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OCTOBER-DECEMBER 2018

Critical Enabling Technologies

GAME CHANGER
Mixing gaming and business architecture,
ARDEC creates blueprint for Army

JUST ADD WATER!
ARL's new nanomaterial paves way
for efficient and green energy solutions

IF IT AIN'T BROKE …
Unit saves time and money doing
vehicle repairs only when needed

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ARMY AL&T

OCTOBER-DECEMBER 2018

FEATURES

ON THE COVER
Critical enabling technologies—equipment, technology or methodology that provides increases in performance and capabilities of the user—are the foundation for the weapons and other gear that Soldiers will need in five, 10 or 15 years. It's Army acquisition's job to find ways of developing them faster.
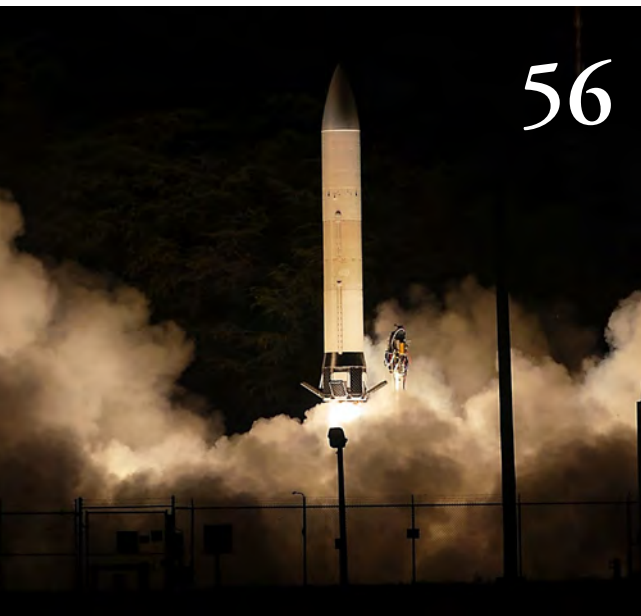
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From the Editor-in-Chief

"Whenever we envision the future, we should recognize the difficulty of accurate prediction and the likelihood of getting it wrong."

—*Gen. Robert W. Cone (Ret.), former commanding general,*
U.S. Army Training and Doctrine Command

I never had the pleasure of meeting Gen. Cone, but I admire anyone who can admit they are not a prognosticator. The future of warfare is fairly impossible to predict because, like the butterfly effect, small changes now in tactics, techniques and what we equip our Soldiers with can lead to unpredictable variations in future combat. For a glimmer of what future combat might look like, some, like Lt. Gen. Paul A. Ostrowski, principal military deputy to the assistant secretary of the Army for acquisition, logistics and technology, suggest we look toward visionaries in Hollywood. "Think about it," Ostrowski said, speaking at a July breakfast hosted by the Association of the United States Army. "How many things do we have in our hands today, or just right around the corner, that you saw on the movies when you were growing up?"

That's good news for all you Trekkies out there, but I'll leave determining what the future holds to the new Army Futures Command; good luck!

Undoubtedly you have seen numerous articles from Army leaders, such as Army Secretary Dr. Mark T. Esper, about the urgent need to speed acquisition, accelerate fielding and establish a culture in which acquisition is inherently fast. That all starts with having well-defined requirements that tell us what needs to be developed, a job the Army Futures Command is taking on.

One way that we in the Army acquisition community can meet Esper's vision and overcome our inability to determine the future is to get critical enabling technologies (equipment, technology or methodology that provides increases in performance and capabilities of the user) in place and products to our Soldiers as soon as possible. They are the foundation for the weapons and other gear that Soldiers will need in five, 10 or 15 years—and for developing them in a timely manner instead of taking 20 or 30 years.

Inherent in having the critical enabling technologies to get the solutions to Soldiers that they need, when they need them, is speeding up acquisition. Exactly how we are doing that is the focus of this issue.

Learn how the Army is increasing the lethality of our long-range precision fires while decreasing the acquisition timeline from Maj. Gen. Cedric T. Wins, commander of the U.S. Army Research, Development and Engineering Command (RDECOM). Wins will provide us with insight into how RDECOM is supporting each of the Army's modernization priorities over the next several issues.

But acquisition is only the start. Sustainment is for life. Does equipment really need servicing at the currently prescribed time or mileage intervals, or is there a better way? The Army G-4 is working to answer that question and bring vehicle maintenance into the 21st century through an extended service strategy, including condition-based maintenance, whereby sensors report when equipment really needs service.

Perhaps the most difficult of the critical enabling technologies to understand for anyone without an advanced degree in math is quantum mechanics. It's slowly transforming from science fiction to science fact. That's why our very smart friends at the U.S. Army Research Laboratory and the Office of the Deputy Assistant Secretary of the Army for Research and Technology are providing a "Quantum 101," so that the rest of us can grasp just what as-yet unknown capabilities might actually emerge to enable "technological surprise."

These articles are just a few of those in this issue that explore how the Army is working hard to translate critical enabling technologies into actual warfighting capabilities. Enjoy!

If you have an idea for how to speed up acquisition or insight into some aspect of acquisition, or just want to comment, drop us a line at **ArmyALT@gmail.com**. Anyone with a great idea for Army acquisition, logistics and technology can submit an article for this magazine. We look forward to hearing from you.

@ **Email Nelson McCouch III**
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Nelson McCouch III
Editor-in-Chief

THE FUTURE FORCE

Soldiers assigned to 3rd Armored Brigade Combat Team, 1st Armored Division, Fort Bliss, Texas, emerge from a secured building during Decisive Action Rotation 18-08 in June at the National Training Center, Fort Irwin, California. Like combat training rotations such as this one, reaching out to traditionally nondefense small businesses that have potentially game-changing innovations is an essential element of modernizing the Army to meet the demands of future contingencies. (U.S. Army photo by Sgt. JD Sacharok, Operations Group, National Training Center)

THE **SEARCH** IS **ON**

Army targets nontraditional partners with competition for next-generation, game-changing technological advances

"Innovation is the result of critical and creative thinking and the conversion of new ideas into valued outcomes."

—*"U.S. Army Operating Concept, 2020-2040: Win in a Complex World"*

In preparing to write this column, I thought broadly about the role that technological innovation has played in changing the nature of warfare over the years: robotics, night vision technology, air mobility, the internal combustion engine, GPS, radar, the internet, the machine gun, the chitosan bandage, freeze-drying technology (both food and blood) and even duct tape. I could go on and on, but my point here is that continued innovation—in forms both large and small—has improved the lives of our Soldiers and contributed immeasurably to their success on the battlefield, and will be critical to modernizing the force. Not only that, those innovations have created countless jobs and helped create untold wealth.

Recently, I have endeavored to reach out to traditionally nondefense small businesses that have never worked with the government but have great ideas and perhaps revolutionary innovations that could be of some benefit to the Army. In order to maximize the Army's reach to industry, in 2014, while working in private industry, I created the Innovator's Corner, a popular engagement opportunity at the Association of the United States Army's (AUSA) Annual Meeting and Exposition in Washington and more recently at AUSA's Global Force Symposium in Huntsville, Alabama. At this month's AUSA Annual Meeting, the Innovator's Corner will once again showcase individuals and small companies with unique products or services that can meet the needs of the Soldier.

A CATALYST FOR NEW TECH

I have long recognized that the Army must enhance engagements with the entrepreneurially funded community, small businesses and other nontraditional defense partners by: **1.)** understanding the spectrum of technologies being developed commercially that may benefit
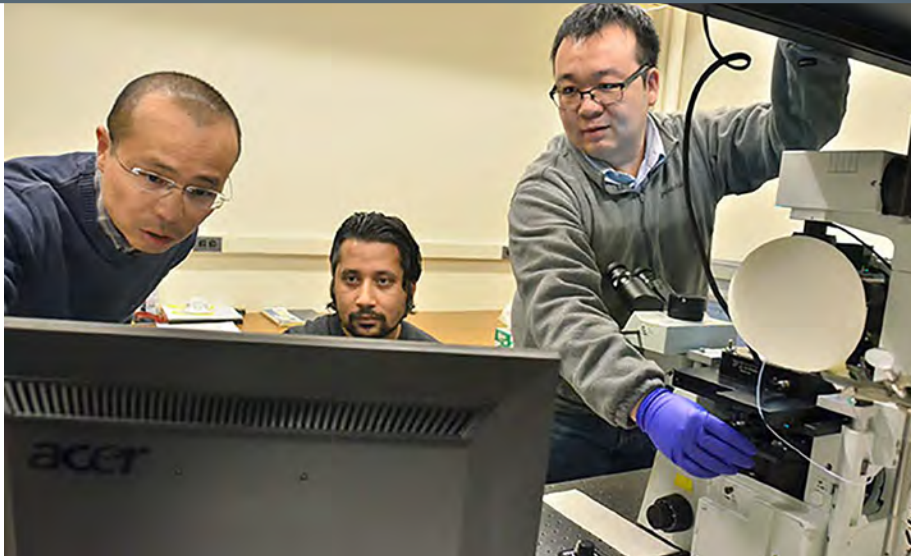
GOOD CHEMISTRY
Cornell University Chemistry Professor Peng Chen, left, principal investigator in Army research that resulted in the first real-time visualization of single polymer chain growth, and Dr. Susil Baral, postdoctoral research associate, look at data while Dr. Chunming Liu, right, postdoctoral research associate, adjusts the microscope stage. In an example of the Army's collaboration with academia on technologies critical to battlefield success, scientists at Cornell, funded by the U.S. Army Research Laboratory, researched new analytical techniques for probing polymer dynamics and how to manipulate those dynamics to control polymer microstructure. (Photo courtesy of Cornell University)

the Army; **2.)** integrating nontraditional innovators into the Army's research and development ecosystem; and **3.)** providing mentorship and expertise to accelerate, mature and transition technologies of interest to the Army.

Our office has been rapidly developing and implementing new, innovative and exciting opportunities to work deliberately with small, nontraditional Army partners, with a specific focus on streamlining or even eliminating cumbersome administrative barriers for Army engagement, developing mechanisms to work with the Army laboratories and test centers, and fostering transition to the Army program executive offices or organic industrial base. Through these efforts, the Army can:

- Provide seed capital to accelerate technology maturation.
- Provide access to collaborative research space at Army Open Campus locations across the country.

- Facilitate partnership opportunities with Army laboratories and test centers.
- Provide mentorship to transition technologies back to the government.

These innovative activities coalesce the collective expertise of entrepreneurs, technologists and warfighters, all with a vision for making an impact on the defense of our nation.

The first instantiation of this new concept is the Expeditionary Technology Search (xTechSearch), launched in June as a catalyst for the Army to engage with this promising business sector, driving American innovation for Army challenges and spurring economic growth. Aimed at attracting game-changing innovation, xTechSearch expands our sources beyond the traditional defense industrial base and provides access for pitching novel technology solutions directly to Army leadership.

Having come from industry and understanding the challenges associated with entering "the process," I know firsthand that the Army must proactively and aggressively engage with innovators to see what new ideas, concepts, systems and subsystem components they can bring to the table. The next generation of enabling technologies required to achieve our modernization priorities may not currently exist—or they may, and not be apparent to the Army.

A four-phase competition, xTechSearch offers up to $1.95 million in prizes to discover innovative technology that will support the Army's modernization priorities: long-range precision fires; Next Generation Combat Vehicle; Future Vertical Lift; the Army network; air and missile defense; and Soldier lethality.

CONCEPT, PITCHES, PROOF
Phase I: The concept white paper contest is where eligible contestants describe their novel technology concept and outline its integration with one of the Army's modernization priorities. This phase was completed in July, and the response was encouraging. We accepted 349 white papers, with 129 related to Soldier lethality; 25 addressing air and missile defense; 80 regarding the Army network; 39 for Future Vertical Lift; 51 related to the Next Generation Combat Vehicle, and 17 for long-range precision fires. In the category of "other," eight papers were submitted that did not relate directly to a specified modernization priority. They may still be of value, offering a capability heretofore not militarily considered. Of the entrants, 125 winners received $1,000 each and an invitation to participate in Phase II.

Phase II: As many as 125 selected contestants will have the chance to compete in the xTechSearch technology pitches. Each contestant will complete an in-person

COLLABORATIVE ENVIRONMENTS
U.S. Sen. Richard J. Durbin of Illinois addresses the audience Nov. 10, 2017, at the ribbon-cutting for U.S. Army Research Laboratory (ARL) Central at the University of Chicago's Polsky Center for Entrepreneurship and Innovation. ARL Central is part of the laboratory's Open Campus public-private collaborative network. Also on stage during the ceremony were, from left, then-acting Secretary of the Army Ryan D. McCarthy; Maj. Gen. Cedric T. Wins; commanding general of U.S. Army Research, Development and Engineering Command; and ARL Director Dr. Philip Perconti. (Photo by David McNally, ARL)

A MAGNET FOR INNOVATORS
The Innovator's Corner, an area of the AUSA Annual Meeting and Exposition in Washington and at its Global Force Symposium in Huntsville, Alabama, is a well-attended venue where individuals and small companies can showcase unique products or services that can meet the needs of the Soldier and explore partnership opportunities with the Army. The Innovator's Corner during this year's annual meeting, Oct. 8-10, will feature the 25 semifinalists in the Army's new xTechSearch competition, as many as 12 of whom will receive $125,000, six months to develop a proof of concept and an invitation to participate in the Phase IV proof-of-concept demonstration. (Photo by AUSA)

technology pitch to a panel of Army experts and judges at select locations across the United States. The final number of Phase II winners had not been determined as of this writing, but up to 25 winners will receive $5,000 each and an invitation to participate in Phase III.

Phase III: The xTechSearch semifinalists, as many as 25, will be featured at the Innovator's Corner during AUSA's 2018 Annual Meeting and Exposition, to be held Oct. 8-10 in Washington, with up to 12 winners receiving $125,000, six months to develop a proof of concept and an invitation to participate in Phase IV.

Phase IV: In the xTechSearch Capstone Demonstration, up to 12 selected finalists will demonstrate the proof of concept for their technology solutions to DOD, government and industry leadership to determine the winner of the $200,000 prize. If the winner does not have or understand how to establish a relationship with the government and Army, they will be shepherded through the process to ensure our access to them.

CONCLUSION
The xTechSearch is a new way to link innovators directly with Army labs, with a focus on lowering the entrance barriers and spurring innovation. I look forward to sharing the results of the competition with you.

Private sector innovation is critical to the Army's future and an important part of our strategy to provide the right capability to the Soldier at the right time. During my tenure, we will look everywhere for opportunities to accelerate innovation and deliver advanced technologies that will enable Soldiers to win our nation's wars and come home safely.

THE GAME'S AFOOT
Katherine Guarini and Dave Magidson study the war game created to help ARDEC understand the value of business architecture—itself a valuable tool for understanding what an organization is capable of, and how to manage those resources. (Images courtesy of the author)

GAME CHANGER

Understanding the whole of Army acquisition is exceedingly difficult, and that's why ARDEC—to change its culture, improve decision-making and unleash its own agility—created an innovative combination of war gaming and business architecture. In doing so, it has created a blueprint for the rest of the Army, and DOD.

by Ms. Kathleen R. Walsh

S ometimes the best way to learn something is to do it.

A bunch of GPS coordinates is just a bunch of numbers. Plug them into a geographical information system, like Google Earth, and suddenly those numbers come alive as a real, concrete place.

That, in effect, is what the U.S. Army Armament Research, Development and Engineering Center (ARDEC) set out to do recently when it created a war game that used its business architecture. The war game itself was something of a ruse, in the same way that high school robotics competitions are, on the surface, about robots, but the real intent is creatively teaching math, engineering, computer programming and teamwork.

Similarly, ARDEC's business architecture war game pitted two teams against each other to compete for an engineering services contract. But it wasn't *really* about engineering services. It was an educational tool to turn the dull abstraction that is "business architecture" into something concrete that users could see and interact with as they competed for bragging rights in the game.

In creating the war game, ARDEC created a reusable tool that not only educates its workforce in business architecture, but also facilitates and improves any organizational decision at any level, including strategic decisions involving budget and planning, and even potential mergers and acquisitions.

WHAT IS BUSINESS ARCHITECTURE?

Business architecture forms a standardized framework that enables an organization to comprehensively classify what it does, or what its capabilities are, through the creation of a common vocabulary, allowing any employee to view the organization through a common lens. That's important because each organization within the Army acquisition enterprise must balance its physical, financial, intellectual or human resources with its limitations.

The problem with business architecture is that it is complex and sounds about as exciting as watching grass grow. But for those who understand it, business architecture is a powerful tool and just the thing that Army organizations must have to best support the Army's needs as it continues to modernize. For ARDEC, it became a way for leadership to continue challenging conventional thinking about how a public sector organization should operate to begin a real culture change.

ARDEC Director John Hedderich believes that "we live in a relentlessly changing and fiercely competitive world and need to be ready for challenges we may not anticipate today. We need to be creative about how we define and solve problems to stay ahead of future threats and future enemies technologically. Outside-the-box thinking is crucial in putting us in a position to lead."

The combination of business architecture and war gaming bridges disparate but complementary perspectives to accomplish just that. Business architecture aims to provide a holistic view of an organization—its policies, strategies and products—yielding important insight into capabilities, end-to-end value delivery and information. War gaming turned the abstract into something tangible and urgent that employees could use and interact with.

The model we developed at ARDEC can be adapted to any DOD organization.

FIRST, WHY DO WE EXIST?

Think of Lego bricks labeled with a variety of capabilities, such as customer management, portfolio management or program management. Business architecture is made up of Lego bins that tell you which Lego bricks you have to play with, what those capability blocks can do, and who else is using them.

Business architecture has several parts. (See Figure 1.) If an organization is just starting to develop a business architecture, it's best to begin with a mission model (if the organization doesn't have one), followed by the capability map.

A mission model, shown in Figure 2, is a business model for a nonprofit organization like the Army. The organization's mission—why it exists—provides the means to know which Lego bricks we have, or should have. For ARDEC, the mission is to "lead research, development and engineering of systems solutions to arm those who defend the nation against all current and future threats, at home and abroad."

FIGURE 1
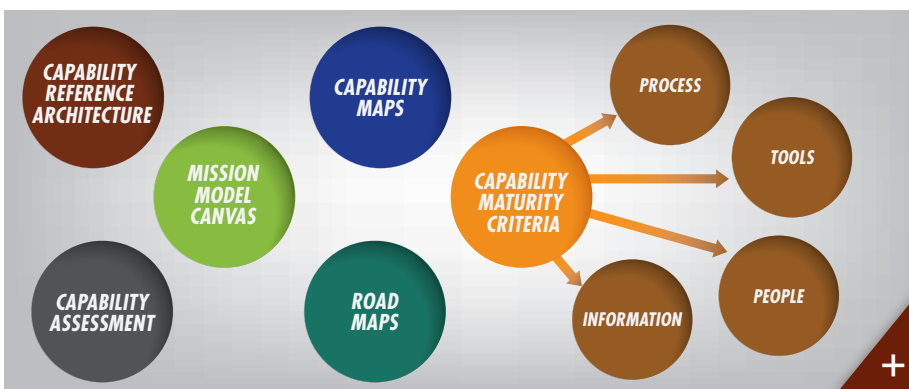
BUSINESS ARCHITECTURE PRODUCTS

Business architecture forms a standardized framework that enables an organization to comprehensively classify what it does, or what its capabilities are, through the creation of a common vocabulary, allowing any employee to view the organization through a common lens. For large organizations facing changes to the external environment—like ARDEC—this framework for thinking helps reduce risk and keep the organization on track.

FIGURE 2

| KEY ACTIVITIES | KEY PARTNERS | VALUE PROPOSITION | BUY-IN AND SUPPORT | BENEFICIARIES |
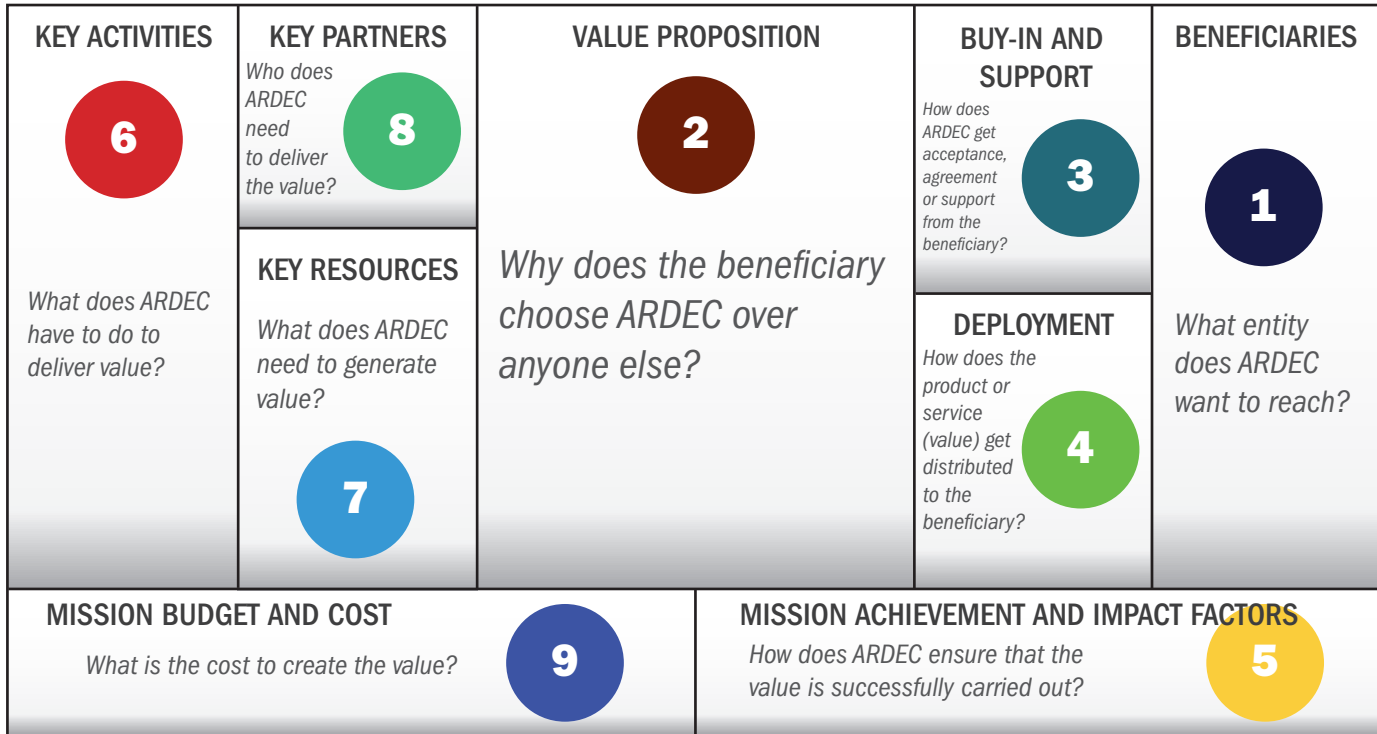
UNDERSTANDING THE MISSION

A mission model helps an organization begin to understand what capabilities it should have to carry out its functions. The mission model adapts the principles of the "business model canvas," a mapping strategy for commercial enterprises, to nonprofit organizations like the Army. ARDEC's process for the mission model canvas was inspired by Steve Blank.

When data can't be consumed easily, it might as well be garbage.

