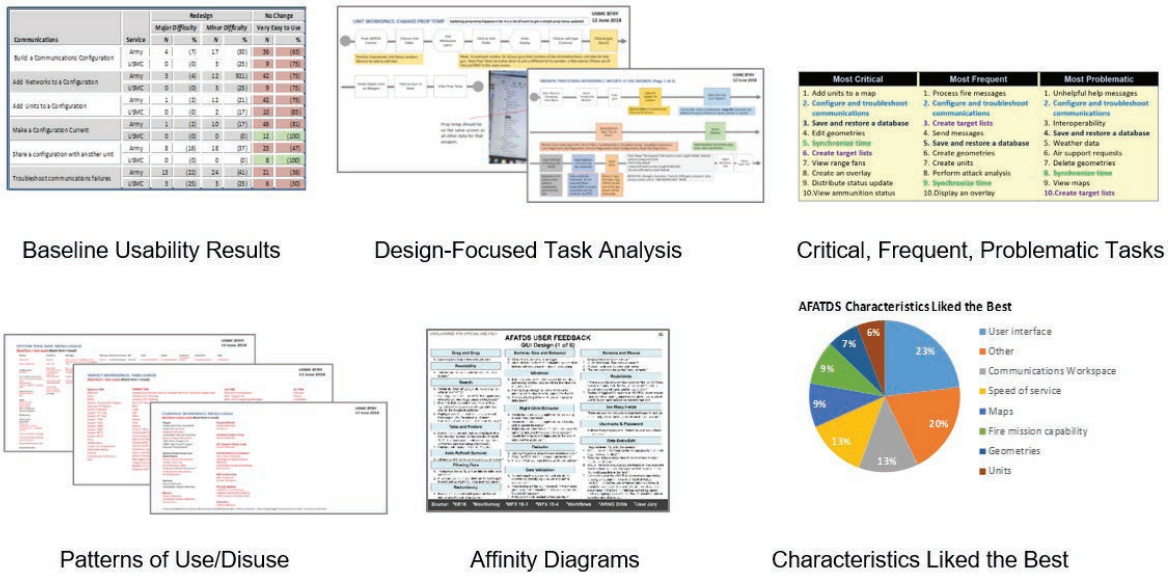
We conducted user juries, an online survey, observational studies and design-focused task analyses. Critical information needs driving STP activities included … What are the most critical tasks our users perform? What are the most frequent? The most problematic? What is working well? What information do users need from the system when all is working well? What do they need to know when all is not working well—when connectivity and system performance are degraded? What system functionality should be automated?

Much of the data collected was qualitative and visualized through annotated photographs, workflows, and affinity diagrams. Examples to the right show (from top left to bottom right):

- Baseline usability results for comparing against the legacy system.
- Design-focused task analysis describing how the legacy system is used with annotated capability gaps, design inefficiencies, and suggested design enhancements.
- Critical, frequent, and problematic tasks pinpointing where to focus design emphasis – especially for issues spanning two or more categories.
- Patterns of use/disuse indicating functionality specific to particular user populations – critical information for creating a solid default for role/duty based access to functionality, and in-the-large for identifying functionality for elimination.
- Affinity diagrams identifying user needs for technical merit evaluation by stakeholders. Those with merit are slotted for implementation in the appropriate software release. GUI design issues (e.g., a missing drop-down field option) are low-hanging fruit easily corrected by developers.
- Characteristics liked the best identify system design elements that should be sustained.

As software design evolved, a style guide was developed in accordance with contractual deliverable specifications, and wireframes (two dimensional web page mockups) were shown during STPs to gather early user feedback. When an engineering release with "enough functionality" for testing became available, the first of five usability tests was conducted with 79 Soldiers and Marines.

FIGURE 2 Affinity Programs



STP: Usability Testing with Early Engineering Software Releases

Usability tests produced a prioritized list of 150 design issues and their potential mitigations that are being tracked by an HSI tracking document and the developer's change management system.

Best Practices Identified by Lessons Learned

Some of the more salient lessons learned through implementation of a UCD process with STPs at critical points in the development process are listed here as suggested best practices for use by other development efforts.

- Identify user needs as early as possible—prior to contract award. Amassing this body of knowledge and delivering it in a consumable format provides the data necessary to jump start the design process and identifies where design emphasis needs to be focused.
- Have a style guide as a contractual deliverable. It contains critical content needed for training and technical documentation development and facilitates a common look and feel across many small agile development teams.
- Trace requirements by mission thread. Mission threads facilitate the ability to create meaningful scenarios for capability demonstration and usability testing.
- Ensure representative users participate in STPs—we have included 750 Warfighters with more than 6,000 years of FA experience thus far.
- Collect workflow, task analysis, and baseline data for the legacy system or manual operations.
- Identify usability metrics to track design progress.
- Conduct incremental usability tests as prototypes and/or engineering releases become available. Choose critical points during the process when it makes the most sense to gather feedback—we identified 5 points in a year-long development effort.
- Usability issue identification and mitigation should be tightly integrated within an iterative development process. Mitigating usability issues should not be considered rework – an important distinction for earned value analysis.
- Increase user awareness as well as buy-in for usability test results by obtaining test facilitators from stakeholder and development organizations.

FIGURE 3 STP: Usability Testing with Early Engineering Software Releases

Conclusion

Not only are technological advances foundational to the success of modernization efforts, so too are solving real world problems for our users. By leveraging industry-standard UCD practices to include Soldiers, Marines, and other users in the design and development process, the Army will be positioned to ensure our military systems provide critical capabilities that are just as intuitive and easy to use as the ubiquitous commercial products we all use every day.

Photo Credit:

All graphics: Pam Savage-Knepshield, CCDC DAC

3 Photos "STP: Usability Testing with Early Engineering Software Releases"

1 & 2: First and Second photo: Pam Savage-Knepshield, CCDC DAC

3: Last photo: Katy Badt-Frissora, ASRC Federal

Notes:

[1] Office of the Secretary of the Army, Army Strong: Equipped, Trained and Ready, Final Report of the 2010 Army Acquisition Review.