The mission model lays out who ARDEC's customers are and asks what ARDEC needs to do to provide value to each customer. So we ask, for example, "What does ARDEC have to do to deliver value?" An answer might be that we have to manage science and technology (S&T) projects.

Our mission model will have a whole list of activities we need to accomplish to do that, and we can use it to generate the list of Lego bricks that exist to accomplish those tasks. "Managing S&T projects" is a key activity that might lead us to identify capabilities such as "project performance management" and "project risk management." Those capabilities are the building blocks to help develop

plans that meet objectives to achieve our mission.

SECOND, WHAT DO WE DO?
A capability map (Figure 3, Page 14) is like a blueprint that represents bins of Lego bricks that the organization uses to organize its capabilities. Each item in the capability map is a Lego brick that represents something ARDEC does, or is capable of doing, to build projects and make decisions.

While business architecture should be used for any decision in the organization, for our purposes, each project that ARDEC undertakes is a Lego house. Let's say I'm a project manager who needs to construct a Lego house. I'll look in the

Lego bin to see if I have enough pieces, and see if the pieces are the right size and color. Similarly, ARDEC needs to make sure it has the right organizational pieces, or capabilities, to achieve its strategy.

THIRD, HOW DO WE DO IT?

Let's say I need to build a new roof for one of my Lego houses. First, I'd need to make sure that I have not only the capability (roof management), but also the capacity. Is someone else using those bricks? Do I need to hire more people skilled in roof management?

We have the same type of strategic discussions in our organizations. If we have multiple projects that require the same capabilities—maybe we're working on three different artillery systems that all require modeling and simulation—we need to discuss whether we should outsource, hire more people or hold off doing the project. Business architecture is a great tool for analyzing risk and foreseeing resource issues rather than responding to them after they arise.

Randy Rand, senior associate for production and sustainment in the Munitions Engineering and Technology Center, described the value of his participation. "Applying business architecture at ARDEC enables us to better understand and map the interrelationships that drive our armaments enterprise," he said, "and thereby to better achieve our strategic goals through technology and innovation, value-based business processes, ultimately delivering new and more effective products to the warfighter."

A QUIET INSURGENCY

When I joined the Army team 12 years ago as a computer scientist, I quickly became frustrated by the lack of clear business rules. Army policies can be purposefully vague, leaving it up to the lower

FIGURE 3

Key
X – Level 1 Capability
X.X – Level 2 Capability
X.X.X – Level 3 Capability
X.X.X.X – Level 4 Capability

WHAT CAPACITY DO WE HAVE?
A capability map is like a set of bins, where each bin is a broad category like "engineering management," with building blocks inside the bins. The building blocks are more specific descriptions of what the organization being mapped can do—what kinds of engineering, for instance.

levels of the organization to determine how they want to implement them. That may work fine in some instances, but in large organizations that need to think and operate strategically as an enterprise, that vagueness can result in data that varies from group to group, making it hard to consume. When data can't be consumed easily, it might as well be garbage.

In an effort to clear up the vagueness, we looked at several disciplines known for organizing "enterprise," or big-picture, information, such as enterprise architecture, systems engineering and business architecture. We found that they shared architectural principles, such as designing for purpose and aligning efforts toward a common goal. However, they all had a similar problem: They all created two-dimensional pictures. The only way to show business architecture's value was to add a third dimension to make it tangible.

Realizing that I needed to find a creative way to explain the value of building the architecture and promoting its value, I began a personalized outreach initiative across the organization. Twenty-two employees attended three days of business architecture classes because they became convinced of its value, not because it was required training. They spent the summer of 2017 in weekly three-hour workshops that I created and facilitated to generate the mission model and Levels 1 and 2 of the ARDEC capability map.

Although the capability map we created in those workshops is intriguing, managers still had difficulty visualizing how ARDEC could actually make business architecture work. How could I help them realize the value? I had to disrupt the way people thought about strategic planning. In a frenzied brainstorming session, we came up with a revolutionary idea:

Business Architecture: The War Game. For how the game eventually came to work, see "About the Game" on Page 16.

A SURPRISE REVEAL

Two teams of ARDEC employees played the game for three days. On the final day of the game, the Tiger Team was declared the winner over Skunk Works. We held an after-action review with all of the participants and made clear the real purpose of the game. Most of the participants knew little or nothing about business architecture, and that was the point. We used the war game to drive home the message that business architecture can help make decisions at all levels of the organization.

Dan Crowley, chief of the Process Improvement and Management Group at ARDEC and a war game participant, said that he supports the development and use of a business architecture because "by adopting a business architecture, anyone in the organization is able to assess the capabilities and use this information to make quicker and better strategic decisions."

War game participant Kevin Hayes, deputy director in the Enterprise and Systems Integration Center, observed that "business architecture can be used to support annual budget planning as it provides the ability to quickly see where weak areas of the organization are and make better investment trade-off decisions."

Managers can act in the role of the market team, determining which capabilities are necessary for investment. Just as, in the game, the budget proposal will contain capability investments and justifications. Managers, or higher-level organizations, now have data helping to drive decisions and support an enlightened strategic discussion.

CONCLUSION

We have entered an age of disruption, where agility trumps scale and strategy takes on a new role and a new meaning. ARDEC Military Deputy Col. Richard Hornstein considers business architecture "a great leader and management capability for strategic leaders to decompose information and aid in the decision-making process."

The business architecture war game is a powerful tool that can be used for any significant strategic undertaking that is fraught with uncertainty. As a planning tool, it raises the visibility of the make-or-break uncertainties that are sure to be common in modernizing the Army. The acquisition enterprise is so complex in its vast number of capabilities that it takes a tool like this to make it comprehensible to those who know only their little corner of it.

With a task as monumental as modernizing the Army—the largest service branch of the world's largest bureaucracy—the ability to visualize organizations as a whole, and understand what they are capable of, matters more than ever.

I'm determined to show that business architecture can enable ARDEC—or any organization—to do a better job of looking at our capacity to execute our mission as the external environment changes. These changes might include budget cuts, hiring freezes and new requirements.

ARDEC, through its use of business architecture, is ensuring adaptability and flexibility to meet the challenges required to develop the future force. This model can be used by any Army organization—indeed, DOD itself—to think in a more holistic way and to promote organizational learning and continuous improvement.

As we continue to find new opportunities to apply business architecture concepts to improve our planning and execution of the armament research, development and engineering mission, ARDEC will remain relentlessly focused on developing the world's best armament and munition systems for the warfighter.

*For more information, contact the author at **kathleen.r.walsh.civ@mail.mil**.*

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CONTRIBUTORS:
Mr. Joseph A. Brescia, chief of the Strategic Transformation Office, ARDEC; and **Ms. Radhika Pate**l, systems engineer, ARDEC.

• • • ABOUT THE GAME ▶

As an educational tool, the war game shows how to use business architecture by enabling people to actually experience it. Customization and personalized game play were key to designing the game. Giving players the freedom to make their own decisions motivates them to proceed and persist because the game was progressing according to their choices. My colleague Radhika Patel, a systems engineer at ARDEC, and I spent six months creating the game scenario and all of its components.

COMPETING TEAMS

The game began with two competing teams, the Tiger Team and Skunk Works. (See Figure 1.) Each team comprised six or seven ARDEC government employees, mixed in age and experience, who assumed the role of midlevel managers.

FIGURE 1

TEAMS
• Create an offering for the Market Team.
• Execute strategies.
• Make adjustments based on reactions of market.

CONTROL TEAM
• Structure and run the game.
• Introduce external shocks.
• Track models and variables.
• Play all other participants.

MARKET TEAM
• React to strategies of the different competitors.
• Drive the market dynamic.
• Judge attractiveness of offerings.
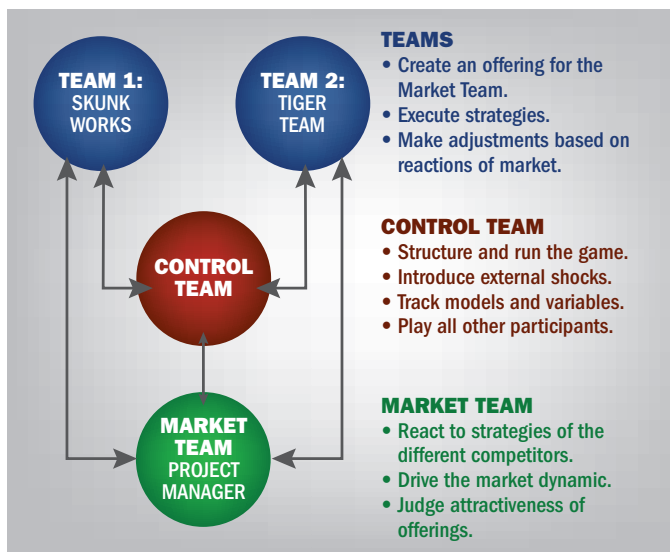
THE PLAYERS
The game pitted two teams (Skunk Works and Tiger Team) against each other. The Market Team was a third team that role-played as an ARDEC customer: a project management team. The Control Team was made up of the author and Patel, who ran the game and influenced team actions with outside forces. (Graphics courtesy of the author)

Each team received an email from its respective director, played by the Control Team, that included their competency plan and explained some of the strategic goals they were trying to achieve. Their objective was to develop a budget proposal to be reviewed by the Project Management Team. The director was convinced that the project management office could use their services to help perform threat analysis on potential new projects. (See Figure 2.) Based on this insight, he assembled the Skunk Works team and the Tiger Team to devise strategies to tackle the problem.

Team members got colored tokens to use with the capability map. Each token represented an enabler of a given capability. In our game, capabilities are enabled by four key aspects, including people, process, tools and information. These enablers define how well ARDEC performs a capability.

Players used a maturity rating table that outlined the four enablers and how to measure their ability on a scale of 1 to 5, with 5 being the highest maturity. Every project manager needs to know the level of ability the organization has to perform a job. (In fact, the tool provides that information to anyone—office chief, director, president or anybody else in the organization.)

For example, if I lack trained and experienced people, the people enabler for the capability in the game will be red. I might have a procedure to follow that is working well, so my process enabler is marked green. That signals to me that I have an issue with my people, but not my process.

Similarly, one of the capabilities in the game had the people enabler marked as red. Determining that they needed to invest in the people enabler of that capability, the teams selected as many green people tokens as they felt necessary. It was important for teams to see that they not only had to pick which capability, but also that there could be different reasons for investment. Do you need to invest in your people? Do you need to develop a process? Those different enablers all have different costs associated with them and require a strategic discussion to determine what's needed to get the job done.

To make the data more visible, we developed a tool using the measurement criteria from the maturity rating table to automate

the effects of investments on the maturity level of each capability. This tool also automatically calculated the cost to the program manager (PM). Since they were competing, there was lots of discussion about how much money they thought the PM would be willing to spend. Teams were aware that they were competing to win a contract; this competition underscored the importance of strategic discussions on what to invest in, and how.

MEANWHILE, ON THE PM TEAM …

Meanwhile, the Market Team—made up of five ARDEC employees acting in the role of a program management office—also received an email from their director, played by the Control Team. A more scenario-driven narrative gave them a sense of urgency. This scenario focused on an anti-access and area denial situation in which adversaries are able to destroy our GPS technology, causing a serious problem with navigation and communication. In the game, participants kept returning to this threat and why it was so important to make certain moves, because ultimately they were keeping our Soldiers safe.

We added another variable to the mix. Changes in resources prompted the director to request the cost to outsource the work to an engineering services group at ARDEC. He assigned the team the task of determining if the value ARDEC could provide was worth the cost.

WHAT CAPABILITY DO WE HAVE?
The maturity table lets players objectively evaluate the group's ability to perform given capabilities—key information for any manager trying to plan for a project or a leader planning a merger of organizations. (SOURCE: Mandy Spiess, Insignis Consulting Services LLC)

FIGURE 2

Plan and Identify Major Threat Categories	Conduct Environmental Scan	Analyze Data	Make Strategic Decisions	Train and Disseminate Information
Identify necessary activities and creating high-level groupings of current and future threats.	**Collect and verify** source data used to identify and classify the threats.	**Assess** our technical capabilities and those of adversaries, including ranking them in terms of priorities for each specific threat.	**Decide** how best to allocate resources to address the threats with the most impact.	**Share** the organization's prioritized threats and mitigation strategy, as well as provide necessary training to understand the identified threats.

THREAT ANALYSIS STEPS
In the war game scenario, the project management office sought to outsource work when doing a threat analysis. The two teams evaluated their capabilities to see if they could support the PM and created a proposal that included the cost to the PM to build up capabilities that were not at a sufficient capacity to meet the PM's objective.

The PM team knew ARDEC's capabilities, but had no insight into the ratings of their enablers. Selecting and ranking ARDEC capabilities that they believed needed to be used for a threat analysis provided a basis for comparison with what was in the ARDEC proposals.

To help make a decision, the team created a decision-analysis-and-resolution tool. Decision analysis and resolution is a structured approach to evaluating alternative solutions against established criteria to determine a recommended solution. Some of the criteria the PM team established were correlated to their strategy and whether the capabilities aligned with their capability prioritization.

THE GAME CONTINUES
The game continued over the course of three days, with two three-hour sessions on days one and two and a one-hour session on day three. The driving motivation came from two main forces built into the game: urgency and competition. In addition to competition, the anti-access and area denial scenario provided a sense of urgency and explained the strategy behind the decisions.

By giving the teams the business architecture artifacts, ARDEC was able to create the right environment for decisions that allow us to align with the future. Teams aligned their decisions with where they wanted to go—our strategy for the future—and their proposals included the business decisions required to back up the technical ones.

—MS. KATHLEEN R. WALSH

DEFENSIVE POSTURE

During exercises in Poland, the 2nd Cavalry Regiment conducted the first active electronic attack within a European country since the Cold War, using prototypes developed and fielded by the Army RCO and the Project Manager for Electronic Warfare and Cyber within PEO IEW&S. (U.S. Army photo by Spc. Hubert D. Delany III, 22nd Mobile Public Affairs Detachment)

CHARTING a NEW PATH

Tanya Skeen

The new director of the Army Rapid Capabilities Office discusses her vision for delivering major capabilities fast and helping to shape Army modernization.

by Ms. Nancy Jones-Bonbrest

Doubling the range of towed cannon artillery in less than two years. Delivering the Army's first electronic warfare systems for brigade and below. Training artificial intelligence algorithms to detect enemy signals.

The Army Rapid Capabilities Office (RCO) doesn't do small goals. And that's why the Army selected Tanya Skeen to lead it.

A 10-year veteran of the Air Force RCO, on which the newer Army version was modeled, Skeen helped the Air Force prove that a small, specialized acquisition shop can deliver major capabilities—even a long-range strike bomber—fast.

Now, Skeen hopes to bring that formula to the Army, by preparing the RCO to partner with the Army Futures Command (AFC) to deliver the Army's top six modernization priorities: long-range precision fires, Next Generation Combat Vehicle, Future Vertical Lift, the network, air and missile defense, and Soldier lethality.

"We are in a great-power competition, and we cannot afford to be apathetic—we must have the stamina to really see through some of these game-changing capabilities," Skeen said. "Army Futures Command is looking at how to achieve overmatch against our near-peer competitors. When they identify a need that is a good fit for the RCO to take on, we will leverage our acquisition model to deliver that capability directly, in the near term."

Skeen, a Tier 3 member of the Senior Executive Service, took the reins of the Army RCO in April and wasted no time putting her experience and vision into action. She aligned the organization's project teams with the Army's top six priorities, built its capacity to execute larger and more complex programs, and acquired several new projects, while continuing to develop and deliver capabilities to Soldiers in Europe and the Pacific. She took the authorities in the two-year-old Army RCO charter—similar to the Air Force RCO version—and brought them to life. She demonstrated the opportunities that rapid acquisition presents for a Futures Command, and an Army ready to take risks to achieve big things.

"It's not for every program," Skeen said.

"It's not really any more technical risk, and it's not risky, if you will. It really is about, 'Where are you willing to have less oversight and allow a smaller team to be accountable for something really important?' "

During an interview on July 25, Skeen discussed the Army RCO, from its processes and partnerships to its potential.

Nancy Jones-Bonbrest: The Army RCO is a relatively new organization, entering its third year. What is your vision moving forward?

Tanya Skeen: The Army RCO is about delivering capabilities faster and better. Acquisition in general is focused on that across the Army. So what makes the Army RCO different is really the authorities in our charter, which is signed by the secretary of the Army, chief of staff of the Army and the Army acquisition executive. The charter gives us the ability to streamline and tailor the processes and policies that are in place for acquisition and how we do business.

We aren't going against any statutes or doing anything that is not aligned with the law, but it does allow us to take a look at the various processes, approvals and policies in place and evaluate if those are

ARMY'S GAIN, AIR FORCE'S LOSS
Skeen takes a look at a Stryker vehicle integrated with position, navigation and timing equipment during a July 25 visit to the U.S. Army Aberdeen Test Center (ATC), Maryland. Skeen, who became director of the Army RCO in April, joined the organization after 10 years with the Air Force RCO. (Photo courtesy of ATC)

SIGNAL STRENGTH
Staff Sgt. Kristoffer Perez, part of the Cyber Electromagnetic Activities section within the 1st Armored Brigade Combat Team, 1st Infantry Division (1/1 ABCT), trains with his section's new electronic warfare equipment at Fort Riley, Kansas, in April. The 1/1 ABCT is the first unit stateside to receive the systems, which were developed by the Army RCO and the Project Manager for Electronic Warfare and Cyber within PEO IEW&S and fielded to Europe earlier this year. (U.S. Army photo by Sgt. Michael C. Roach, 19th Public Affairs Detachment)

value-added, if they are necessary for this particular effort that we might be doing, and ask if there is another way to accomplish the mission. The programs that are assigned to the RCO are strategic and critically important to the Army, so we should be challenging the norms, challenging those traditional ways and traditional processes to deliver capabilities faster.

Another critical component of the vision is small teams: How do you use a very small team and deliver capabilities that are truly meaningful with fewer people, less time and, frankly, less bureaucracy?

Jones-Bonbrest: You came to the Army in April, after last serving as the Air Force deputy director of test and evaluation, and previously in several senior positions at the Air Force Rapid Capabilities Office. What lessons do you bring from how the Air Force RCO does business?

Skeen: The charter that I mentioned previously is definitely modeled directly from the Air Force RCO. In their 15 years of history, I was there for about 10 years, and we learned a lot of lessons. One is that it really is about high-quality, motivated people, and having them all together working toward a common objective, which is to deliver capability to the field. It's not about awarding a contract, it's not about any one functional area—it's truly about delivering the capability.

The other key lesson learned is having a short, narrow chain of command. The fact that the Army RCO reports directly to a board of directors consisting of the secretary of the Army, chief of the staff of the Army and the Army acquisition executive—having that ability to shorten the decision chain is really vital if you want to go fast. Another lesson learned is that we need to gradually model that rapid behavior for the Army. The Air Force RCO did that. You don't start out with 100 programs.

> **It's not about awarding a contract, it's not about any one functional area—it's truly about delivering the capability.**

You start out with a few really important programs, model the behavior that you're trying to display and build from there. So a key lesson learned is not only what you assign to an RCO to focus on, but also how much. If you give them the world, it will truly fail and collapse under its own weight.

Jones-Bonbrest: With the standup of the AFC and its eight cross-functional teams, the Army is prioritizing modernization. First, how can the RCO support the cross-functional teams?

Skeen: We're already supporting the AFC and cross-functional teams. I work with Maj. Gen. James M. Richardson [the special adviser for program integration in the Office of the Vice Chief of Staff of the Army] often and I've met with all the cross-functional team leadership. The cross-functional teams are focused not only on delivering the Army's six top modernization priorities, but also on getting those requirements right.

So the RCO can support the cross-functional teams by helping to refine requirements through prototyping and demonstration, by doing something quicker, smaller and then evaluating those requirements again. Then we feed that information into a more formal program of record.

When the AFC or cross-functional teams identify a need that is a good fit for the RCO to take on, we are recognized as a tool to deliver capability quickly. So when they have a concept, a set of requirements, and the RCO looks to be a good acquisition model for them, we can approach the secretary and the chief with that idea, and if that is directed to come to the RCO, we will leverage our acquisition model to deliver that capability directly.

Jones-Bonbrest: What about other support to the Army Futures Command?

Skeen: One thing that is very important that I bring forward from the Air Force RCO into the Army RCO is this evaluation of the threat, and what is the capability that we need to be successful in the threat environment, whether it be Russia, China, etc. If we develop a capability that is not effective against the threat, it's not terribly interesting. AFC is looking at how we achieve overmatch against our near-peer competitors. The analysis and the evaluation that the RCO can bring to take a look at a certain capability and how it would be effective against a threat, and then taking that concept and demonstrating it or prototyping it, I think that will truly inform the AFC on the question of, "How do you stitch together the priorities and deliver game-changing overmatch against our adversaries?"

Jones-Bonbrest: With so much attention focused on AFC and cross-functional teams, will the RCO continue to work with PEOs [program executive offices] for some of its projects?

Skeen: Absolutely. We've had many great successes in partnering with PEOs, and that's a very fast way to show a different model, a different acquisition approach. We did that with our electronic warfare project in Europe, and that was a wonderful partnership with PEO IEW&S [Intelligence, Electronic Warfare and Sensors]. With that effort, we got to leverage the RCO charter, the RCO authorities and the excellent engineering and acquisition folks in the PEO to deliver a capability very quickly to the field. That's another great way to change acquisition and change the culture across the Army.

THE LONG GAME

Soldiers with the 3rd Cavalry Regiment fire artillery alongside members of the Iraqi Security Force at known Islamic State group locations near the Iraqi-Syrian border in June. The Army RCO is partnering with the PEO for Ammunition on a long-range cannon project to rapidly prototype and equip an artillery battery with the M777 Extended Range howitzer, a new projectile tracking system, survey device and rocket-assisted projectile. (U.S. Army photo by Spc. Anthony Zendejas IV, Combined Joint Task Force – Operation Inherent Resolve)

Jones-Bonbrest: At its founding, the Army RCO was initially assigned to focus on electronic warfare and position, navigation and timing. With the mission growing to include long-range precision fires, active protection systems, artificial intelligence, cyber and other areas, what technology or technologies are you most excited by?

Skeen: When you talk about tech, I like tech that's fast. What can we deliver that truly is game-changing to the Army, and how do we do it quickly? My inner engineer can get excited about everything from a chip to a rocket to a tank to a long-range cannon. So there isn't one particular area. It's really about how we harness these brilliant ideas that are across the country and turn those into capabilities.

Jones-Bonbrest: The most recent National Defense Strategy asserts that the U.S. is engaged in a great-power competition with near-peer adversaries, and that DOD is behind in critical modernization areas. Are there threats that keep you up at night?

Skeen: Hypersonics and the investments that our adversaries, particularly China, are making in hypersonics concern me. Cyber and the focus on offensive cyber capabilities of our adversaries, particularly Russia, concerns me. But the biggest threat that would keep me up at night is apathy. It's not a technical area, it's not something that someone is producing. But when I see the investments and focus of our adversaries in certain areas, I get concerned. I get concerned that we will not have the focus and stamina required to deliver the capabilities we need as a nation. We are in a great-power competition and we cannot afford to be apathetic—we must have the stamina to really see through some of these game-changing capabilities.

Jones-Bonbrest: How can the Army RCO positively influence the larger acquisition system and culture?

Skeen: You need to start with a few projects where you demonstrate that you can deliver with fewer people, faster timelines, less oversight and less process. You start small and it grows from there. When we have people who are going to rotate in and out of the organization—particularly the military members of the Acquisition Corps—we will want to harness all of their talent as they learn and contribute to the Army RCO approach. When they transition to their next position of leadership, they can carry forth all of those lessons learned. So it's not a big bang approach; it's, "Be really good at what you do first, show and prove that, and then have the folks who are from the organization move out and help spread that culture."

For more information on the Army RCO, go to ***http://rapidcapabilitiesoffice.army.mil*** *or follow the RCO on LinkedIn at* ***https:// www.linkedin.com/company/us-army-rco/***.

MS. NANCY JONES-BONBREST is a public communications specialist for the Army RCO and has written extensively about Army modernization and acquisition for several years, including multiple training and testing events. She holds a B.S. in journalism from the University of Maryland, College Park.

MOVING TARGETS

The Army and the Navy are developing tactical missiles that will have seekers to precisely hit moved, moving or poorly located targets in an anti-access and area denial environment. (U.S. Navy photo by Master Chief Mass Communications Specialist Brian Brannon)

RDECOM'S ROAD MAP TO MODERNIZING THE ARMY:
LONG-RANGE PRECISION FIRES

First in a series of articles on how RDECOM is supporting the Army's six modernization priorities.

by Maj. Gen. Cedric T. Wins

To prepare for the battlefield of the future, the U.S. Army must be ready to fight in a very different operational environment from any wars previously fought. The character of war has changed significantly, and the Army, along with its joint service partners, must be ready to deploy and fight in a high-intensity environment where all domains will be challenged. To rebuild readiness and modernize the force, the Army has refocused on six modernization priorities: long-range precision fires (LRPF), Next Generation Combat Vehicle, Future Vertical Lift, the network, air and missile defense and Soldier lethality.

In response to the Army's shift, the U.S. Army Research, Development and Engineering Command (RDECOM) reviewed previously approved funding strategies and shifted emphasis from planned and ongoing work to focus on the new modernization priorities. While RDECOM's Armaments Center leads the LRPF modernization effort, the nature of the threat, the technologies and the environment of future battlefields dictate that only a truly integrated approach will meet the Army's requirements. Our six research, development and engineering centers

FASTER, DEADLIER
The Paladin Integrated Management System under development will be much faster than this M109A6 Paladin self-propelled howitzer, and will have an increased range. (U.S. Army photo by Sgt. Christopher Case, 1st Armored Brigade Combat Team, 1st Cavalry Division)

> **RDECOM uses the lessons learned from experimentation and prototyping to refine technology for capabilities that the warfighter will need to fight and win in multi-domain operations.**

and the U.S. Army Research Laboratory, RDECOM's corporate lab, are working together, along with domestic and international academic and industry partners.

The centers and lab also work closely with the eight cross-functional teams to develop a concept of operations and provide support in technical analysis, portfolio alignment, proposal and program briefings and coordinated modernization strategy development, as RDECOM plans its announced move from the U.S. Army Materiel Command to the Army Futures Command (AFC).

THE LONG-RANGE PRECISION FIRES FAMILY OF TECHNOLOGIES

A number of potential adversaries have missile systems that exceed the range of the Army's currently fielded systems, so the Army has identified LRPF as its No. 1 modernization priority.

This effort includes new artillery weapons—missiles, howitzers, shells and rockets—that are more precise and more lethal over a longer range. These new systems must have the capability to target and destroy or degrade the enemy's anti-access and area denial (A2AD) systems to enable the joint force's freedom of maneuver and action. This makes LRPF an excellent example of RDECOM's threat-informed development, as well as an early test of the command's ability to supply overmatch capabilities for Soldiers fighting on an as-yet-undefined multidomain operations battlefield.

To extend the range and destructive power of Army weapon systems, the RDECOM Aviation and Missile Center is working on the LRPF family of technologies, which will replace the Army Tactical Missile System that has been fielded for 35 years. The Precision Strike Missile is slated to replace the obsolete Army Tactical Missile System in 2023, with extended range (out to 499 km), along with improved GPS jamming resistance, increased rate of fire from one to two missiles per pod and lower cost per missile.

The Aviation and Missile Center is looking at projects to improve the energetics and efficiency of these weapons. Advances in energetics will result in longer-range weapons without additional volume or weight. The team is also studying the requirements and technologies necessary to expand into intermediate ranges with weapons that comply with the Intermediate-Range Nuclear Forces Treaty—the 1987 bilateral agreement between the U.S. and the former Soviet Union that limits both nuclear and conventionally armed missile ranges from 500 to 5,500 km. (Today, Russia, Ukraine, Belarus and Kazakhstan actively participate in the Intermediate-Range Nuclear Forces Treaty with the United States.)

UPDATING THE HOWITZER

While the Army has fielded the Paladin howitzer for more than 25 years with only minor improvements, a new system has been developed to meet the needs of the current force. The updated Paladin Integrated Management System is much faster than its predecessor, enabling it to keep pace with the maneuver formations that it was designed to support. The range of the new Paladin self-propelled howitzer will increase from 22 km with standard rounds to 30 km with rocket-assisted projectiles.

Soldiers from the 1st Battalion, 5th Artillery at Fort Riley, Kansas, tested the system earlier this year, driving the vehicle more than 60 miles per day while firing more than 100 projectiles daily.

While the state-of-the-art howitzer addresses critical issues of its earlier variants, a next-generation Extended Range Cannon Artillery (ERCA) prototype is being developed for fielding in 2025. The ERCA consists of two parts—a new rocket-boosted shell, the XM1113, and a longer howitzer barrel. The XM1113, which has a current range of 30 km when fired from the Paladin, was tested at Yuma Proving Ground in Arizona in April this year.

The prototype was tested using the currently fielded Precision Guidance Kit, which is a fuze that turns a conventional artillery round into a semiguided one. During testing, the XM1113 projectile exceeded 60 km; the Army is working toward fielding systems that are capable of accurately striking targets 100 km away. The advanced hypersonic cannon shells that will reach 100 km will provide lethal options for commanders and reduce the need to shoot rockets that cost substantially more.

In addition to longer range, ERCA will have a longer cannon rifle tube, a fully automated ammunition loading system and a communications system that will work in GPS-denied environments. RDECOM's Ground Vehicle Center is developing high-voltage components that will give the ERCA system more power to maintain overmatch against evolving threats. For example, by replacing a four-channel distribution box with a 12-channel high-voltage power controller, ERCA will not only have significantly more capability, but also improved reliability and safety. These changes will enable the system to distribute all of the electrical power that it can generate without negatively impacting space and weight.

SMART, FAST, INTERCONNECTED WEAPONS

In multidomain operations, the Army anticipates that Soldiers will be attacked from land, sea, air, cyber and space, and they will need to perform a variety of missions quickly. Soldiers will not only need the most advanced weapons available, but they also will need to know which weapons will be most effective in different scenarios. While a weapon directed at a single target may result in destroying the target, other situations may require delivering artillery shells that amass over an area, loitering until needed.

The U.S. Army Research Laboratory (ARL) is developing technologies to support collaborative weapons that are interconnected, precise and smart. By sharing sensing, computing and navigating capabilities using a network of sensors, these weapons will send information back to the warfighter, including situational awareness to make informed decisions.

MORE PRECISE, MORE LETHAL
The Army is seeking new artillery weapons—missiles, howitzers, shells and rockets—that are more precise and more lethal over a longer range and that are capable of destroying or degrading an enemy's anti-access and area denial systems. (U.S. Army photo)

These future collaborative weapons will need to create physical damage, as well as nonkinetic effects to jam communications systems, disturb sensors and stop electronics. To give Soldiers the flexibility, technical expertise and maneuverability to survive in multidomain operations, these collaborative weapons will need to deploy in both mounted and dismounted variants.

ARL scientists are also looking at ways to develop weapons that will accelerate from subsonic to supersonic speeds and morph into different shapes to adapt to emerging conditions, using information gathered from the enemy.

COLLABORATING WITH THE NAVY AND AIR FORCE
In addition to working with hundreds of domestic and international industry and academia partners, RDECOM collaborates with other Army organizations, DOD laboratories and joint services to develop and test science and technology (S&T) efforts. The command shares information and discusses collaboration opportunities with Navy and Air Force counterparts during quarterly DOD lab sync meetings that each service hosts on a rotating basis. Working with the joint services provides opportunities to leverage technologies and capabilities across the DOD enterprise and reduces the risk of researching and developing the same or similar technologies.

In developing the approach for the Land Based Anti-Ship Missile Program, RDECOM's Armaments Center is working with the Navy to leverage its expertise in maritime targets. The Army has not studied the unique challenges of finding and attacking ships since it disbanded the Coastal Defense Artillery in the 1950s.

The Army has the capability now to destroy targets from land to land and from land to air using long-range missiles, but multidomain operations will require additional flexibility for the weapons to operate in the maritime domain. The Land Based Anti-Ship Missile Program reflects a fundamental change in field artillery rockets and missiles. For the first time, the Army will have tactical missiles with seekers to precisely hit moved, moving or poorly located targets in an A2AD environment. (Poorly located targets are targets for which we lack precise information on where they are located—we may have had the precise location, but the target moved, for example.) These missiles will have significant impact on joint operations, including the Air Force and Navy, by giving them opportunities to conduct air and sea operations that may have been previously difficult or impossible to execute. RDECOM will continue to work with experts from the Navy to understand the problems that exist and work possible solutions.

The Army is also looking at best-of-breed technologies from all of the services, including the Air Force's work in hypersonics. (See "Experiments in Hyperspeed," Page 56.) The Air Force is developing novel concepts for airframes and propulsion that could be applicable for any Army mission that may require hypersonic munitions.

These munitions will be more advanced and smaller, enabling aircraft to carry more munitions without adding weight or sacrificing firepower.

CROSS-FUNCTIONAL COHESION

The Army Futures Command's cross-functional teams have representatives from different functions and communities of expertise across the Army, including members of the S&T, materiel, acquisition, test, cost and estimate, contracting, analysis, capability and requirements, funding, intelligence and public affairs communities. The Long-Range Precision Fires Cross-Functional Team, located at Fort Sill, Oklahoma, has two RDECOM employees dedicated to supporting the LRPF modernization priority, with reachback to two dozen RDECOM employees for support at any time. The LRPF Cross-Functional Team leveraged the Aviation and Missile Center's S&T road map for missile investment as the basis for its deep strike missiles future plan.

As long-range precision fires is an integrated system of systems that supports and enables capabilities for aviation, missile defense, armaments and tank, automotive and Soldier systems, the LRPF Cross-Functional team works closely with other cross-functional teams through working groups. These working groups analyze modernization dependencies to ensure that capabilities and technologies align with portfolio investments.

The driving mission of the LRPF Cross-Functional Team is to enable technologies for cannons, munitions, rockets and missiles with enhanced precision and lethality effects at extended ranges in degraded A2AD operational environments. The team's near-term goals are to develop cohesive modernization road maps to deliver technology for long-range precision fires and maintain Army S&T portfolio investments to support current and future overmatch capability gaps.

In looking to support the future of the Army, RDECOM is planning technology demonstrations with cannons, munitions, rockets and missiles with various ranges. Demonstrations began in May 2018 and are scheduled to continue over the next several years as the technologies transition to programs of record, which are fully funded, or become directed requirements, which are expedited requirements to fill an urgent need.

CONCLUSION

As RDECOM transitions into the new Army Futures Command, it will continue to support the modernization effort by working on projects with internal and external partners to sharpen the Army's competitive advantage. Leveraging the Army's modernization strategy to fail early and fail cheaply, the centers and labs promote continuous experimentation and prototyping that reduces risk, demonstrates technical maturity and evaluates technical solutions to inform requirements for near- and far-term capabilities.

RDECOM uses the lessons learned from experimentation and prototyping to refine technology for capabilities that the warfighter will need to fight and win in multidomain operations. It has long shared those lessons learned with the Army Capabilities Integration Center and other partners. The command is now deeply involved in helping the Army design the new Army Futures Command to maximize its core competencies while achieving the greatest possible synergy with its new partners in that command.

For more information, go to **http://www.rdecom.army.mil/** *or contact RDECOM Public Affairs at 443-395-3922.*

MAJ. GEN. CEDRIC T. WINS is the commanding general of RDECOM. Wins graduated from the Virginia Military Institute and was commissioned in the Field Artillery in July 1985. His military education includes Field Artillery Officer Basic and Advanced Courses, U.S. Army Command and General Staff College and the National War College, where he earned an M.S. in national security and strategic studies. Wins also holds an M.S. in management from the Florida Institute of Technology.

Soldiers will not only need the most advanced weapons available, but they also will need to know which weapons will be most effective in different scenarios.

65'

TUNISIA NAVY

P102

25'

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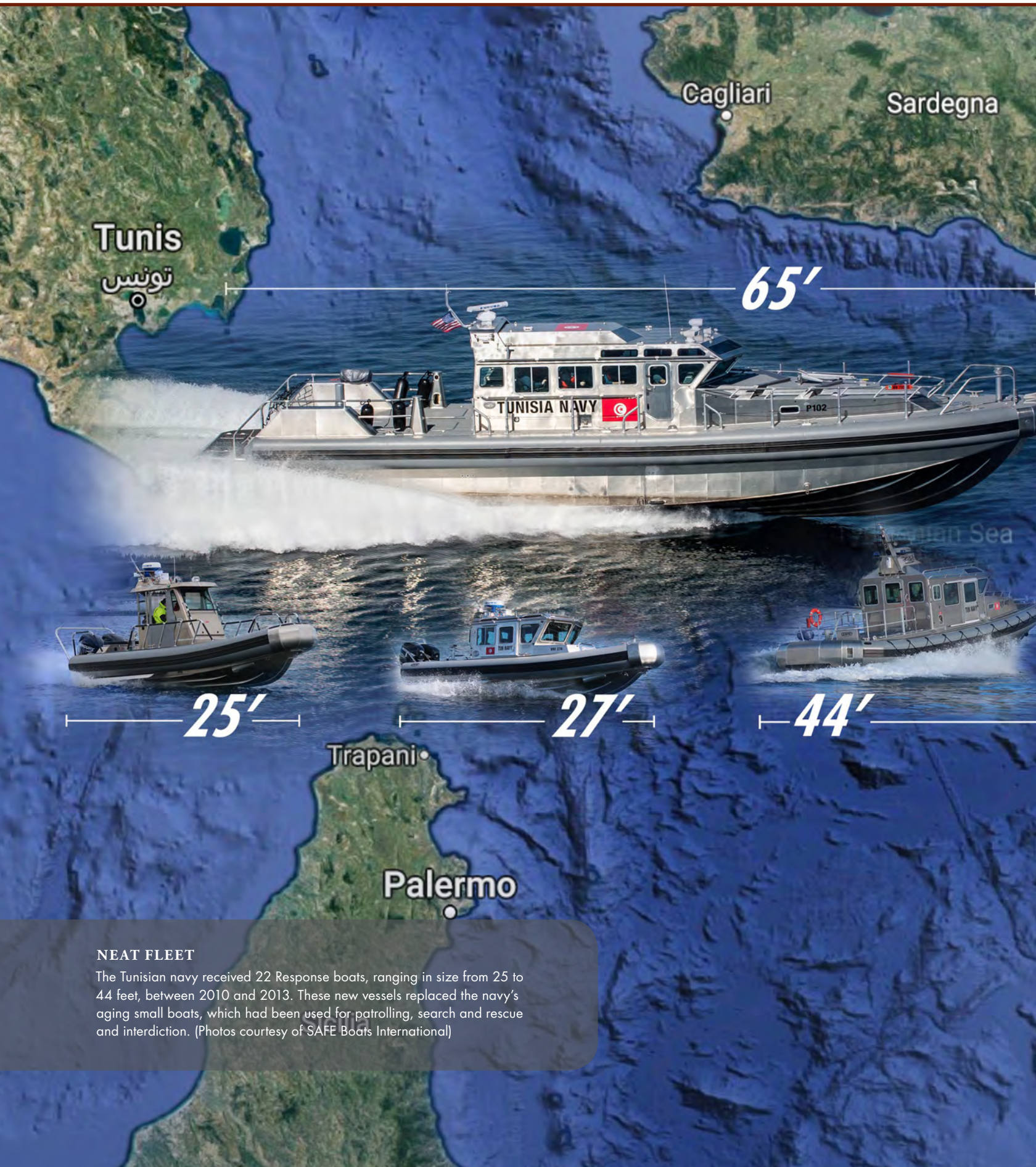
NEAT FLEET
The Tunisian navy received 22 Response boats, ranging in size from 25 to 44 feet, between 2010 and 2013. These new vessels replaced the navy's aging small boats, which had been used for patrolling, search and rescue and interdiction. (Photos courtesy of SAFE Boats International)

Naples

SHIP SHAPE

| Tunisia's navy is the embodiment of a true FMS partner for the U.S.

by Mr. Benjamin Posil

"Coming together is a beginning; keeping together is progress; working together is success."
—*Henry Ford*

The United States' foreign military sales (FMS) program with the Tunisian National Navy is the embodiment of a security cooperation "win." It has accomplished both the practical and ideological goals that the program is designed to advance and is a model that stakeholders in developing FMS programs can strive to replicate.

Defining Tunisia's identity is an exercise in balancing competing influences. Tunisia exists both literally and figuratively between the haves and the have-nots. The culture of Tunisia, located in the center of North Africa, is influenced as much by its ties to Europe as by ties to its Arab neighbors. Much like its culture, Tunisia's economy is also closely tied to North African and European markets. Surrounded by major oil-producing OPEC members, Tunisia possesses few of the petroleum resources that fill its neighbors' coffers. Despite the lack of natural resources (or perhaps because of it), Tunisia has developed a relatively balanced economy that ranks among the highest in Africa.

Despite Tunisia's emergence as the only sustained success story from the Arab Spring of 2010, Tunisia still faces existential challenges because of lingering regional instability. The volatility that defines the country's borders—particularly with Libya to the east—has

created a compelling need for enhanced border security, holistically comprising land, maritime and air components. The Tunisian government has chosen to leverage its security cooperation relationship with the United States effectively to strengthen naval capacity and counter the heightened threats the country faces—exemplifying one of the overarching purposes of U.S. security cooperation efforts, to "develop allied and friendly military capabilities for self-defense and multinational operations."

A CONFLUENCE OF EVENTS

The catalyst for the dramatic recent growth in the Tunisian navy's FMS program was two separate but virtually identical cases. In 2009, the Tunisian government received $7 million in foreign military financing from the U.S. for enhancement of maritime security, as well as $7.5 million to complement Tunisian foreign military financing through the Building Partnership Capacity program. These two cases led to the delivery of 10 25-foot Response boats (nearly identical to the U.S. Coast Guard's Response Boat-Small) and five 44-foot Response boats (similar to the Coast Guard's Response Boat-Medium), along with a robust package of spare parts, training and support.

This large, singular injection of vessels into the Tunisian fleet amounted to a wholesale recapitalization of its existing territorial water patrol capability. The new vessels replaced the Tunisian National Navy's aging small boats (smaller than 65 feet), which up to that point had been used for patrolling, search and rescue and interdiction.

The first 15 Response boats were delivered in 2011 as the country was still adjusting to the new realities brought about by the Jasmine Revolution. In a twist of irony, the instability caused by the revolution proved to be extremely fortunate for the Tunisian navy's FMS program. The ousting of President Zine El Abidine Ben Ali established several conditions that impacted the United States' FMS relationship with Tunisia.

The first of these conditions was that the Tunisian military remained apolitical during the revolution. This deference to the will of the people instead of the orders of the long-standing president engendered a profound respect for the professionalism, competence and judgment of the military as an institution. This enabled the United States to continue its security assistance programs, provided added justification

for investing U.S. funds, and ensured that the Tunisian military was well-positioned to justify future internal funding within Tunisia's nascent democracy.

Second, the removal of the Ben Ali regime allowed for re-energized engagement with the United States. The final years of the regime were marked by a visible shift away from engagement with the United States, which by 2010-11 was impeding bilateral military efforts. Ali's departure allowed for a reset in what had been for years a harmonious bilateral relationship.

The last major condition was a sequence of events set in motion by the revolution that dramatically increased the need for enhanced maritime security. One immediate result of the turmoil was a huge increase in the number of migrants taking to small vessels and attempting to cross the Mediterranean. This included Tunisian nationals looking for greater opportunity in Europe as well as other African nationals using Tunisia as a transit point.

With the nearest Italian islands roughly 45 miles away, Tunisian coastal waters became a key transit zone for refugees willing to risk their lives to reach Europe. Many of the vessels used for this journey
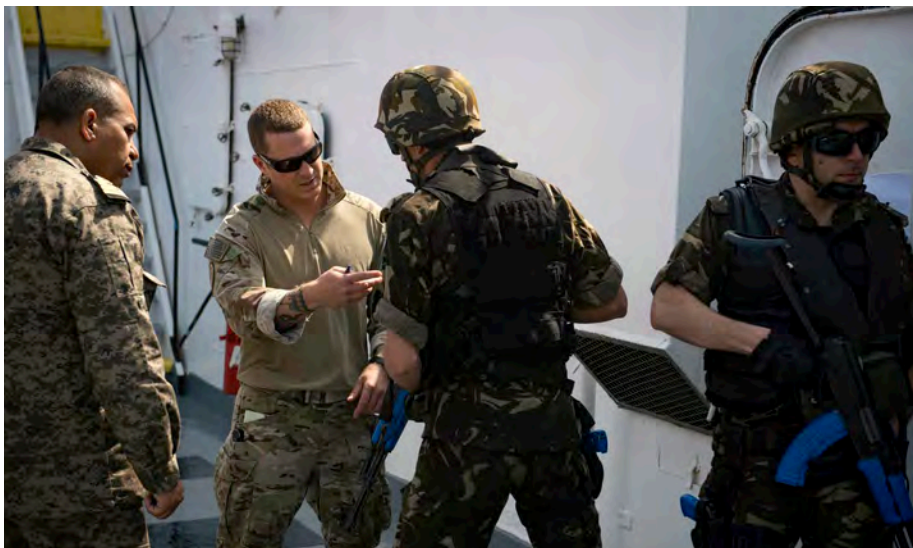
PLOT POINTS
U.S. Coast Guard Boatswain's Mate 1st Class Daniel Sylvester, center, provides training to Algerian sailors aboard the Tunisian Navy's MNT Khaireddine in early May during Phoenix Express. Sponsored by U.S. Africa Command and facilitated by U.S. Naval Forces Europe – Africa and the U.S. 6th Fleet, the exercise is designed to improve regional cooperation and operational capabilities and enhance safety and security in the Mediterranean. (U.S. Navy photo by Mass Communication Specialist 2nd Class Ryan U. Kledzik).

TEAMWORK

Sailors from Tunisia and the guided-missile destroyer USS Arleigh Burke (DDG 51) simulate clearing a ship during a training exercise on April 25. The Tunisian navy operates with a level of professionalism that equals its European partners, and most of its officers supplement their training with developmental opportunities with navies and industry partners around the world. (U.S. Navy photo by Mass Communication Specialist Seaman Raymond Maddocks)

were not seaworthy, and the Tunisian navy's workload dramatically increased as it attempted to rescue thousands of migrants from doomed crossing attempts.

REGIONAL INSTABILITY

The security challenges for Tunisia were compounded as the Arab Spring spread across the region. The single most impactful event of this period for Tunisia was the fall of the Moammar Gadhafi regime in Libya in 2011. The destabilization of Libya dramatically increased the need for enhanced maritime security because of the amplified risk from smuggled goods, weapons and militants to and from Libya and the exponential increase in the number of migrants taking to small vessels and attempting to cross the Mediterranean.

After the success of the initial FMS cases in 2009, the United States increased foreign military investments in the Tunisian National Navy. Between 2010 and 2013, the Tunisian navy received 22 Response boats ranging in size from 25 to 44 feet,

along with a large support package. The Tunisians also spent their own national funds to help purchase four 65-foot Archangels made by SAFE Boats International of Bremerton, Washington.

The Tunisian navy consistently shaped the expansion of its fleet to mirror its operational requirements. The focus on building significant sustainment capabilities into its FMS cases reflected an institutional awareness of the essential role of maintenance in capacity development. The Tunisian government's willingness to make a significant financial commitment to complement the United States' investment in a Tunisian institution reflects a level of partnership rarely seen with countries receiving foreign military financing.

BUILDING ON SUCCESS

For recipients of foreign military financing from the United States, the concept of national defense self-sufficiency is a bit like a unicorn: People can picture what it looks like, but few have actually seen it materialize. Most recipients lack the will,

organizational capacity and resources to generate domestic solutions to defense-related challenges.

The Tunisian navy took a step in that direction in 2015 with the commissioning of its first domestically produced frigate. The vessel, named Al Istiqlal (Independence), was the product of a public-private effort that leveraged the local industrial base. The procurement was run by the Tunisian navy and the entire effort, from funding to design and construction, was carried out domestically.

While the practical impact of vessels from this program will be minimal, at least initially, the symbolic meaning is significant. Moreover, the level of effort and resources it took the Tunisian navy to actually build its own frigate is representative of a highly determined and capable FMS partner.

So why has the FMS program with the Tunisian navy been so successful? Despite the significant maritime security

responsibilities that Tunisia's geography entails, its navy employs fewer than 5,000, roughly 10 percent of the Tunisian army's total. There are several key factors that, when aggregated, illustrate why the Tunisian navy has been a far more willing and capable partner than its geographical location or moderate resources would suggest.

The Tunisian navy operates with a level of professionalism that is on par with its major European partners. The vast majority of its naval officers have supplemented their domestic professional military education with courses, exchanges and extended experiences with various navies and industry partners around the world. Unlike the corruption, competing agendas and misallocated resources that define a disproportionate number of FMS programs within U.S. Africa Command, the Tunisian navy has been able to channel its human and material capital into effective use of FMS procurements.

Another major component of the success is the value the Tunisian navy puts on maintenance. A visit to the naval base in Bizerte provides a window through which one can see firsthand the investment the Tunisian National Navy has made in developing repair facilities and technical expertise. Unlike other countries' militaries, whose extensive financial resources allow for the outsourcing of maintenance support, the Tunisian navy has grown its maintenance capability organically. Today its capabilities are on par with commercial shipyards in the region. The combination of having the required elements on hand to conduct the actual maintenance as well as having the institutional focus to maximize these assets has made this capacity development possible.

Finally, the Tunisian navy has actively embraced international partnerships in a way that has allowed the organization to gain maximum benefit. Unlike its neighbors whose paths to independence created cultural fissures that still dramatically impact their foreign policy, Tunisia's independence became an enabler of political relationships.

The break from France in 1956 left fewer lingering repercussions than the independence process in much of North Africa, and did not result in the Tunisians gravitating to an ideological hegemon at the expense of all other relationships. Tunisia has remained close to France while also building on historical and geographical ties with numerous other partners. Tunisia was even formally recognized as a U.S. major non-NATO ally in 2015.

As a result of these relationships, the Tunisians have been able to draw on both material resources and expertise from a wide range of sources. A look at its fleet shows vessels built in the U.S., Germany and Italy, among others. The Tunisian navy is a regular participant in multinational exercises such as Phoenix Express, sponsored by the U.S. Africa Command and conducted by U.S. Naval Forces Africa.

Operationally, the Tunisian navy regularly works with its European and African neighbors to address the ongoing humanitarian and security crises in the southern Mediterranean. The Tunisian navy is able to benefit from all of these relationships in a way that dramatically increases overall institutional capacity.

CODE ORANGE
Moroccan Royal Navy sailors participate in training aboard the Tunisian Navy's MNT Khaireddine during Phoenix Express 2018 in early May. By participating in multinational exercises like Phoenix Express and working with European and African neighbors to address humanitarian and security issues, the Tunisian navy can access resources and expertise from a wide range of sources to boost its capabilities. (U.S. Navy photo by Mass Communication Specialist 2nd Class Ryan U. Kledzik)

WATCHFUL ANGEL

A Tunisian navy 65-foot Archangel Patrol boat is underway near the Tunisian navy base in Bizerte. The security cooperation relationship between the Tunisian government and the United States exemplifies one of the major purposes of U.S. security cooperation efforts: to "develop allied and friendly military capabilities for self-defense and multinational operations." (Photo courtesy of U.S. Embassy Tunis)

CONCLUSION

The Security Assistance Management Manual, the document that codifies the policies of the U.S. security cooperation program, does not provide a checklist for defining a "successful" program. It does, however, define ideological and practical objectives that the program is designed to develop, including:

- Progression from development of a basic capacity to more capable assets.
- The establishment of an organic ability to maintain those assets.
- An eventual progression to self-sustainability.

Governing the capacity development aspect of security cooperation is the overarching goal of establishing a vested sense of "ownership" in the partner service. To reflect a true partnership at the most fundamental level requires a commitment of resources from both partners. The United States' FMS program with the Tunisian navy has evolved over the past 10 years to reflect these ideological and practical objectives to a degree rarely seen in any FMS partner, let alone one working through the fiscal constraints and security challenges faced by the Tunisian navy program. This partnership provides the ideal model of security cooperation for other developing FMS partners to emulate.

*For more information, go to **http://www.dsca.mil/**.*

DISCLAIMER

The opinions and conclusions expressed herein are those of the individual author and do not necessarily represent the official position or view of the Department of Defense or any other governmental entity. References to this article should include the foregoing statement.

MR. BENJAMIN POSIL is a security cooperation professional with more than 10 years' experience in the field. He is a major in the Maryland Army National Guard, where he recently completed a 10-month deployment to Afghanistan. He has earned MBA degrees from the University of South Carolina and Wirtschaftuniversität Wien in Vienna, Austria, along with an M.S. in international relations from Troy State University. He also has a B.A. in international relations and Latin American studies from the University of Delaware. He is a Navy Acquisition Corps member and a certified program manager through both DAWIA (Level II) and the U.S. Department of Homeland Security (Level III).

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OLD ALLY, LIKE-NEW EQUIPMENT

Morocco strengthens its capacity to stabilize region and fight terrorism through partnership with U.S.

The Kingdom of Morocco is currently the largest U.S. weapons buyer in the 53-country region covered by U.S. Africa Command (AFRICOM). U.S. assistance to Morocco enhances its capacity to promote security and prevent acts of terrorism, and its ability to meet current and future threats. The support has had a positive impact beyond Morocco, in both the Middle East and Africa. Morocco is emerging as a major partner for regional stabilization efforts and fighting terrorism, which furthers U.S. security.

One of the United States' oldest partnerships is with Morocco. According to the U.S. Department of State, "Morocco formally recognized the United States by signing a peace treaty in 1786. Full diplomatic relations began in 1905, and normal diplomatic relations were resumed after U.S. recognition of Moroccan independence in 1956. The two countries share common concerns and consult closely on regional security and sustainable development."

Scott Huther, AFRICOM regional operations division chief at the U.S. Army Security Assistance Command (USASAC), said the Kingdom of Morocco recently requested 222 M1A1 Abrams tanks in an upgrade to its tank fleet that began in 2016. The transfer of the Abrams tanks progressed rapidly, with the scheduled delivery to the Royal Armed Forces completed in August. This significant sale has assisted Morocco with building its capacity. DOD provided the vehicles through the Excess Defense Articles program, where excess equipment is offered at reduced or no cost to eligible foreign recipients on an "as is,

where is" basis in support of U.S. national security and foreign policy objectives.

"These tanks continue to modernize the Kingdom of Morocco's military and will enhance its readiness to meet current and future needs," Huther said. "The Moroccans are very astute regarding their equipment requirements, and the fact they chose to use our depot system to refurbish their tanks speaks to the strength of the relationship our militaries share. The customer has choices for where to obtain equipment, but because of the relationship between the U.S. and the Kingdom of Morocco, plus the total-package approach provided by the U.S. military, Morocco chose the M1A1 tank, our excess equipment."

The U.S. Army's top priorities include readiness to deploy, fight and win, and to modernize and evolve to build greater capabilities and capacities. However, the U.S. military cannot both engage in multiple conflicts around the world and modernize the force without enhancing the strength of partner nations. So, also included in the top Army priorities is enhancing the professional relationships, training and overall coordination with our allies and partners.

While multinational exercises are one way to do this, the initial building blocks that allow the U.S. to develop relationships with allies and partners are security cooperation and assistance. The security cooperation and assistance mission is a vital foreign policy tool, and sales of military equipment are part

REPURPOSED AND READY

One of more than 50 Abrams tanks that were delivered to Morocco in June, bringing total deliveries to more than 170 of the 222 requested. (Photo courtesy of U.S. Army)

of it. USASAC, headquartered at Redstone Arsenal, Alabama, manages and implements the Army's security assistance programs and foreign military sales for more than 150 countries.

Foreign military sales have a fundamental value to Army readiness and to the military's interoperability with international partners. This is particularly important in the AFRICOM region, where supporting relationships is key to addressing the significant terrorist threats in the area.

According to Amy Weichel, chief of the Morocco Program Office for Main Battle Tank Systems at the Program Executive Office for Ground Combat Systems, the initial vehicles underwent a complete overhaul and were rebuilt at the Anniston Army Depot, Alabama. Anniston was responsible for the teardown and rebuild of the tanks, including all the components except turret armor. General Dynamics Land Systems installed the exportable turret armor at the Joint Systems Manufacturing Center in Lima, Ohio. Using this production process, which results in like-new vehicles, another 72 vehicles were produced.

Anniston and General Dynamics overhauled an additional 150 tanks through the Abrams integrated management process. This is a partnership between the two entities; Anniston does the teardown, General Dynamics does the reassembly. The rebuild of a used M1A1 tank with this process enables the installation of modifications and emerging technologies. The purchase was beneficial in employing U.S. personnel at the Joint Systems Manufacturing Center during the early production.

"The tank production supports the U.S. industrial base, providing work to the depots and contractors, and can result in mutual costs savings with economies of scale," Weichel said. "It also adds

to the long-standing relationship between the U.S. and Morocco, allowing them to modernize their military forces."

Huther also pointed out that "the U.S. Army's modernization is like a domino effect—our partners, like Morocco, are pushing just as hard to have compatible and comparable equipment to ensure continued logistic support."

Along with large systems, other necessary tools provided through foreign military sales include radios, training ammunition, spare parts, tools, training aids and simulators. Personnel training is also part of the program, which allows the Army to train partners on the equipment as well as to develop leaders in partner nations. "This is all part of the total-package approach, which ensures the capability is not only developed but sustained," Huther said.

USASAC is the lead for the security assistance enterprise of U.S. Army Materiel Command, which is USASAC's headquarters. Through the support of Army Materiel Command entities such as the industrial base and its life cycle management commands, USASAC is able to assist partners with their readiness, whether it be through new or excess material and equipment, or sustainment.

Huther also emphasized that evolving an Army Materiel Command line of effort is about setting the conditions for integrating new technologies and systems, and that each AFRICOM partner is doing this in its own way. "Every facet of the USASAC mission is in support of U.S. national security and is designed to support strategic readiness," he said. "We will continue to look at ways to improve our processes and help ensure that when it's time to conduct coalition operations, our partner nations are ready and indisputably capable."

—MS. TERRI STOVER, USASAC Public Affairs

FACES
of the
FORCE

ROBERT F. MCKELVEY III

COMMAND/ORGANIZATION: Cybersecurity and Electromagnetic Activities (CEMA) Combat Systems Division; Survivability Evaluation Directorate; U.S. Army Evaluation Center; U.S. Army Test and Evaluation Command

TITLE: CEMA evaluator and test manager

YEARS OF SERVICE IN WORKFORCE: 14

DAWIA CERTIFICATIONS: Level III in test and evaluation; Level II in program management

EDUCATION: M.S. in program management and public policy, Naval Postgraduate School; B.S. in mechanical engineering, Penn State University

AWARDS: Superior Civilian Service Award; Commander's Award for Civilian Service; Achievement Medal for Civilian Service; Secretary of Defense Medal for Global War on Terrorism

IT'S ALL CONNECTED

Turns out your kindergarten teacher was right: Learning to play nicely with others is a vital skill, no matter your profession. "Acquisition work always comes down to people," said Robert F. McKelvey III, cybersecurity and electromagnetic activities (CEMA) evaluator and test manager for the U.S. Army Evaluation Center (AEC). "Everyone in the acquisition workforce has a job to do and sometimes those jobs are at odds with one another; that's by design. Those intellectual impacts can lead to a better product for the Soldier and DOD, but we need to show respect for our co-workers and their missions across the community. If you can package your expertise in a respectful way that is useful to your customers on their schedule, you'll be unstoppable."

McKelvey is part of the CEMA Combat Systems Division within AEC's Survivability Evaluation Directorate, which focuses on survivability, ballistic and nonballistic battlefield threats, live-fire evaluations and reports, vulnerability and lethality of Army and joint systems, and cybersecurity in assessing information assurance and interoperability.

AEC, a subordinate organization of the U.S. Army Test and Evaluation Command (ATEC), "is the Army's 'Consumer Reports,' " said McKelvey, tasked with characterizing the readiness of a broad portfolio of programs for integration into the operational environment. Surprisingly, he noted, most Soldiers are unaware of the organization's existence. "The typical Army unit does not routinely interact with AEC," he noted. "But once they understand AEC's mission and the multitude of systems being supported, Soldiers tend to be surprised with how much we actually do and have to offer in the realm of system effectiveness, suitability and survivability to ensure their safety on the battlefield."

McKelvey studied mechanical engineering in college, with the goal of designing cars, but he switched to systems engineering after the events of 9/11. His work leading the vehicle dynamics team that was part of Penn State University's entry into the Defense Advanced Research Projects Agency Grand Challenge attracted the attention of the Survivability Evaluation Directorate at a job fair. His first acquisition position was as a nonballistic survivability analyst working on Future Combat Systems within the directorate, and he has remained there for 14 years, tackling different assignments at increasing degrees of responsibility and difficulty.

"I've learned that there are lots of opportunities for motivated people to help move a project forward," he noted. One of his first opportunities came not long after he was hired. "I had a great first mentor in Capt. Tom Stocks and a supportive division chief in Jim Myers. They took me under their wing and helped me build a strong foundation in the tenets of survivability." In 2007,

Myers put McKelvey in charge of the Mine Resistant Ambush Protected (MRAP) vehicle program, which introduced him to joint operations, support contracting and condensed schedules. "I managed to find my way through interoperability and compatibility assessments for government-furnished equipment suites for MRAPs," he said. Eventually, McKelvey led efforts to ensure that the suites—additional equipment such as sensors, jammers and antennas—installed by the Army, Marine Corps, Navy, Air Force and U.S. Special Operations Command on MRAPs would be effective in an operational environment.

That background was invaluable in 2011 when McKelvey became lead evaluator and test manager on rocket-propelled grenade defeat systems and served as lead live-fire evaluator for the MRAP All-Terrain Vehicle (M-ATV). "I planned, scheduled and executed the first test of homemade explosives on an M-ATV underbody improvement kit. That work, which included a relook of test-bed soil, led to more repeatable and operationally realistic live-fire platform assessments," he said.

In 2013, McKelvey joined a forward operational assessment team out of Fort Hood, Texas. During Operation Iraqi Freedom and Operation Enduring Freedom, ATEC deployed 21 forward operational assessment teams to the Iraq and Afghanistan theaters to assess new systems under combat conditions. McKelvey was selected as the survivability subject matter expert and deployed to Afghanistan for six months. His primary job was collecting MRAP "black box cards," assessing improvised explosive events and reading "nine-liners"—medical evacuation requests—to correlate various intelligence feeds into actionable information for more survivable systems.

A few years later, McKelvey was selected for a one-year developmental assignment as the assistant technical director of the U.S. Army Aberdeen Test Center (ATC), working directly with John Wallace, ATC technical director. He supported approximately 290 test center initiatives and had a hand in producing ATEC's application for a national cyber range in collaboration with several Army organizations and the Office of the Secretary of Defense.

McKelvey was selected for AEC's Emerging Leaders Cohort in late 2016 and, as his individual project in that program, published a process guide for cyber and electromagnetic assessment of autonomous and robotic systems. As the lead cybersecurity evaluator for autonomous and robotic systems, he saw firsthand that there was confusion over what a cybersecurity and electronic warfare assessment should look like for those systems. "That confusion wasn't being addressed elsewhere, so I set about creating a general process guide that was system-agnostic," he explained. By separating programs from procedures and opening up his strategy for comment, he was able to gather input from more than 30 senior leaders across the acquisition community, "and the guide became a more useful tool on a faster schedule than I could have ever executed alone." (To read the guide, go to the online version of Army AL&T magazine at **http://usaasc.armyalt.com/**.)

The guide addresses a critical gap for two emerging acquisition areas: cybersecurity and autonomous systems. It has been piloted with the Program Executive Office (PEO) for Simulation, Training and Instrumentation and the PEO for Combat Support and Combat Service Support (CS&CSS), McKelvey said, with PEO CS&CSS finding the guide to be useful with scoping of early contractor-led cybersecurity scans and electromagnetic activities. "This helps with identifying and addressing concerns early and ultimately expediting the fielding of these systems to the force," he said.

When he's not at work, McKelvey spends time "working with my hands alongside other people. One thing I've found is that whether you're installing a can light, changing brake pads or building a stool, you're more successful when you plan the work with an understanding of how the project will affect its surroundings." That system-of-systems approach has been critical to his success, across defense acquisition and beyond it. "Sometimes the 'system' is a PowerPoint file, sometimes it's a brainstorming session, sometimes it's an armored brigade combat team, but a system-of-systems approach alongside supportive, motivated teammates makes work easier."

—*MS. SUSAN L. FOLLETT*

EVALUATING SYSTEMS IN THEATER
McKelvey, right, and Forward Operational Assessment 20 Commander Col. Greg Applegate in Kabul, Afghanistan, prepare to travel to an assessment site in June 2013. At the time the picture was taken, McKelvey served as the team's survivability subject matter expert and acting deputy commander. (Photo courtesy of Robert F. McKelvey III)

HELPING TO FILL A DOCUMENTATION GAP

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BRAD D. BLEDSOE

COMMAND/ORGANIZATION:
Aviation Rockets and Small Guided
Munitions Product Office, Joint Attack
Munition Systems Project Office, Program
Executive Office (PEO) for Missiles and Space

TITLE: Product support integrator

**YEARS OF SERVICE
IN WORKFORCE:** 10

DAWIA CERTIFICATIONS: Level III in life
cycle logistics; Level I in program management

EDUCATION: M.S. in logistics, Florida
Institute of Technology; B.S. in
economics, Alabama A&M University

AWARDS: Employee of the Quarter and
Team of the Quarter, PEO for Simulation,
Training and Instrumentation

The squeaky wheel gets the grease, as the saying goes. For Brad Bledsoe, product support integrator and senior logistician for the Program Executive Office (PEO) for Missiles and Space (MS), that squeaking resulted in a unique opportunity to help improve sustainment policy for major weapon systems.

Bledsoe is assigned to the Aviation Rockets and Small Guided Munitions Product Office, part of the Joint Attack Munition Systems (JAMS) Project Office and the joint services lead for the 2.75-inch rocket program, also known as the Hydra-70. The Hydra-70 is a free-flight rocket with multiple warhead configurations; it has been the standard ground-attack rocket since it was first used in the Korean War.

"The Hydra-70 can fill a variety of roles against a wide spectrum of targets," said Bledsoe. "Multiple types of warheads provide a solution to many tactical situations within a battle area by providing area suppression or high-explosive solutions for anti-personnel, anti-materiel, armored vehicles, bunkers and reinforced military operation in urban terrain targets. The Hydra can also provide target illumination, smoke screening, target marking and training."

The system has undergone numerous modifications since it was first designed, including motor and nozzle configurations, fuze modifications and new warhead combinations. "Even with all those changes, the system basics have remained the same," said Bledsoe. However, he noted, while the system meets the needs of the warfighter, it does not conform to current acquisition documentation standards required by the assistant secretary of the Army for acquisition, logistics and technology.

That's something Bledsoe discovered when he was assigned to lead an integrated product team tasked with developing the life cycle sustainment plan (LCSP) for the newest variant in the Hydra-70 program, the Advanced Precision Kill Weapon System. An LCSP outlines the program manager and product support manager's plan for formulating, implementing and executing a system's sustainment strategy. It describes the approach and resources necessary to develop and integrate sustainment requirements into the system's design, development, testing, deployment and sustainment phases. According to "DOD Instruction 5000.02, Operation of the Defense Acquisition System," program managers are responsible for developing and maintaining an LCSP beginning at milestone A and for updating it at each subsequent milestone.

"LCSP development should begin in the earliest stages of the life cycle and should be updated regularly to ensure that it remains relevant," Bledsoe explained. "But it's really difficult to document those early milestones when you're decades into production, which was the situation we were dealing with."

The integrated product team determined that it lacked critical acquisition documentation and the milestone data to complete the LCSP in accordance with the requirements identified in "Army Regulation 700-127, Logistics Integrated Product Support." The team put together a draft LCSP that was missing many key data elements and provided it to the deputy assistant secretary of the Army for acquisition policy and logistics (DASA(APL)), in the hopes of getting some guidance on resolving the issue.

Meetings with the DASA(APL) followed and helped identify gaps in current Army policy in addressing sustainment documentation for legacy systems. "There are a number of these legacy systems in the field—the HELLFIRE missile, for example—which means there's a need to revise Army acquisition policy to include provisioning for them," Bledsoe said. The DASA(APL) will use the LCSP for the Advanced Precision Kill Weapon System as a basis for updating regulations for systems of systems, and will then expand the effort to update regulations for LCSPs for other systems, including families of vehicles and families of ammunition. The goal of the effort is one foundational document for each system and a shorter document for each variant that spells out any differences.

Bledsoe learned a lot from his involvement with the LCSP effort and is grateful for the time and expertise of all of the participants, including representatives from the U.S. Army Aviation and Missile Command Logistics Center, the JAMS Project Office and the Joint Munitions Command. "I really appreciate the DASA(APL)'s willingness to listen to our challenges. Their commonsense approach will help streamline acquisition policy and will allow for the continuous modernization of the force. Also, the burden on the workforce will be greatly reduced so we can concentrate on what really matters: getting capability to the warfighter."

Bledsoe started his acquisition career in 2008, leaving a private sector sales position for an internship at the U.S. Army Aviation and Missile Command. As an intern, he joined the PEO for Simulation, Training and Instrumentation (STRI), working with the Targets Management Office. "The targets office was an excellent opportunity because the threat requirement evolves quickly and the acquisition is fast-paced," Bledsoe said. "Also, working in the test and training environment is exciting because you get to get out of the office for a live-fire or test event and see how systems perform in the field."

The internship also exposed him to mentorship—something he continues to be involved in, despite an uneven start. "The mentor who was assigned to me didn't have much time to assist me because of his busy schedule. However, another person stepped up and he helped me out on tasks, shared his knowledge, reviewed my work and pushed me outside of my comfort zone," Bledsoe explained. "He gave me the confidence I needed to take on additional tasks."

Bledsoe stayed with PEO STRI for nine years, joining PEO MS a little more than a year ago. He and his mentor no longer work together but are still in contact, he said. "I often think about him when I meet someone just entering the workforce by letting them know that I would be glad to assist when they need it—so I can help provide guidance and insight to help develop their skills and confidence."

His advice to junior acquisition personnel is to obtain required certifications early. "Once you acquire more responsibilities and get involved in a lot of different projects, it is challenging to find the time to take a week or more off to attend acquisition classes pertaining to your given area of work. Get it done early and take good notes."

—*MS. SUSAN L. FOLLETT*
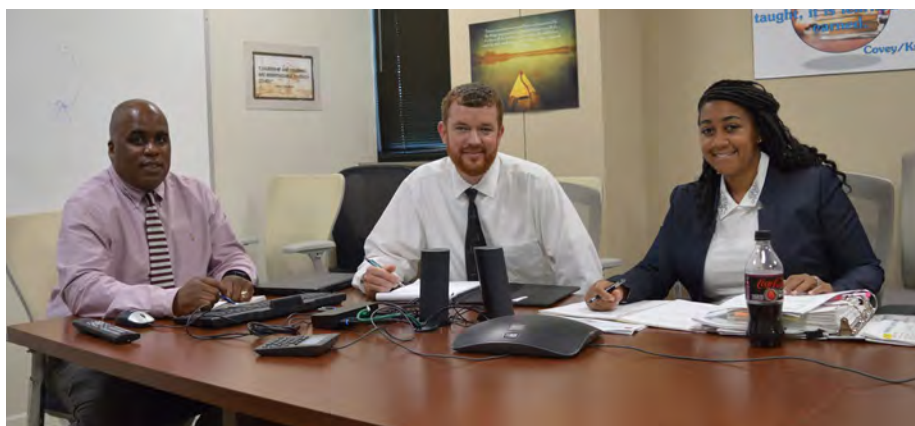
PROVIDING SUPPORT
Fellow PEO MS integrated logistics support specialists Wes Calloway and Jessica Daniel flank Bledsoe. (U.S. Army photo by Chuck Braziel, PEO MS)

VEHICLE DOCTORS
Soldiers from the 25th Transportation Company use diagnostics software on the M1083 Family of Medium Tactical Vehicles, Schofield Barracks, Hawaii, in December 2015. The trial of a new maintenance schedule, based on vehicle fault codes, refreshed the diagnostic skills that had atrophied in maintenance units over the last two decades. (U.S. Army photos by Jesse Fields, AMSAA Operational Sustainment Analysis Team)

IF IT AIN'T
BROKE...

The 25th Transportation Company moved from an "every X months" preventive maintenance schedule to servicing vehicles as needed as part of an AMSAA study. Soldiers strengthened their ability to troubleshoot and repair precise problem areas instead of replacing whole parts, and the unit saved time and money.

by Mr. Kevin Guite

Soldiers performing preventive maintenance on their M4 carbines disassemble, inspect, clean and reassemble the many parts to ensure that their primary weapon will fire properly during close combat operations. Readiness plans for the hundreds of thousands of Army ground vehicles require just as much attention. Yet the process of performing preventive maintenance for Army vehicles is enormously more complex.

Today's vehicle systems are built with expensive components, electronics and subassemblies that demand properly trained operators and maintenance personnel keenly aware of the performance of their vehicles. However, the man-hours, resources and costs needed to accomplish proper preventive maintenance for Army vehicles have led to concerns among the Army sustainment community over efficiency.

It's the worst-kept secret in Army maintenance units that the Army has been over-maintaining its equipment and that its processes are not very efficient. However, the Army's official policy gives little room to sidestep scheduled service responsibilities. Those concerns about inflexible maintenance schedules led the Army G-4 to formally request that the U.S. Army Materiel Systems Analysis Activity (AMSAA) assess Army preventive maintenance policy, methodology and execution.

The study, which ended in February 2018, examined traditional scheduled maintenance practices and policies, focusing on current maintenance intervals and prescribed functions, and determined that, yes, preventive maintenance policy and execution could be greatly improved. Each of the Army's more than 400,000 tactical wheeled vehicles has a preventive maintenance requirement, so getting the process correct will pay huge dividends across the Army.

CRUNCHING THE NUMBERS

In the study, AMSAA compiled real-world data to quantify the current volume of preventive maintenance actions for the Army's fleet of wheeled vehicles. Vehicle maintenance data collected through the Army's Sample Data Collection and Analysis Program from 2014 through 2016 indicated that approximately 97 percent of the tactical wheeled vehicle fleet and 98 percent of the 1,310 instrumented Strykers were being serviced based solely on time rather than actual use. Semiannual, annual and biennial services dictated through Army maintenance policy were being performed to replace fluids and vehicle parts well before their condition would warrant maintenance attention.

For a fleet of vehicles in which approximately 95 percent of equipment is characterized as "low-usage" or driven less than 3,000 miles a year, premature maintenance actions presented an excellent opportunity for potential improvement in the Army's sustainment strategy.

AMSAA partnered with the U.S. Army Tank-automotive and Armaments Command (TACOM); the U.S. Army Research, Development and Engineering Command's Tank Automotive Research, Development and Engineering Center; the U.S. Army Combined Arms Support Command; the Program Executive Office for Combat Support and Combat Service Support (PEO CS&CSS); and the 25th Transportation Company of the 25th Infantry Division at Schofield Barracks, Hawaii, to conduct the two-year project. The project focused on improving service strategies for wheeled vehicles at field-level maintenance sites. The objectives of the study were to reduce maintenance burdens with no detriment to safety, reliability or readiness; realign resources from activities that don't add value to those that do; reduce costs; and reduce waste from

DATA GATHERING

A hub odometer on the rear wheel of an M1092 trailer (in the Family of Medium of Tactical Vehicles) belonging to the 25th Transportation Company, Schofield Barracks. AMSAA used hub odometers, which track how many miles the trailer has covered, to compare how much a vehicle was being used with how frequently Army policy required it to be serviced.

premature disposal of components that were still functioning properly.

In the initial phase of the study, the semiannual and annual preventive maintenance intervals were extended to 24 months and the impact on safety, repair and maintenance resources was assessed. (See Figure 1.) The extended maintenance interval would allow for additional vehicle usage that would more closely align with the mileage triggers for preventive services. The study mandated 10-mile road exercises every 30 days for vehicles and every 90 days for trailers, to alleviate any perceived risks to vehicle performance because of extended service intervals. The road exercises mitigated the risk of unexpected component failure by requiring each vehicle and trailer to be run through less time-consuming quality assurance and quality control checks to check for

seal deformations, lubricate gaskets and charge batteries on a regular basis.

In addition, researchers implemented pre-dispatch checklists that required qualified maintenance personnel to lay eyes and hands on key components such as steering linkages, suspensions and fluid systems at least monthly. Operators, supervisors and maintenance technicians all bore responsibility to validate the current state of each piece of equipment.

The extended services strategy led to an annual savings of approximately $69,000 in service parts in the 25th Transportation Company, on such items as engine oil, transmission fluid, filters, seals, wheel bearings, belts and brake shoes. Adopting similar service strategies for the total Army's fleet of Palletized Load System, Family of Medium Tactical Vehicles

FIGURE 1

Current Semiannual Time or Mileage Service Triggers

miles

| Semiannual | Annual | Semiannual | Biennial |

6,000 mile service requirement

Current plot to reach 6,000 miles is less than 60 months

PAM 750-8 low usage program (3,000 miles)

It appears FMTV is serviced 5,000+ miles prematurely every six months

Actual mileage when services performed

Example unit A: 568 average semiannual miles

months

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

~18.7 hours   ~38.6 hours $986 parts   ~18.7 hours   ~40 hours $986 parts

Key:
FMTV: Family of Medium Tactical Vehicles
PAM 750-8: "Department of the Army Pamphlet 750-8, The Army Maintenance Management System (TAMMS) Users Manual"

TOO MUCH OF A GOOD THING

Preventive maintenance is good, but AMSAA's study showed that medium tactical vehicles were being serviced nearly 5,000 miles sooner than needed, tying up mechanics and not improving safety in any measurable way. (Graphic by U.S. Army Acquisition Support Center and AMSAA)

(FMTV) and Heavy Expanded Mobility Tactical Truck platforms has the potential to save the Army $47 million annually. More importantly, 6,100 man-hours were freed within the 25th Transportation Company for unscheduled, deferred and other preventive maintenance necessary to maintain operational readiness of the unit's equipment. (See Figure 2, Page 47.) Despite

initial concerns from maintenance personnel about not being able to properly maintain their equipment because of extended service intervals, repair data showed there was no increase in part wear or failure, nor was there any measurable negative impact to safety, readiness, availability or reliability.

A NEW APPROACH TO MAINTENANCE

The 25th Transportation Company's participation in the study presented an excellent opportunity to introduce condition-based maintenance for the unit's fleet of tactical wheeled vehicles and trailers.

Condition-based maintenance monitors vehicle health, maintenance and usage data to provide actionable information to improve maintenance and fleet management decisions. The Army is expected to begin the process of adopting condition-based maintenance for all vehicles in FY19, so AMSAA seized on the opportunity to leverage its time working with the 25th Transportation Company to highlight the use of condition-based maintenance in an operational unit.

AMSAA worked directly with the 25th Transportation Company to install digital source collectors on 91 vehicles and hub odometers on 91 trailers to provide vehicle health and usage data. The digital source collector is a device connected to the controller area network of Army tactical wheeled vehicles and Strykers that records more than 80 data elements from various electronic control units on the vehicle. The digital source collectors

collect and store fault and performance data from engines, transmissions, starters, engine control modules, transmission control modules, braking systems and tire inflation systems, among others, so it can be downloaded and analyzed. Hub odometers are mounted on trailer axles and use the wheel's rotation to determine miles traveled.

AMSAA field analysts and 25th Transportation Company maintenance personnel downloaded the data weekly and used it to assess the condition of the vehicles and prioritize part orders and repairs necessary to return the equipment to mission-capable status. Most of the electronic non-mission-capable fault codes would be invisible to the Army without the data from the digital source collector. Condition-based maintenance makes

these fault conditions visible, helping maintenance personnel better understand conditions affecting vehicle operation and focus on specific repair actions instead of costly component replacements. Depleted diagnostic skills within field-level maintenance units over the last 10 to 20 years have produced a culture of remove-and-replace versus troubleshoot-and-repair. Maintenance personnel who understand and leverage error faults can confidently

make subassembly repairs instead of simply replacing major subsystems. The 25th Transportation Company has not replaced a single engine since the beginning of the study, thanks to the fault code information gained through condition-based maintenance.

What was quickly evident with the use of condition-based maintenance during the study was the need for additional training for unit maintenance personnel on how to interpret the digital source collector codes. AMSAA provided unit technicians with diagnostic training and technical support needed to configure diagnostic devices as well as troubleshoot and isolate electrical faults coming from the digital source collectors. After a series of classroom lessons and hands-on diagnostic exercises, technicians could understand error fault codes and systematically track the issues to perform the correct repair.

MAN-HOUR TRADE-OFF

Maintenance personnel with the 25th Transportation Company went from using no fault codes during vehicle inspections, before digital source collectors were added, to up to 70 fault codes a day; diagnostic and component failure information quickly became a valuable maintenance resource that Soldiers never knew existed. Soldiers reported newfound confidence in their ability to correctly diagnose issues and save both time and money in the repair process. However, the increased visibility into vehicle faults also brought an increase in repairs needed to maintain operational readiness.

Condition-based maintenance tools such as the digital source collectors, laptops connected to onboard vehicle networks and diagnostic software products made Soldiers more informed, but they also made them much busier. Maintenance units will desperately need the

> **The extended services strategy led to an annual savings of approximately $69,000 in service parts in the 25th Transportation Company, on such items as engine oil, transmission fluid, filters, seals, wheel bearings, belts and brake shoes.**

FIGURE 2

Monthly Services Workload

BEFORE — Week 1 2 3 4 — **OPTIMIZED**

- 196 hrs/wk required
- 784 hrs/mo required
- ~50% of authorized mechanics devoted only to services

- 58 hrs/wk required
- 232 hrs/mo required
- Unit reduced scheduled service team from 12 mechanics to 4

Current annual parts cost:	Annual savings:	
FMTV - $45,898	$22,949	**Total savings**
PLS A1 - $84,221	$42,111	**$69,004**
HEMTT A4 - $7,887	$3,944	

Key
FMTV: Family of Medium Tactical Vehicles
HEMTT A4: Heavy Expanded Mobility Tactical Truck A4 Variant
PLS A1: Palletized Load System A1 Variant

HOW IT WORKED OUT
The results of the project worked well enough for the 25th Transportation Company that the unit petitioned to continue using the trial schedule with its longer service intervals and condition-based maintenance while the Army studies their wider application. (Graphic by U.S. Army Acquisition Support Center and AMSAA)

maintenance man-hours freed through adoption of optimized preventive maintenance as the Army moves to fully implement condition-based maintenance across all its sustainment units. Optimized preventive maintenance greatly benefits the Army without the use of condition-based maintenance tools, but repairs identified by condition-based maintenance cannot be performed without the resources returned through the optimized (longer) service intervals.

Expanding time and cost savings experienced within the 25th Transportation Company to other Army maintenance units will require a change to official policy that documents the preventive maintenance process and its current timelines. AMSAA materiel systems analysts led the way in the maintenance policy review and documented recommendations in an updated Maintenance of Low-Usage Equipment section of "Army Regulation 750-1, Army Materiel Maintenance Policy."

AMSAA's recommendations seek to formalize the extended service intervals, quality control inspections, quality assurance reviews and pre-dispatch checklists for nondeployed, low-usage equipment. AMSAA vetted its final version through TACOM, which concurred with the changes and delivered a final version to the Army G-4 for final approval. Army G-4 is currently reviewing the suggested changes to the policy.

EXPANDING THE IMPACT

The benefits highlighted in the extended services study were immediately apparent with the 25th Transportation Company, and continue to generate additional

Condition-based maintenance tools such as the digital source collectors, laptops connected to onboard vehicle networks and diagnostic software products made Soldiers more informed, but they also made them much busier.

attention across the Army. The 25th Transportation Company petitioned the G-4 to continue its exemption for the use of extended preventive maintenance intervals. The G-4 granted the request, permitting the 25th Transportation Company to continue to operate on the extended services schedule as new policy is being considered.

Additionally, TACOM has engaged the original equipment manufacturer of the FMTV in a review of the preventive maintenance strategy for that platform. The objective is to benchmark the manufacturer's recommended service schedules and determine changes to the FMTV's preventive maintenance process to decrease life cycle costs and optimize service intervals. Historical fault codes collected by AMSAA will be combined with operational requirements for the FMTV to produce recommended optimized service intervals. TACOM has also identified the Stryker combat vehicle as a potential beneficiary of the optimized service strategy.

AMSAA has since partnered with the Army Study Program Management Office, within HQDA G-8, and the 1st Squadron, 2nd Calvary Regiment headquartered in Vilseck, Germany, to undertake a similar optimized preventive maintenance study focused on its Stryker platforms. The study began in February 2018 and is proceeding through the fall of 2019, following an implementation plan similar to the one used with the 25th Transportation Company.

Initial findings have identified reductions in required services, savings in service parts and an increase in man-hours for unscheduled maintenance actions. Final study findings will be briefed to TACOM and PEO CS&CSS in September 2019 at the conclusion of the two-year study, and will be used to support formal recommendations for updated Army maintenance policy.

CONCLUSION

Initial concerns over the efficiency of the Army's preventive maintenance policy led to a new approach to sustainment operations. Implementing an optimized service strategy that removes the requirement for premature time-based services proved to be a wise, cost-saving approach that also returned valuable man-hours to Army maintenance personnel to support operational readiness repairs.

The new approach is quickly generating additional support throughout the Army sustainment community and, most importantly, with those who set official policy. Data supporting the adoption of updated sustainment processes for today's complex systems will ultimately prove to benefit tomorrow's systems and the Soldiers they support. Savings in costs, resources and maintenance man-hours with no change to safety is a winning formula the Army can live with, and fight with into the future.

*For more information, contact the author at **kevin.m.guite.civ@mail.mil** or go to **https://osat.amsaa.army.mil**.*

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JUST ADD LITERALLY ANY LIQUID
Anthony Roberts, materials engineer, prepares a fuel canister for a remote-controlled tank demonstration. Nanogalvanic aluminum-based powder goes into the canister first, followed by water or any water-based liquid—liquids like coffee, sports drinks or even urine. (Photos by Jacqueline M. Hames)

JUST ADD WATER!

| The Army Research Laboratory's new nanomaterial paves the way for efficient and green energy solutions.

by Ms. Jacqueline M. Hames

Like many great scientific advancements, the U.S. Army Research Laboratory's (ARL) new nanomaterial was invented by accident. Materials engineers at ARL on Aberdeen Proving Ground, Maryland, were trying to engineer a nanostructured aluminum alloy in January 2017 when, during polishing and hardness testing, they discovered the aluminum powder was disappearing—it was reacting with the water used in the polishing process to create hydrogen. While the discovery surprised ARL scientists, they knew they had come across something quite extraordinary.

"This is the main thing: It can generate power on demand in the field, wherever we need it," Dr. Anit Giri, materials engineer with the Materials and Manufacturing Science Division at ARL, said of the powder.

EUREKA

The nanogalvanic aluminum-based powder came about as scientists were researching better, stronger materials for armoring Soldiers and vehicles—specifically, an aluminum with the strength of steel. This effort to make better materials for armor is ongoing, despite the excitement of new discoveries like the powder.

Dr. Chad Hornbuckle, materials engineer on the powder's development team, explained that the original intent was to create a nanostructured aluminum alloy that would have increased strength, making a material that was lightweight like aluminum but comparable in strength to steel. A material on the nanoscale is less than 100 nanometers long, Hornbuckle said. (A nanometer is one-millionth of a millimeter; a millimeter is very small, but is visible to the naked eye.) The nanoscale is often used to measure dimensions of matter on an atomic level.

"All metals are made up of grains, similar to sand on a beach, but instead of being sand, it's whatever your metal is," Hornbuckle explained. "We were trying to make a bulk piece of aluminum, but the grains themselves were on the nanometer scale."

The aluminum material they were trying to create began as a powder, and during the usual analysis process, it had to undergo hardness testing, said Anthony Roberts, also a materials engineer on the development team. The team pressed the powder into a compact, a solid piece, to polish to a mirror shine for the hardness test. "Well, while we were polishing it, we noticed it disappeared, so we made another compact, and we start polishing it, and we noticed it started disappearing real quick," Roberts said.

"A part of the polishing process is sandpaper and water, and we noticed that the water was reacting with it and it was disappearing. We found out it was creating hydrogen," he said.

The hydrogen was created during a hydrolysis reaction: aluminum reacting with water to produce aluminum hydroxide, or aluminum oxide, plus hydrogen, Giri said. This reaction occurs with all aluminum, and normally the formation of an aluminum oxide layer inhibits the creation of hydrogen. However, in the case of the nanogalvanic aluminum-based powder, the reaction was disrupted—the aluminum oxide layer did not form.

Nanogalvanic aluminum powder's scientific definition is a powder that consists of galvanic cells in nanoscale with aluminum as the anode, coupled with another element acting as the cathode; galvanic corrosion occurs when two dissimilar metals make contact with one another in the presence of an electrolyte—any liquid that contains water—thereby forming a galvanic couple, the development team said. That means the powder is an electrochemical substance where the coupling of a positively charged electrode from the aluminum (anode) and a negatively charged electrode from another element (cathode) in water produces electricity.

"The powder has some aluminum with some extra additional elements, so what happens is, when the water comes in contact with the powder, some of these additional elements want to basically pull electrons from the water. So it essentially caused the water to break down," Hornbuckle said. The water reacted with the extra elements in the powder and separated the hydrogen and oxygen. Because the reaction took place on the nanoscale, the powder could not form an encapsulating oxide layer and it continued to
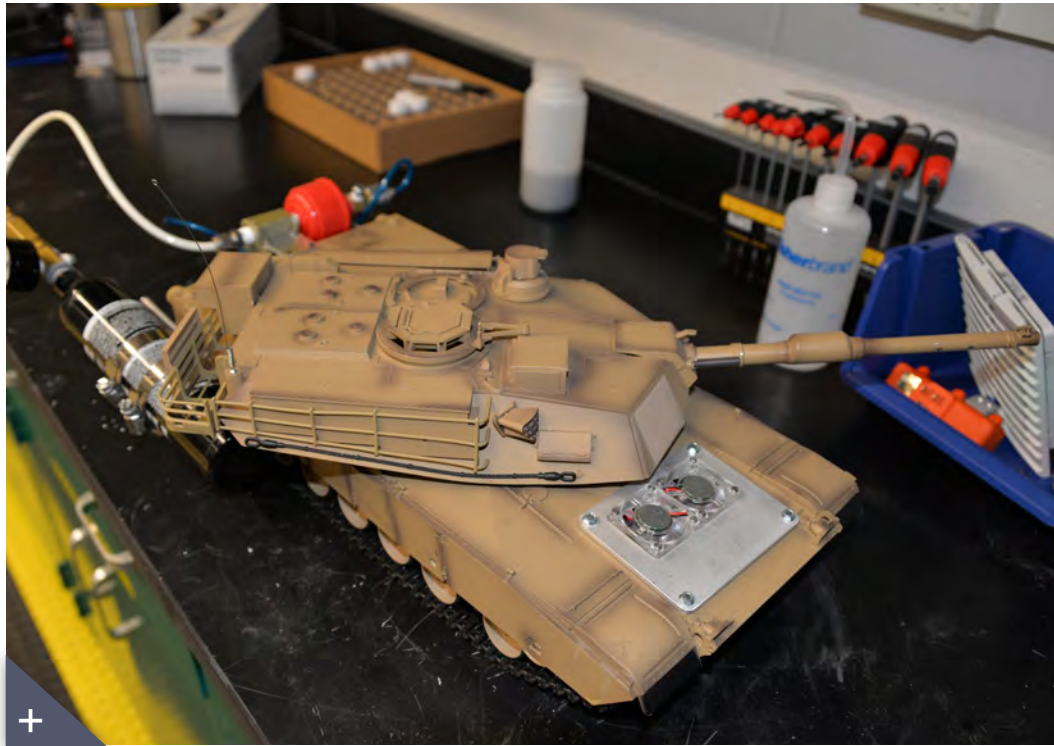
SAFE HYDROGEN FUEL
A remote-controlled tank at ARL, powered by hydrogen-electric fuel, awaits demonstration. Fuel systems like this one eliminate the need for high-pressure hydrogen canisters that can pose an extreme hazard on the battlefield if ruptured.

react with water, creating hydrogen. The hydrolysis reaction in the powder occurs at room temperature without any catalysts, chemicals or external power, making the powder a good source of on-demand hydrogen fuel.

DEVELOPING THE TECHNOLOGY

Robert Dowding, materials engineer and chief of the Lightweight and Specialty Metals branch, said that, to his knowledge, ARL is the only laboratory working on developing the nanogalvanic aluminum-based powder. "We're doing a systematic investigation of these materials. We're interested in what compositional range is going to work for us, what sort of microstructures are going to be important, how

things are arranged—and then the process becomes important," he said.

ARL is using a milling process to make the powder, which tends to be expensive, Dowding said. The lab is looking at other methods to make the powder that would be less expensive and more commonly available. Part of that process includes partnering with industry to find better, less expensive methods of production and distribution. At the time of these interviews, ARL has filed a patent application for the powder; once the patent has been issued, ARL will be able to license it to industry to aid its development.

"We are mandated by Congress per our mission lines to do R&D [research and

development]—it is not our job [to], nor has Congress told us we should, be in the business of competing with industry for commercial markets," said Joshua Houck, a representative from ARL's Technology Transfer and Outreach Office. "What we've found is the best way, one of the least expensive ways, the Army can procure a capability, is by developing a technology that hopefully has what we call dual use." A dual-use technology, one that has both military and commercial applications, enables ARL to license the technology to industry for mass production and then buy it back at a less expensive rate from a competitive market. When the government licenses its intellectual property—such as the nanogalvanic powder—to industry for production, the overall unit cost of the item drops considerably, and the Army is able to buy it back at a much lower cost than if it had kept the technology and made it at one manufacturer, he said.

"Also, here at the lab, doing basic and fundamental research, the technologies we generate aren't necessarily commercial products," Houck added. "We've got a material that can go through and generate hydrogen that goes into a fuel cell, but we aren't making

the fuel cell. We aren't putting them into a package with a user's manual for someone, so we need someone to make that product consumer-friendly."

> **"It can generate power on demand in the field, wherever we need it."**

Within the Army itself, creating a consumer-ready product is done through, for example, the U.S. Army Armament Research, Development and Engineering Center, product managers and program executive offices, Houck said. But if a product is produced commercially, then the Army can buy it back and tailor it to military requirements.

A LOGISTICAL DREAM COME TRUE
The powder is an exciting breakthrough for ARL and the Army, particularly for the logistics involved in energy distribution. "One of the major issues now with the distribution of energy is usually JP-8 in large bladders," Houck said. JP-8, or Jet Propellant 8, is the fuel used in most military systems now. These bladders of JP-8 contain a large liquid volume and are somewhat fragile. "It is very difficult to airdrop liquids in these large bladders. They have a tendency to burst when they hit the ground," Houck said.

"If you shoot them, they get a hole in them and stuff sprays out," he continued. "So one of the advantages of this powder is it being a solid, whether it's in powder form or compressed tablet form." If shot, it will just break, maintaining all of its properties even in pieces. It won't catch fire, it won't explode—unlike what the high-pressure hydrogen fuel cylinders used today might do if they rupture. The powder gives the Army the ability to store "energy capacity, the ability to generate energy in a safe and nonvolatile form for transport," he said.

The powder, which can be manufactured in any quantity, can be scaled down in volume enough that Soldiers could carry their own supply. "I can just have however much of it I want, again, either in powder or this Alka-Seltzer-type tablet form, and then

'EAT ME'

A new hydrogen fuel source, nanogalvanic aluminum-based powder opens up many new possibilities, from standard fuel cells and internal combustion engines to on-demand battery power for personal devices, all the way up to a future that could include self-cannibalizing drones. While such a drone is just a pie-in-the-sky idea at the moment, the logistical implications are intriguing.

The conceptual drone's structure would be made of bimetallic tubes, Dowding said. Inside the tube would be a layer of the nanogalvanic aluminum composition, while the outside would be made of conventional aluminum alloy. Water would flow through the actual structure of the drone, reacting with the layer of nanogalvanic aluminum to create hydrogen that would act as a secondary or emergency fuel source. Parts of the drone would, in effect, become sacrificial. "The idea is that you can have it eat away part of itself that is not very important to keep going and create energy from that," Roberts said.

This would eliminate the need for a cumbersome fuel tank or power source, potentially making the drone smaller and more maneuverable.

pull it out and drop it to generate hydrogen where I need it," Houck said.

To begin the reaction, the powder—loose or compressed—is mixed with water in a canister. The hydrogen that is created then feeds into a fuel cell, where it can generate electricity for vehicles, computer systems or anything that needs power. One kilogram of the powder can generate 4.4 kilowatt-hours of energy—enough to power 10, 60-watt incandescent lightbulbs for more than seven hours or the equivalent LED bulbs for over 50 hours, Giri said. And the only emission from the reaction is water—pure water, Roberts said.

If the reaction is created using a fixed amount of water, a Soldier could get back about 50 percent of the original water, with diminishing water returns, Giri said. Once the water source runs out, the Soldier would be out of power. Given an unlimited supply of water and powder, the reaction could continuously produce hydrogen for fuel. The source of water doesn't have to be pure water, either—it can be any water-based liquid, like coffee, soda, wastewater, spit or even urine.

"We noticed that urine worked best so far in this reaction," Roberts said. "We're not quite sure if it's because it is a little acidic, or if it's because of the electrolytes in it or the salts in it that's causing it to react a little bit faster. But we did notice [the reaction] goes almost twice as fast with the urine."

The emissions from the reaction would not change, even if the water-based liquid

> **"One of the least expensive ways the Army can procure a capability is by developing a technology that hopefully has what we call dual use."**

A SCIENTIFIC SURPRISE
Roberts watches the pressure gauge on a fuel canister, waiting for the nanogalvanic aluminum-based powder to react with water, releasing hydrogen to power a remote-controlled tank in a demonstration. Scientists discovered this hydrogen reaction accidentally in 2017 while trying to develop an aluminum alloy.

were varied. "That's the great thing. You could use urine to create this energy, right? And then what comes out on the other side is pure water. So then you could have drinking water again," Roberts said.

CONCLUSION
Practical applications for the powder cover the spectrum of electrical power needs, in both the Army and commercially. ARL and the powder's development team are currently working with U.S. Army Tank Automotive Research, Development and Engineering Center on the ZH2 tactical wheeled vehicle, a modified Chevrolet Colorado truck that will run on hydrogen-electric power. "The hydrogen was produced in a different manner, which is very cumbersome, expensive, not easy to do," Giri said. "We are working with them to replace their method of producing hydrogen by our method."

Hornbuckle believes the powder could be used commercially for on-demand charging of batteries for things like cellular phones, computers or a portable GPS while out hiking or camping. Houck said that the powder may help accelerate the move toward an electric economy.

Two challenges with electric vehicles have been battery-charge locations and wait times, or the need for a high-pressure hydrogen cylinder that may pose an extreme hazard if involved in an accident. "That's not going to happen with this technology," he said. "I'm just going to have, you know, sand on the ground or a bunch of little tablets on the ground. The real idea is trying to see how this could jump-start or accelerate that move to an electric-based [economy], away from petrochemical, and this is sort of one more step in that process."

Regardless of how it is applied—in the military or commercially—ARL scientists are confident in the powder's potential. "Wherever you need power, you can use it," Giri said.

*For more information on ARL, go to **https**://**www.arl.army.mil/www/default.cfm**. For more information for industry, go to **https**://**www.arl.army.mil/alnanogalvanicpowder**.*

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ELECTRIC POWER, NO CHARGING STATION REQUIRED
Roberts prepares a fuel canister for a remote-controlled tank demonstration. Hydrogen-electric fuel generated from nanogalvanic aluminum-based powder, like the kind used in this tank, could solve many logistical problems for the Army—and could facilitate the transition to electric cars.

FIRST, THE BOOST

The U.S. Army Space and Missile Defense Command/Army Forces Strategic Command conducted the first flight of the Advanced Hypersonic Weapon (AHW) concept in November 2011. AHW is a boost-glide weapon that is launched to a high altitude, curves back to the Earth's surface and then glides or skips along the atmosphere, without power, for the remainder of its flight. (U.S. Army photo by U.S. Army Space and Missile Defense Command/Army Forces Strategic Command)

EXPERIMENTS IN
HYPERSPEED

| What are hypersonic weapons, why does the Army want them, and are they as revolutionary as they sound?

by Ms. Mary Kate Aylward

— 1998 —

U.S. intelligence locates Osama bin Laden at an al-Qaida camp in Afghanistan. Navy ships in the Arabian Sea launch cruise missiles, which take two hours to reach the target 1,100 miles away. The camp is destroyed but bin Laden survives: He had left less than an hour earlier.

— 2003 —

DOD requests funding for the Conventional Prompt Global Strike program, citing the need to be able to hit "fleeting targets."

— 2011 —

After several failures, DOD's first successful test of a hypersonic weapon occurs: The Army launches a missile from Hawaii that lands 30 minutes later in the Marshall Islands, approximately 2,000 nautical miles (or 2,300 standard miles) away.

— 2013 —

The Chinese military's "Science of Military Strategy" (an authoritative study of China's strategic position) notes: "The United States is in the process of implementing a conventional 'Prompt Global Strike' plan. Once it has functional capabilities, it will be used to implement conventional strikes against our nuclear missile forces and will force us into a disadvantaged, passive position."

— 2014 —

China conducts the first of at least seven tests of a hypersonic weapon.

— March 2018 —

Russian President Vladimir Putin claims to have finished testing an "invincible" Mach 10 hypersonic cruise missile that "can also maneuver at all phases of its flight trajectory, which also allows it to overcome all existing and, I think, prospective anti-aircraft and anti-missile defense systems, delivering nuclear and conventional warheads," according to translations provided by the Russian government.

HYPER VS. SUPERSONIC

"Hypersonic" describes any speed faster than five times the speed of sound, which is roughly 760 miles per hour at sea level. Multiply that by five and you have a weapon that travels at least 3,800 miles per hour or more. But is speed enough to change the game? Does a missile flying at Mach 7 outperform one at Mach 3 on metrics other than speed? Apart from flying very fast, what does DOD—and what do its adversaries—think hypersonic weapons can accomplish?

If a targeted country does not know whether the weapon due to arrive in minutes is carrying a conventional or a nuclear warhead, would it take the risk of leaving what could be a nuclear strike unchallenged?

MACH 20, ANYONE?

This illustration depicts the Defense Advanced Research Products Agency's (DARPA) Falcon Hypersonic Test Vehicle as it emerges from its rocket nose cone and prepares to re-enter the Earth's atmosphere. DARPA has conducted two test flights of the vehicle; in the second, in 2011, the HTV reached a speed of Mach 20 before losing control. (Image courtesy of DARPA)

"It's really meant to kick the door open," said Bob Strider, hypersonics chief at the U.S. Army Space and Missile Defense Command, "and then allow other assets to come in." (The door, in this analogy, is closed by the anti-access and area denial measures a country could deploy to prevent others from entering or passing through a given area of land, air or sea.) Strider oversees the Army's contributions to the Conventional Prompt Global Strike technology demonstration program, to support the building of a ground-launched hypersonic weapon. The Army conducted two technology demonstration flights of the Advanced Hypersonic Weapon—one successful, in 2011, and one aborted in 2014 after testers detected an anomaly with the booster seconds into the flight.

The Army, specifically, is after a long-range missile that redefines long range—Chief of Staff Gen. Mark A. Milley has stressed that he wants to see "10x" improvements. "We, the Army, have as our number one priority for modernization long-range precision fires; a subset of that is the hypersonic piece to it," Milley said March 15 in testimony before the House Appropriations Subcommittee on Defense. What's publicly known about DOD hypersonic progress suggests that hypersonics offer

that kind of range. Less has been said about their precision, though Strider said the Army's Advanced Hypersonic Weapon "is showing a lot of capability to be able to get where it's supposed to get and hit with a lot of energy. … In our upcoming tests we'll be testing those bounds more and looking at what the vehicle really is capable of as far as maneuverability."

Some defense analysts are unconvinced that the United States needs a hypersonic strike and are skeptical of some technical claims made about hypersonic weapons, pointing out that there are other ways to hit fleeting targets, get into denied areas or strike a rogue nuclear facility—ways that cost less, and risk less.

WHY GO HYPERSONIC?

Research on hypersonic flight goes back to the 1960s, but it has been technically challenging to achieve. At hypersonic speeds, the air molecules around the flight vehicle start to change, breaking apart or gaining a charge in a process called ionization. This subjects the hypersonic vehicle to tremendous stresses. Spacecraft, and ballistic missiles, spend most of their flight out of the atmosphere, free of the heat, pressure and friction, while hypersonic vehicles have to push through the atmosphere. "The thermal protection system for the hypersonic weapon is one of the key, very key, technologies that have to be in place because the hypersonic weapon is pretty much in the atmosphere through its flight; it gets temperatures in excess of 2,000 degrees for quite a few minutes," said Strider.

Hypersonic flight has several applications. A reusable hypersonic airplane (of the "two hours from Beijing to London" variety) is the most distant, though NASA and the Defense Advanced Research Projects Agency have both explored preliminary steps; it's weapons that are

capable of hypersonic speeds that DOD is actively pursuing. These come in several varieties, including hypersonic cruise missiles and boost-glide vehicles. The former are powered during their flight by an attached engine; the latter are unpowered after launch and, as the name suggests, glide to their destination.

The U.S. military began pursuing hypersonic weapons in earnest under the Conventional Prompt Global Strike program in 2007. The program sought to achieve a non-nuclear strike anywhere around the globe within an hour. Now, a prompt global strike also appears useful as part of a package of options to counter anti-access and area denial measures. As concern grows about China's efforts to close off what it considers its part of the Pacific, a weapon that could fly undetected into the denied area while the launch platform stays well outside becomes more attractive to U.S. military planners.

The Army's Advanced Hypersonic Weapon demonstrator, tested in 2011 and 2014, relied on boost-glide technology. Rockets launch—boost—the glide vehicle to a high altitude, giving it enough speed and energy to reach its target. The glide vehicle then curves back toward the Earth's surface, and glides or skips along the atmosphere without power for the remainder of its trajectory. (Though "glide" might suggest gentle motion, the vehicle is tearing through the atmosphere at Mach 5 or faster.)

The U.S. Army Aviation and Missile Research, Development and Engineering Center, in Huntsville, Alabama, developed the thermal protection system. The Army team collaborated with a number of national laboratories on the launcher and glide vehicle design, and refined it in wind tunnels where vehicle forces were measured at hypersonic speeds.

> **"These very breathless technical claims about hypersonic weapons being these silver bullets, without the question mark, that can do everything—at the very least the jury is still out."**

CHANGING THE GAME?

Hypersonics have been spoken of as game-changers (whether because of their speed or their radar-evading low flight profile), though opinions vary across the defense community as to whether current hypersonic technology is advanced enough to be revolutionary. In the "yes" column is Strider. "I see it as a game changer. I'd say there's very few mechanisms today that could stop a hypersonic weapon."

Whether they change the game or are an incremental shift is, to some extent, a moot point by now: China is testing hypersonics, so is Russia, and therefore, so is the United States. "I do think for better or

FIRST TEST FAILS

NASA's X-43A hypersonic research aircraft and its modified Pegasus booster rocket spiral into the Pacific Ocean off the California coast in June 2001. After being released from NASA's NB-52B carrier aircraft, the X-43A and the Pegasus booster, which was supposed to accelerate the X-43A to Mach 7, lost control about eight seconds after ignition of the Pegasus rocket motor. Explosive charges were triggered to terminate the flight, which was part of NASA's research into alternative uses for hypersonic flight. (Photo by Jim Ross/NASA via Getty Images)

for worse hypersonic weapons are likely to become a significant feature of the international landscape and could have quite significant strategic implications. I think we're kind of feeling our way through what those implications could be," said James Acton, a nuclear physicist with the Carnegie Endowment for International Peace, in a September 2017 interview with Army AL&T.

WHAT'S ON THAT WARHEAD?

Blundering into a nuclear exchange is one such possible implication that concerns defense analysts, and it has occasionally concerned Congress since the advent of the Prompt Global Strike program in the early 2000s. Congress has generally supported the program, but it has withheld funds for some requests from DOD, citing concerns about the possibility of accidental nuclear war. "Radars would provide much less warning time of a boost-glide weapon attack than a ballistic missile attack," Acton wrote in his 2013 study "Silver Bullet?" If a targeted country does not know whether the weapon due to arrive in minutes is carrying a conventional or a nuclear warhead, would it take the risk of leaving what could be a nuclear strike unchallenged?

Acton is not convinced that DOD has made a serious case "that the strategic benefits [of having hypersonic weapons] outweigh the strategic risks of escalation with Russia and China." Others worry about the wider risk of arms-racing and missile proliferation. Air Force Lt. Col. Jeff Schreiner wrote in a 2014 Stars and Stripes op-ed calling for a hypersonic test ban: "The tactical planner in me sees countless uses for hypersonic delivery platforms against a range of target sets. The strategic planner sees the ability to help offset other nations' strategic assets with a conventional versus nuclear strike. The pessimist in me sees a technology that has the potential to spiral out of control in many nations into deadly new nuclear delivery platforms."

MACH 10 IS NOT ENOUGH

One benefit that could counterbalance the risks of inadvertent escalation would be the ability to get around an adversary's missile defense systems. Right now missile defenses are designed with a ballistic missile's flight path, altitude and speed

Tech Ready:
2020+
HIGH-SPEED STRIKE WEAPONS
Rapid strike from standoff

Tech Ready:
2030+
TACTICAL STRIKE/ISR
Deep strike of high-value targets

Tech Ready:
2040+
REUSABLE/ PERSISTENT
Penetrating, persistent reusable ISR & strike

POTENTIAL MISSIONS

A U.S. Air Force graphic shows some of the different applications of hypersonic flight and how close they are to being realized, from intelligence, surveillance and reconnaissance (ISR) to strike weapon. The Army's Advanced Hypersonic Weapon falls in the strike weapon category. (U.S. Air Force image)

in mind, but whether that means hypersonic weapons will be able to easily break through them is unknown.

"Systems like THAAD, PAC-3, Aegis, are actually pretty good at intercepting ballistic missiles now of medium range. They've now been tested against intermediate-range ballistic missiles," Acton said, referring to the Terminal High Altitude Area Defense system and the Patriot Advanced Capability 3 missile. "Those things are moving faster than many hypersonic weapons." Apart from speed, what should set hypersonic weapons apart from ballistic missiles is the ability to maneuver, rather than fly in a straight line, as the weapon approaches the target. "The real issue is the extent to which these things can execute very rapid terminal maneuvering, in terms of their ability to penetrate missile defenses, and we haven't seen that demonstrated yet," Acton said. "… These very breathless technical claims about hypersonic weapons being these silver bullets, without the question mark, that can do everything—at the very least the jury is still out." Little data has been released after DOD's hypersonic tests—and verifiable data about the accuracy of Russian and Chinese missiles is also scarce—so not much information is publicly available about how well current prototypes maneuver or how accurate they are.

SEA-BASED OPTION

U.S. and South Korean warships escort the aircraft carrier USS Carl Vinson in the western Pacific Ocean. After years of research and tests, including the Army's tests of the AHW, the Office of the Secretary of Defense has determined that the best option for a conventional prompt strike is a sea-launched hypersonic weapon. (U.S. Navy photo by Mass Communication Specialist 2nd Class Sean M. Castellano)

MAKING MOVES: KEY, AND VERY DIFFICULT

The dynamics of hypersonic flight make it hard for a speeding missile to make rapid evasive maneuvers shortly before target impact. Think of trying to make a quick, precise turn while driving: It's easier at 35 miles an hour, harder at 70, and much harder at 7,000 miles an hour. Strider said the Advanced Hypersonic Weapon has overcome some of the challenges. "Maneuverability is a key aspect to its military utility. … Once it's gliding, it's able to fly cross-range, left or right in its flight path."

Researchers have a math problem: how much energy to put into the weapon at launch—essentially, how much of a boost to give it—to make sure it hits its target with enough force. Engineers add up the energy required to lift the vehicle above the atmosphere, the distance it needs to cover, how much time it will spend fighting the atmosphere's drag when it re-enters, and how many deviations from a straight trajectory it needs to make.

"It's just like you throw a paper airplane: The harder you throw it, the farther it's going to go," Strider explained. "Same thing here. We've got to put enough energy into something that weighs quite a few pounds to throw it several hundred miles. Any maneuvers you make bleed off energy because you're not powering it [at that point in its trajectory], so you have to be careful how many maneuvers you make so you can manage the energy that's in it to make sure you can get to the target you want to."

WHAT'S NEXT

Whether the Advanced Hypersonic Weapon or any land-based hypersonic vehicle will be fielded is still an open question, though

Strider and others believe the United States needs to field something quickly to counter Russia and China's progress. "Currently they're due to have some operational capability in the near future, and the U.S. needs a similar capability to be able to show them we've got one, too," Strider said. "And so that's what we're shooting to do." Funds from the Conventional Prompt Global Strike program will shift to the Navy, which is working on a sub- or ship-launched hypersonic glide vehicle, in 2020.

At this stage, Strider's office does not plan further tests of the Advanced Hypersonic Weapon—he is now coordinating the planned flight tests of the Navy's developing hypersonic capability, which is similar to the Army's in design and build—until Army leadership makes policy and budgeting decisions. The ball is in the court of the cross-functional team dedicated to long-range precision fires, headed by Brig. Gen. Stephen J. Maranian. "Gen. Maranian at Fort Sill [Oklahoma] has the responsibility to bring the best concept forward to Gen. Milley" after examining all the options to improve the Army's long-range precision strike ability, Strider said. "And because the hypersonic weapon that we have developed through OSD sponsorship is the only flight-proven hypersonic weapon, we think we've got a front seat in being the best concept to take forward."

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MISSILE DEFENSE DEFEAT?

A Sabre short-range ballistic missile launches in June 2017 at White Sands Missile Range, New Mexico, for a test of the Patriot Advanced Capability-3 (PAC-3) Missile Segment Enhancement, an advanced missile defense system. Hypersonic missiles might be able to penetrate PAC-3 and similar systems. (U.S. Army photo by U.S. Army Space and Missile Defense Command/Army Forces Strategic Command)
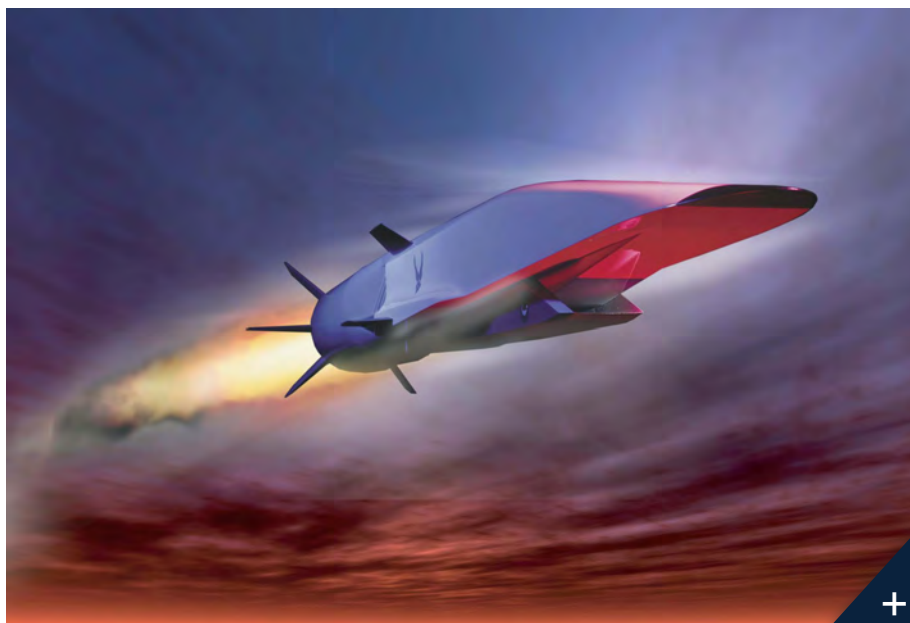
REVOLUTIONARY ADVANCE

The U.S. Air Force is set to demonstrate the hypersonic X-51A Waverider, which is designed to ride on its own shock wave and accelerate to about Mach 6. Hypersonics will "revolutionize military affairs in the same fashion that stealth did a generation ago, and the turbojet engine did a generation before," according to an Air Force study. (U.S. Air Force image)

REUSABLE
and
REFRESH-*ABLE*

Ground Combat Systems' Common Infrastructure Architecture integrates multiple systems and eliminates redundancies in fighting vehicles by using open architecture. Soldiers have an easier-to-use interface that the Army can reuse across combat platforms, and vehicles can be easily refreshed as new technologies or new requirements arise.

by Dr. Macam S. Dattathreya, Maj. Gen. Brian P. Cummings and Mr. Fasi Sharafi

In March 2014, the Program Executive Office for Ground Combat Systems (PEO GCS) launched a successful open systems software and hardware architecture solution now referred to as GCS Common Infrastructure Architecture (GCIA). Using the GCIA solution, PEO GCS spearheaded an Army combat vehicle program into a new paradigm with a more efficient, faster and interoperable platform for integrating warfighter capabilities into GCS vehicles. Within two years of GCIA inception, one of the GCS programs successfully implemented the GCIA solution in one of their vehicles. (The Ground Combat Systems portfolio includes the Abrams tank, the Stryker combat vehicle and the Bradley fighting vehicle.)

The nature of warfare is changing, and combat vehicles must support new technologies quickly, with the promise that they'll perform reliably and interoperate with related warfighter capabilities. An open systems architecture makes it much easier for Army program managers to rapidly deliver to the warfighter new capabilities that are critical on the battlefield of the future. "Open systems architecture" is a technical approach that enables systems' implementation using widely supported, consensus-based standards that are published and maintained by a recognized industry consortium. The standards support a modular, loosely coupled and highly cohesive system structure that includes publishing of key interfaces within the system and full design disclosure.

FIGURE 1

PRINCIPLES OF OPEN VEHICLE SYSTEMS
PEO GCS' Common Infrastructure Architecture, the key points of which are shown here, stresses common hardware and software that can be reused across platforms and that make it easier for different combat platforms to communicate. (Graphic by U.S. Army Acquisition Support Center and PEO GCS)

A system is modular when it is decomposed into multiple components that may be easily rearranged, replaced or interchanged in various configurations. A loosely coupled system has no or minimal dependency on components of other systems to carry out its functions, and changing one system will not impact other systems. A cohesive system carries out a single, well-defined function and contains only the parts that are required to carry out that single function.

GCIA exhibits all the characteristics of an open systems architecture. It creates a common approach across all combat vehicle platforms to support new innovations and technologies, promote competition, decrease costs and shorten integration timelines.

GCIA uses open standard specifications developed by PEO GCS for integrating C4ISR (command, control, computers, communications and intelligence, surveillance and reconnaissance) and electronic warfare (EW) devices. The specifications are known as VICTORY—Vehicular Integration for C4ISR/EW Interoperability. Different vendors can add, modify, replace, remove or support warfighter capabilities through GCIA's standardized interfaces throughout the life cycle of a vehicle platform.

The reusable artifacts of GCIA, such as government-owned software, specifications and implementation guides, can add value to other Army vehicle programs for developing or enhancing their information technology capabilities with lower-cost and low-risk options.

KEY TENETS, BENEFITS AND USES

Before GCIA, for combat vehicle programs such as Stryker, Bradley or a tank, each warfighter capability would provide its own specific infrastructure functions with proprietary interfaces for a military vehicle integration. These unique functions increase the complexity of integration, and they add a significant amount of integration and testing time to the acquisition program. This would impact budgets and schedules for Army acquisition programs. However, GCIA provides common system-level infrastructure capabilities such as shared display and computing resources, data sharing, common fault handling, software configuration management and a common data-communication network that all the warfighter capabilities can use instead of having their own specific infrastructure capabilities. The infrastructure is analogous to a robust highway with strategically placed standard services

SIMPLER SYSTEMS STRIKE HARD
Army fighting vehicles like this Stryker combat vehicle must integrate new technologies quickly and interoperate with other combat platforms to perform reliably on the future battlefield. Using open systems in the vehicles' onboard computers is a step in that direction. (Photo by PEO GCS)

such as rest areas, gas stations, exits and toll booths where they are needed.

Expected capabilities of today's combat vehicles require the integration of sophisticated technologies within the constraints of a vehicle platform, such as the cost, size, weight, power and cooling requirements. Reusability was a reason for developing GCIA— but not the only one. Moreover, the other drivers, or GCIA tenets, as depicted in Figure 1 (on Page 66), facilitate letting multiple competing vendors develop innovative solutions, rather than locking the PEO in to one supplier for the life of the product.

GCIA's common infrastructure solution, which works on any vehicle, allows for increased reuse across multiple platforms, reducing development testing costs and schedule, and increasing use of common products, thereby reducing life cycle support costs. Additionally, standard interface specifications in GCIA significantly reduce integration timelines by reducing interoperability-related challenges and issues. Since the infrastructure functions are common, once it is tested in one successful Army program, the testing organizations can leverage the results for any other programs that use GCIA instead of retesting them. This will drastically reduce the testing time and cost for any new programs that use GCIA.

Using open standards in GCIA increases opportunities for competition, enabling rapid introduction of innovative solutions at reduced cost instead of proprietary solutions that tend to lock the customer to one supplier for the life of the product.

Interconnecting multiple systems within a vehicle network, and using common communication protocols and common services

for sharing available information in GCIA, give the vehicle crew increased situational awareness while reducing redundant hardware solutions.

Delivering reliable and alternative mechanisms for resources to operate and communicate effectively with each other in GCIA provides for a robust solution that enables the vehicle systems to continue to operate properly during software failures.

systems, such as fire control or remote weapon systems, on GCIA.

CONCLUSION

Future efforts will evolve GCIA incrementally to allow multiple open-systems frameworks, such as the Future Airborne Capability Environment, modular open radio frequency architecture, sensor open systems architecture and open mission systems to work together without any disruptions to the operation of the vehicles. Planned enhancements in the next

GCSCIS/PEO+GCS+Common+Infrastructure+Architecture+Home.

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The nature of warfare is changing, and combat vehicles must support new technologies quickly, with the promise that they'll perform reliably and interoperate with related warfighter capabilities.

INTEGRATING CAPABILITIES

The GCIA platform provides all the required computing and display resources, network, infrastructure-related common capability services software, commonly used shared data services software, a library for assisting the development of VICTORY-compliant interfaces and an infrastructure for managing the network using open-standard specifications. Capability developers have to develop the drivers, devices and their system-specific software to interface with GCIA. The platform allows any VICTORY-compliant systems, such as digital radios, to interoperate with other VICTORY systems, such as computing resources, electronic warfare sensors or Ethernet switches, and non-VICTORY-compliant

12 to 16 months will improve GCIA's technical maturity in the areas of security, performance and software configuration.

The opportunities for reuse of this product go well beyond PEO GCS platforms or programs; it could also be used in High Mobility Multipurpose Wheeled or Mine Resistant Ambush Protected vehicles. With GCIA aboard vehicles on the battlefield, Soldiers will not only have multiple capabilities at their fingertips, but also a distinct advantage over the adversary.

For more information, email macam.s.dattathreya.civ@mail.mil or visit the website (registration is required): https://confluence.di2e.net/display/

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EVERY
RECEIVER
a SENSOR

In the complex, digitally connected battlespace of the future, situational awareness will be the difference between victory and defeat. By optimizing current capabilities, developing new sensors and harnessing the power of data analytics, engineers and scientists will help commanders gain a better understanding of cyberspace and the electromagnetic spectrum.

by Mr. Giorgio Bertoli, Ms. Danielle Duff, Ms. Courtney Coulter and Mr. Keith Riser

At the 2017 Association of the United States Army (AUSA) annual conference, Chief of Staff of the Army Gen. Mark A. Milley said that "the conflict of the future will almost certainly be in dense urban terrain." The United Nations projects that nearly 70 percent of the world's population in 2050 will live in cities. During the same period, the number of internet-connected devices (including computers, smartphones, home electronics, personal gadgets and even people) is expected to increase dramatically to more than 600 billion, based on current rates of growth in ownership. Current military capabilities will not be able to deal with the complexities and sheer density of signals in such an environment, while robust communications links and extensive infrastructure will provide many advantages to an entrenched adversary.

To understand what a future conflict, even one just a decade or so into the future, might look like in an urban environment, imagine it's 2030. U.S. armed forces have a mission to liberate and then provide security for a city occupied by a hostile force. The enemy is dispersed throughout the city in small operational groups, using an extensive digital mission-command infrastructure to coordinate its activities. To avoid detection, adversary troops are augmenting their military command-and-control equipment by using the communication infrastructure available within this urban environment. The commercial communication standard is now 6G. (Back in 2018, most smartphones ran on a 3G network.) Along with providing extremely robust communications and internet access to the local population, this cutting-edge digital infrastructure also supports the machine-to-machine communications necessary for the internet of things and automation capabilities that are now omnipresent in a typical smart city.

Within this operational environment, friendly forces must be able to identify adversary actions across both physical and virtual boundaries. They will need to rapidly understand the local cyber and electromagnetic environment and identify how an adversary may use cyberspace to cause disruptions that undermine U.S. activities (e.g., cut off power and services, impede traffic flow, conduct targeted propaganda campaigns).

Obtaining situational awareness in such a scenario will be extremely difficult. The nearly uncountable number of devices, the complexity of modern communication waveforms, and the ubiquity of available communication modes are but a few of the

FIGURE 1

Population increase by 2025

8 billion

2 billion

1950   1975   2000   2025

SOURCE: UN Population Division (2017 Revision)

Waveform complexity

Frequency range & BW

Signal/spectrum density

Signal diversity

Processing power

Propensity toward micro cells and shorter-range communications

LTE advanced, 5G ultra-wideband, etc.

VLF, HF to ->mmW, FSO, LiFi 20-50 GB over the air

12B devices today, 100-200B devices anticipated by 2025

IOT M-to-M communications 802.11.xxx 803.15.xxx

CPU & GPU performance increase by 100x

Signal range

KEY

BW: bandwidth
CPU: central processing unit
FSO: free space optics
GB: gigabyte
GPU: graphics processing unit
HF: high-frequency
IOT: internet of things

Li-Fi: light fidelity wireless communications
LTE: Long Term Evolution technology
mmW: millimeter wave
M-to-M: machine-to-machine
VLF: very low frequency

MORE PEOPLE, MORE DEVICES, MORE DATA
Commercial communications are growing in complexity with multiple improvements anticipated over the next decade. Coupled with congested and contested environments, this type of environment will challenge the Army's ability to operate on the electromagnetic spectrum, and in real time. (Graphic by CERDEC)

major technical barriers that will need to be overcome. To address this new challenge, the military must re-evaluate how its systems can be tasked to do more than just their intended function. It must develop new and novel sensors, and find new and novel ways of using existing sensors, that can acquire and discern signals of interest within such dense information environments. And it must use innovative data-processing techniques, such as machine learning, to help make sense of all this information.

A SPECTRUM OF CHALLENGES
To support mission planning and execution, commanders will need situational understanding of both the physical and cyberspace domains. For instance, what adversaries exist in the area and how are they communicating? Are they using the available local infrastructure? What applications are they using to communicate

and share information—are they using Gmail? Are they chatting on Telegram or Snapchat? What radio frequency spectrum do they use? Where are they? To help answer these and other questions, the U.S. Army's research and development community is investigating innovative approaches to identifying signals of interest from such future multifaceted and signal-rich environments. (See Figure 1.)

To obtain situational awareness of the electromagnetic spectrum, the Army currently uses large, dedicated electronic support and intelligence collection systems, mostly mounted on aircraft. Such assets are relatively few in number, overtasked and, if air superiority is not assured, must be situated a considerable distance behind friendly lines to maintain freedom of maneuver. In the electronically dense battlefields of the future, this traditional approach

of using a few large and expensive systems at a considerable standoff will not be sufficient to collect and sift through the vast assortment of signals in the environment.

To combat these technical challenges, the U.S. Army Communications-Electronics Research, Development and Engineering Center (CERDEC), a subordinate organization of the U.S. Army Research, Development and Engineering Command and soon to be part of the new Army Futures Command, has established the Every Receiver a Sensor (ERASE) program. This endeavor comprises at least six related science and technology research efforts managed under one umbrella. Each effort is a distinct building block; when combined, the blocks will create a holistic approach to significantly broaden and expand the Army's tactical sensing capabilities.

ERASE is founded on four core principles:

- Broaden the Army's cyber and electromagnetic sensor aperture by leveraging all available tactical receivers, regardless of their primary design function, as potential sensors of opportunity.
- Extend sensor reach by developing novel sensor and system concepts.
- Leverage all available data by exposing, aggregating and correlating data that is currently hidden within system internals or ignored.
- Speed commanders' decision-making by developing supporting data management, analytics, visualization and command-and-control tools.

BROADENING THE APERTURE
Each U.S. Army brigade combat team has thousands of tactical receivers on the battlefield. These resources (including radios, platform protection systems, radars) have distinct and specific functions. When idle, or potentially in

FIGURE 2

SCATTERING SENSORS
Under the Every Receiver a Sensor program, CERDEC plans to experiment with distributing a very large number of very small, inexpensive and disposable sensors throughout a contested or congested operational zone to acquire specific signals of interest—gathering, for instance, seismic data or radio frequency information. (Graphic by CERDEC)

conjunction with their normal operation, these devices can also serve as sensors. Today, most communications equipment is based on standard, generic hardware, with software providing the specialized functionality. As a result, these systems have the technical flexibility to be used in multiple different ways.

The ERASE program will build on previous capabilities, such as the Defense Advanced Research Projects Agency's RadioMap program, which demonstrated how tactical radios (e.g., the 117G) can be used as radio frequency sensors. While each of these systems will be limited in performance when compared to dedicated spectrum-sensing capabilities, their sheer quantity and proximity to potential signals of interest throughout the battlespace should allow for the acquisition of valuable new data. Furthermore,

this approach to broadening the Army cyber and electromagnetic aperture provides new capabilities without adding additional maintenance and sustainment costs for new equipment.

EXTENDING SENSOR REACH
When operating in contested environments, within which vehicles, planes and helicopters will be restricted in their maneuver, the Army still must have the capability to acquire the information it requires to understand the battlespace. Extending sensor reach to such denied zones can be accomplished in part by leveraging emerging new platforms such as high-altitude balloons and small, unmanned aerial vehicles. These technologies have matured significantly over the past several years and have been demonstrated to be capable of providing data and voice service to hurricane-affected areas.

This technology is being used today to provide wireless service to Puerto Rico as it continues to recover from Hurricane Maria, the Category 4 storm that struck the U.S. territory in September 2017. Additionally, under the ERASE portfolio, CERDEC is investigating the efficacy of using a very large number of very small and inexpensive sensors—like radio frequency sensors, or seismic sensors, for example—that can be distributed in mass quantity over a region of interest to acquire specific insights into the local environment. (See Figure 2, Page 71.)

LEVERAGE ALL AVAILABLE DATA

Our tactical systems already collect a large amount of information as part of their normal operation. However, this data is hidden within the device and is often not available to external systems for further processing. For example, practically all modern fielded communication systems monitor their own performance to help maintain quality of service. The system does this by measuring quantities such as received signal power levels and bit error rates. Most of this monitoring, and any remediating action taken by the device, are invisible to the operator.

For the user, such information will most often be superfluous. However, if this currently invisible data were made visible and then correlated across a large number of systems, it might provide near-real-time warnings of events within the electromagnetic environment. One radio experiencing a high error rate is, in itself, not very consequential. A couple dozen radios all reporting higher than normal error rates within close proximity of one another could, however, be an indication of adversary electronic attack activity.

SPEED COMMANDERS' DECISIONS

Data acquisition is only the first step in situational understanding. Once obtained, data must be ingested, aggregated and analyzed in various ways to derive meaning. For instance, simply collecting the total number of automobile accidents that have occurred over a period of time is not by itself very useful. However, correlating this data with other factors, such as location, weather conditions and time of day, could enable the identification of hazardous roadways and intersection that could then be remedied.

Future operational environments will necessitate the collection of extremely large and diverse data sets that humans will not be able to process using traditional software approaches. To overcome this, CERDEC will employ novel big-data processing and machine-learning techniques to reduce the time it takes to process such vast amounts of information.

Furthermore, such data sets will need to be stored as part of a distributed data-management system that will allow processing to occur at points close to the tactical edge; the ideal scenario is for data to be processed at the lowest level possible, as close to where it was collected as possible, so that resources aren't wasted sending large amounts of data back to higher headquarters. This will ensure that we do not overburden our tactical networks by attempting to move data across tactical communication links, and that relevant insights are made more expediently at the levels where they are most beneficial. In such an architecture, insights derived from data held at lower levels can be condensed and reported up the chain, where rhey can be further aggregated and analyzed to derive broader insights.

CONCLUSION

It's the year 2030. U.S. armed forces have been ordered to liberate and provide security for a city that is occupied by a hostile force. Upon initial entry, they use all available dedicated and opportunistic sensors at their disposal to validate and enrich previously known intelligence. Based on this new data, advanced analytics calculate that the adversary is operating within a small section

ON A ROLL

An adversary dug in to a dense urban environment, using robust communications links and taking advantage of extensive local infrastructure, would have an advantage over U.S. troops trying to decipher the sheer complexity of digital signals—unless military procedures change and allow units to exploit all possible sources of data, including sensors primarily designed for something else. (U.S. Army photo)

URBAN COMBAT

If the future of combat is urban—and given that most of the world's population will live in cities by 2050, most analysts agree that it is—the way the military currently uses, collects and analyzes data to get a picture of the battlespace won't work. (U.S. Army photo)

of the city that is currently inaccessible to U.S. forces. New sensor platforms that can safely access these zones are tactically deployed for final confirmation. Machine learning and advanced analytics subsequently suggest various courses of action for the commander, who then takes decisive action.

The Every Receiver a Sensor program is but a first step to realizing this new capability. By leveraging and expanding upon commercial technological advancements to broaden and extend Army tactical sensing capabilities, the program is working to revolutionize how the Army uses all its available tactical resources to sense the cyber-electromagnetic environment and derive meaning from this information that the tactical commander can use.

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MR. KEITH RISER is a team lead for identity intelligence within I2WD's Intelligence Systems and Processing Division. He holds an M.S. in software engineering from Monmouth University and a B.S. in computer science from Rutgers University. He is Level III certified in engineering.

BUT FIRST, LUNCH

I f you're looking for Tagg LeDuc, don't try calling him at lunchtime. "I believe life is too short to take anything too seriously, so making a point to take a break for lunch at a specific time is a way to maintain some semblance of control for that period where you can take a breath, decompress and relax for a bit," said LeDuc, electronics engineer for the Product Manager for Virtual Training Systems (VTS) within the Program Executive Office for Simulation, Training and Instrumentation (PEO STRI).

He's usually pretty hungry anyway, since he spends much of his free time training for triathlons and other multisport endurance events, including a 29-mile swim-run race in Switzerland and a 70.3-mile triathlon in Estonia. "The acquisition position is multifaceted, just like being a triathlete," said LeDuc. "To deliver a quality product, you need to put time into multiple activities and you need to be able to transition quickly from one to another."

Formerly known as the Product Manager for Ground Combat Tactical Trainers, VTS falls within PEO STRI's Project Manager for Training Devices, which provides Soldiers realistic training environments and equipment. VTS develops, fields and provides total acquisition life cycle management for precision gunnery, driver, route clearance, air and watercraft operation; satellite control and maintenance; and virtual training systems, supporting institutional, home station and contingency operations.

LeDuc's job "is to take the Soldier's needs and turn them into a functional requirement in a training device," he said. "That ensures that the Soldier is training on the most relevant training systems available, keeping them on the forefront of the fight and alive for their families." The short version of what he does for a living? "I tell people I work on very large video games. They always want to learn more when I say that."

The biggest challenge he faces is one he shares with many who juggle multiple projects, deadlines and shifting priorities: last-minute requests with a tight deadline. "Last-minute taskers with a short fuse require me to stop work on all other activities. It's disruptive to

TAGG LEDUC

COMMAND/ORGANIZATION:
Product Manager for Virtual Training Systems; Project Manager for Training Devices; Program Executive Office for Simulation, Training and Instrumentation

TITLE: Electronics engineer

YEARS OF SERVICE IN WORKFORCE: 11

DAWIA CERTIFICATIONS: Level III in engineering; Level I in program management

EDUCATION: B.S. in electrical engineering technology, University of Maine

MEET ANDROID
In July 2017, LeDuc and a colleague traveled to San Francisco and, as part of a larger Army group led by Maj. Gen. Maria Gervais, met with Google representatives to discuss Google's technology capacities and how they might become a player in the Army training and simulation world. (Photos courtesy of Tagg LeDuc)

TOP RACERS
LeDuc and his wife, Reeli Reinu, are congratulated by Mats Skott, race director, after completing a swim-run race in Switzerland in July 2017. LeDuc and Reinu were the top finishers among American co-ed teams.

ongoing projects and often has lasting schedule effects, because of the time that's diverted from that project to accomplish the last-minute tasker or the time it takes to resume the train of thought that was happening when the interruption occurred." How does he overcome it? "By first communicating the change in priorities to my team and then by taking actions to prevent further interruptions from occurring till the tasker is complete," he said.

LeDuc got his start in federal acquisition in 2001. "My first job out of college was working for the Navy's Explosive Ordnance Disposal Technology Division in Maryland. I was there for a little over four years, doing electrical design engineering—building and troubleshooting, with most of my work in the preliminary, pre-milestone A phase of the acquisition life cycle." He then spent a few years in the private sector before coming to PEO STRI in 2008, where he works at the other end of the acquisition life cycle. "Most of my work for [the Product Manager for] VTS is post-milestone C, putting requirements into a contracting package and monitoring the contractor to ensure that they're meeting those requirements."

LeDuc noted that he has been fortunate to have had varied assignments over the years that he has been with PEO STRI. "Each challenge builds upon the previous one, to make the next product that much better for the Soldier," he said. Those assignments have given him opportunities to take on various degrees of program management, and that exposure "helps bring the larger picture into the light and therefore better decisions and requirements development [have] occurred," he added.

Among the most memorable was his work on the Maritime Integrated Training Simulator program, his initial foray into programmatic exposure. "That's where I got my feet wet with collaborating with the multiple organizations that make a program possible, including communicating with finance, contracts and management levels in my own department." One of his most challenging assignments was his work on a foreign

military sales program. "The program had limited communication and slow response times, which was a detriment to maintaining the program's schedule." To ensure that the schedule stayed on track, the team identified "early and upfront" the importance of maximizing all opportunities to meet with the customer to resolve questions, LeDuc said. "We also leaned heavily on our own expertise to resolve questions when we were unable to get information from the client."

LeDuc noted that each program assigned to the Product Manager for VTS "is very dynamic, and lessons learned are pushed forward to the next program. My senior program directors talk about the days when they used typewriters and the introduction of Word-Perfect changed their lives. Even though I don't have the years they may have or [haven't seen] the drastic changes, I've still seen small changes here and there that ultimately drive the method in which we go about our daily tasks."

While most of those changes have improved the way his team works, he noted that not all of them are for the better. For example, he said, "I've seen changes in the regulations for attending conferences, due mainly to poor behavior on the part of someone who probably no longer works for the government anyway. It's frustrating that we're reduced to rules that govern the behavior of the worst employee, and it's a detriment that we can no longer attend conferences—they provide a great opportunity for inspiration and problem-solving." Industry days fill that gap, he noted, but often focus on finding solutions to a specific challenge. "A broader focus—on solving tomorrow's problems—that's where innovation comes from."

Despite those challenges, he said, his work for PEO STRI has given him some great opportunities: travel to several countries, as well as "the chance to meet and work with some pretty amazing people, and a plethora of experiences that many only read about."

—*MS. SUSAN L. FOLLETT*

a LEGACY *of* INNOVATION

RDECOM engineer receives Maj. Gen. Harold J. "Harry" Greene Award for his work to develop potentially time- and money-saving CHIMERA encryptor management system.

by Mr. Kevin Kane and Ms. Susan L. Follett

An engineer from the U.S. Army Research, Development and Engineering Command (RDECOM) has garnered a top Army award for innovation as a result of his work to develop encryption technology that provides Soldiers with secure situational awareness and reduces the training, sustainment and licensing costs associated with previous systems.

Patrick Doyle, an engineer in the Cryptographic Modernization Branch of RDECOM's Communications-Electronics Research, Development and Engineering Center (CERDEC), received the Maj. Gen. Harold J. "Harry" Greene Award for Innovation in the Civilian category at a July 19 ceremony at Aberdeen Proving Ground, Maryland. The U.S. Army Materiel Command (AMC), RDECOM's parent command, gives the award to recognize the technological contributions of Soldiers and civilians that greatly enhance readiness and Soldier performance. It honors the contributions of Greene, a former RDECOM deputy commander, who was deputy commanding general of the Combined Security Transition Command – Afghanistan when he was killed in Kabul on Aug. 5, 2014.

"Today's honoree joins a company of scientists and engineers who have made a significant impact in our Army," said Maj. Gen. Cedric T. Wins, RDECOM commanding general, who presented the award to Doyle. "Thank you, Patrick, for your contribution; it is a great example of the RDECOM mission to empower, unburden and protect Soldiers."

Doyle earned the award for his leadership in developing a tactical encryption technology known as CHIMERA, or the Common High-Assurance Internet Protocol Encryptor (HAIPE) Interoperable Manager for Efficient Remote Administration. CHIMERA is a software system capable of managing up to 15 of the most widely deployed encryptors—HAIPEs—from a single device. Developed by a team of CERDEC engineers, it allows users to configure, inventory and restart encryption devices from one platform in a central location.

RECOGNIZING INNOVATION
Maj. Gen. Cedric T. Wins, RDECOM commanding general, congratulates Patrick Doyle for winning the Maj. Gen. Harold J. "Harry" Greene Award for Innovation for his efforts to develop a system that consolidates and simplifies the use of multiple encryptors. (U.S. Army photo by Conrad Johnson, RDECOM)

LESS COMPLEX, MORE EFFECTIVE

Encryptor management is complicated because the vendors that provide the Army with management software have unique systems that require separate licenses and separate resources. In Doyle's lab alone, he and his team had three different HAIPE managers, each requiring a unique host, licensing fees and associated logistics costs. "Monitoring our network required three different laptops running different software," said Jimmy Latorre, CERDEC systems analyst. "We realized that if we're having difficulty in the lab, those problems are probably multiplied for Soldiers at forward operating bases and in network and tactical operations centers."

In addition to eliminating the need to maintain and operate multiple systems, CHIMERA improves access to network situational awareness information. Soldiers access networks using a Common Access Card, whereas previously they had to log out of one system running on one laptop in order to log into another system on another laptop. "Soldiers could be looking at one system and think everything was operating correctly, but there could be an attack on another system they weren't logged into," Latorre explained. "Soldiers had no full situational awareness of their full network."

CHIMERA also allows warfighters to remotely control multiple communication encryptors from a single, safe location instead of hand-carrying cryptographic keys to encryptors in hostile or remote locations. Previously, Soldiers often needed to travel—sometimes considerable distances—from one location to another to update encryption keys. Additionally, CHIMERA reduces the

time and costs associated with training, as a user no longer needs to learn multiple interfaces.

MANY USERS ACROSS DOD

Initially an engineering test tool, CHIMERA officially transferred to the Project Lead for Network Enablers within the Program Executive Office for Command, Control and Communications – Tactical (PEO C3T) in October 2016 and has since been deployed across DOD. The software is the result of a collaboration among CERDEC, PEO C3T and the Communications Secu-

infrastructure program, which aims to replace the electronic key management system with one that securely generates, distributes and manages encryption keys and other cryptographic products.

Feedback has been good. "Users like its speed and the intuitive interface and have provided some good ideas for additional features in later versions," said Latorre.

Patrick J. O'Neill, CERDEC director, praised Doyle and his team for their work. "Patrick's Soldier-first focus and the excellent work of his team demonstrate

significance in our command. I know that Harry would be honored that his name continues to hold a special significance within our community," he said.

"Maj. Gen. Greene serves as an example for every Army engineer and leader within the Cyber Security and Information Assurance Division," said Doyle. The division, which encompasses Doyle's branch, is part of CERDEC's Space and Terrestrial Communications Directorate. "To even be considered for something with his name on it is truly an honor, and very humbling to myself and the amazing folks I am lucky enough to work with on this project," he said.

For more information, contact the CHIMERA Help Desk at **Army.Apg.Chimera-Support@mail.mil** *or go to the Army Crypto Support Portal at* **https**://**spcs.kc.army.mil/sites/cryptomodportal/default.aspx** *(AKO account required).*

> **❝ We realized that if we're having difficulty in the lab, those problems are probably multiplied for Soldiers at forward operating bases and in network and tactical operations centers. ❞**

rity Logistics Activity, an element of the U.S. Army Communications-Electronics Command. Because CHIMERA is government-developed and government-owned, it saves the Army money by reducing software licensing fees.

The system is in use by the Marine Corps and the Navy and soon will be in use by the Air Force. It is also in use on sizable Army systems, including those at Aberdeen; Fort Huachuca, Arizona; Joint Base Lewis-McChord, Washington; and Redstone Arsenal, Alabama. The National Security Agency is incorporating CHIMERA in its key management

the effort required to field leap-ahead and game-changing technology, to protect critical data and voice communication on the battlefield," he said. "We are honored to be part of this award that honors Maj. Gen. Greene's legacy."

CONCLUSION

The award, which AMC manages in partnership with the assistant secretary of the Army for acquisition, logistics and technology, replaced the Army's Greatest Invention Award and the Soldiers' Greatest Invention Award programs. Wins noted that because of Greene's former role with RDECOM, "this award holds special

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QUANTUM
101

Credit: Getty images/agsandrew

TECHNICALLY SPEAKING

That sound you hear is the tick-tock of a super-accurate quantum clock, counting down the time until quantum information science enables a leap forward in cybersecurity, navigation, code breaking and all kinds of other puzzles.

by Dr. Kimberly Sablon, Dr. Peter J. Reynolds, Dr. Fredrik Fatemi and Dr. Sara Gamble

There are strange phenomena that cannot be explained by the laws of classical physics, unusual enough that they disturbed Einstein. This discovery stemmed from observations in the early 20th century on the nature of light and heat, and gave birth to the field of quantum mechanics, required to describe the behavior of atoms, photons and subatomic particles, as well as the universe as a whole. "Quantum" refers to the fundamental discreteness of nature—that at the smallest scales, measurements of energy, of light, of matter, and so on, come in indivisible packets.

Quantum mechanics revolutionized physics and continues to revolutionize science and technology today. Early research led to numerous technologies including lasers, magnetic resonance imaging (MRI), transistors and microprocessors. These advances leveraged certain properties of quantum mechanics but did not take advantage of all the odd phenomena that quantum mechanics embodies—such as that light is both wave and particle (matter-wave duality), and that a given electron, for example, can be two things at once until observation freezes it in one state (superposition).

In the 1970s, physicists merged quantum properties with information science, and by the 1990s it was clear that the marriage of these fields into quantum information science may have sweeping impacts, not only on defense applications, but also on the day-to-day lives of nearly everyone on the planet.

The tipping point for an appreciation of the importance of quantum information science came courtesy of mathematician Peter Shor. He developed an algorithm that leveraged quantum properties to factor very large numbers efficiently. While this may seem only like a mathematical curiosity, the importance of this algorithm cannot be overstated because the difficulty of the factoring problem is at the root of the encryption—known as the RSA cryptosystem—that encodes nearly every electronic transaction underlying secure government communications, emails, bank

transfers, and so on. While traditional computers cannot crack RSA encryption on any timescale relevant to security considerations, quantum computers would render it useless. As a result of Shor's insight, the Army and intelligence community immediately started investing in quantum computing research.

The United States has held a leading position in the development of quantum information science and associated technologies for many years. The Army, recognizing the importance of the field to the future fight, has even boosted its baseline investments since 2015 to explore capabilities in ultra-secure communications and networks and dramatically to improve precision sensing and timekeeping.

The United States, however, isn't alone. Canada, Australia, the Netherlands, the United Kingdom, the European Union, Singapore, Russia, North Korea and Japan have all invested heavily in research into quantum information science. China established a $10 billion national laboratory primarily targeting pre-eminence in quantum communications and successfully launched a quantum satellite in 2016. After the satellite program's success, China began building a nationwide quantum network for impenetrable military communications and financial transactions.
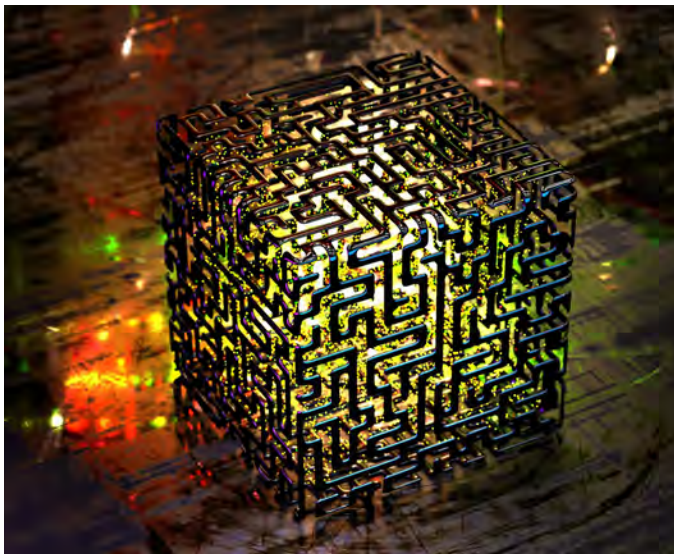
A VERY DIFFERENT KIND OF COMPUTING
Complex quantum computers of the kind depicted in this conceptual rendering are decades away, but quantum clocks and other applications of the knowledge that quantum mechanics has discovered could be in wide use much sooner. (Graphic by Getty Images)

The House Science Committee recently announced plans for a 10-year National Quantum Initiative to increase America's strategic focus on quantum information science. This effort will provide a greater degree of coordination between agencies, essential for successful capability development. Such a large initiative will depend on multiple investments and partnerships in academia, DOD labs and industry.

It's important to understand the basic principles of quantum mechanics essential for information applications, as well as how quantum information science can enhance or establish certain technologies for the Army, including quantum cryptography and communication, quantum metrology (measurement) and sensing, and quantum computation and simulation.

THE BASICS FOR QUANTUM COMPUTING

Three of the most important concepts to understand in quantum mechanics are superposition, matter-wave duality and entanglement.

Superposition is the counterintuitive ability of a quantum entity, such as an electron, to be in two states, "0" and "1", simultaneously, such as the lowest energy level of an atom and its first excited state. However, the atomic state is only defined when it is measured: Until we "look" at the atom, it is in both states at once, with probabilities that can be manipulated with quantum operations. Such "quantum bits," or *qubits*, are therefore unlike classical bits, which are in one state, either 0 or 1, whether we measure them or not. Quantum superposition is also at the heart of how the world's most exquisite atomic clocks and magnetometers function.

Matter-wave duality – Light is often thought of as composed of discrete photons—particles—but simultaneously behaves like a wave, exhibiting interference like water waves. Remarkably, a particle with mass (atoms, etc.) can also interfere with its own path or movement, just like waves can. This nonintuitive property has led to "matter wave interferometers" for rotation sensing that could potentially outperform the best laser-based gyroscopes. (Gyroscopes can provide a reference for how an object is oriented in space, among other things, and airplanes and spacecraft use them to help maintain stability and to navigate.)

Entanglement – Two or more qubits can further demonstrate differences from classical bits: They can be entangled such that a measurement on one instantaneously determines the outcome of the other. Such nonclassical correlations persist even over long distances, seeming to enable information transfer faster

Labels in image:
- Quantum cloud for secure information sharing and computing
- GPS Satellites
- GPS denied by enemy forces
- Inertial sensors for 100x reduction in GPS-free NAV error
- Magnetic field sensor for ASW and underwater mines
- Inertial sensors for precision fire
- Mass sensor for enhanced bunker/tunnel detection and mapping
- Enhanced resolution and ultra-wideband with fused multi-band radar network
- Secure comms between Navy, Army and AF assets
- Fiber link to fixed quantum network for secure comms and improved clock stability
- **KEY** — **ASW:** antisubmarine warfare — **AF:** Air Force — **NAV:** navigation
- **Unprecedented Warfighting capability using quantum information science**

THE QUANTUM BATTLEFIELD
The nonintuitive properties of quantum information science impact many technologies on the battlefield. The properties of superposition, matter-wave duality and entanglement are essential to a variety of current and future sensors and networks. (Graphic by U.S. Army Acquisition Support Center and the authors)

than light. This disturbed Einstein, who dismissed it as "spooky action at a distance." Ultimately, many experiments have shown that the information transfer is still limited to the speed of light as described below. However, the nonclassical correlations do indeed permit a type of communication security and computation unavailable to classical communications and computing systems.

QUANTUM TECHNOLOGIES
Quantum Cryptography and Quantum Communications
Quantum entanglement is expected to provide quantum networks with the ability to transmit quantum information with unparalleled security. An additional security advantage stems from the fact that qubit systems cannot be copied without fundamentally disturbing them. This means any attempted copying will absolutely be revealed, which makes this type of communication system very enticing to the Army.

Current uses of quantum cryptography and secure quantum channels primarily focus on the creation and distribution of quantum keys. Classical channels are still used to transfer information between two parties, but this information has been encrypted by quantum keys and is unreadable by the receiver without receiving the key over a quantum channel.

Ultimately, more complex quantum networks are envisioned that should provide the Army with a robust network secured not only by the protocols but also the inherent rules of quantum mechanics. To fully realize this, the Army is investigating distributed quantum systems that can store, process and transmit information using networks of entangled quantum memories. These are active areas of research within both Army laboratories and supported extramural efforts.

Quantum Metrology and Quantum Sensing
Quantum systems possess advantages over classical systems for some metrology—measurement—and sensing applications. One reason for this is that the transition frequencies of quantum atomic systems are exact, reproducible and identical within

a particular element (e.g., rubidium or cesium). The well-defined transition frequency makes them excellent standards for clocks, with far better performance than quartz crystal oscillators such as those used in wristwatches. A second reason is that qubits can be exquisitely sensitive to environmental fields, such as magnetic or electric fields. While this sensitivity is one of the reasons building a quantum computer is difficult, it is also the reason qubits can be excellent sensors.

Quantum communication networks require the precise synchronization and stabilization that atomic clocks provide. When combined with quantum sensors for acceleration, rotation and gravity, these clocks will also ensure robust navigation in GPS-denied environments. Together, quantum-enabled enhancements such as these contribute to the assured position, navigation and timing capabilities crucial to the Army's future success.

The application of quantum information science to general problems in sensing and metrology has shown that measurements can surpass classical detection limits. This enhanced sensitivity is of interest to the Army for a variety of applications, ranging from ultra-precise magnetometry to distinguish tank and submarine decoys from the real things, to precise chemical detection with limited sample volumes.

As a result of these varied applications, the Army has research programs related to quantum metrology and sensing, and is now targeting assured position, navigation and timing as a crucial area for increased investment.

Quantum Computation and Simulation

Quantum computers function via controlled initialization and manipulation of qubits to execute quantum algorithms like Shor's. During these operations, qubits are placed in superpositions and entangled with one another. Recalling that quantum phenomena are tied to probabilities of being in certain states, we can understand that during a quantum computation, all of the possible results exist with some probability. Quantum algorithms function such that the probability of getting the correct answer upon measurement is enhanced while the probabilities of all of the incorrect answers are suppressed. It is these enhancements and suppressions together with state sampling (is the electronic state

"**Quantum**" refers to the fundamental discreteness of nature— that, at the smallest scales, measurements of energy, of light, of matter, and so on, come in indivisible packets.

1 or 0?) that can enable exponential processing improvements that make quantum computing so fundamentally different from classical computing.

Several physical platforms are viable candidates for building quantum computers. Although qubits based on trapped atomic ions, superconducting and semiconducting systems seem to hold the most promise for large-scale implementations, they are not the only ones, and the question is still open as to what type or types of qubits will enable the first quantum computer capable of solving classically intractable problems. While quantum computers large enough to run Shor's algorithm for code breaking are decades away, when we have these computers they will be able to attack multiple problems of interest to the Army in addition to code breaking, like resource optimization, optimal wargaming, efficient command, control, communications and intelligence, and maximal logistical support.

Quantum simulators can be thought of as special-purpose quantum computers suited to understanding specific problems, such as the design of novel materials. Quantum simulators are expected to solve some long-standing problems in physics and chemistry, including the origin of certain types of superconductivity, and for chemical (e.g., pharmaceutical drug or energetic material) design. This specialization removes many of the constraints that make general-purpose quantum computers decades away from realization, and, as a result, near-term quantum simulators may have a more immediate impact on Army capabilities, especially in materials design.

CONCLUSION

Quantum information science provides unprecedented advantages that are impossible under classical laws of physics. Some of these advantages that rely on superposition or matter-wave duality are already in the early stages of application in quantum clocks and sensors, while some involving multiparticle entanglement are further off, including quantum networks. Some will require decades of additional development, such as complex quantum computers.

Quantum mechanics has proven over and over that with each included quantum ingredient, revolutionary capabilities occur, and we should be confident that this will continue to occur.

Untapped aspects of quantum information systems have the potential to yield far-reaching innovations and unprecedented technologies, with unparalleled precision, sensitivity, speed, information capacity and other decisive factors, and will help the U.S. Army pave the road to dominance for many years to come.

For more information, email Dr. Kimberly Sablon at **kimberly.a.sablon.civ@ mail.mil**.

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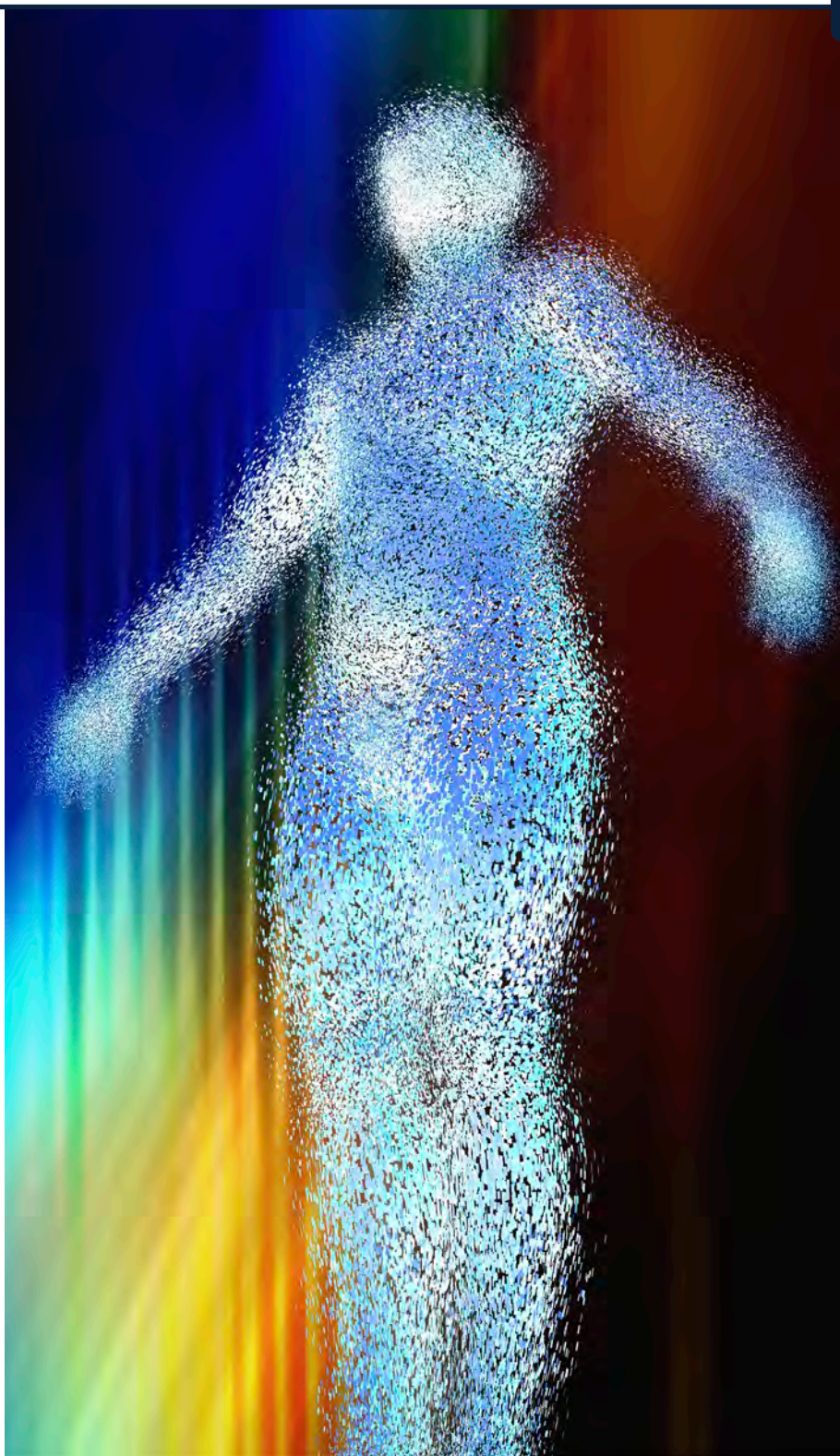
ATOMS ENTANGLED

Two or more qubits, or quantum bits, can transfer information between themselves at the speed of light. This phenomenon is known as quantum entanglement. The communications that quantum phenomena make possible have long intrigued science-fiction writers, who extrapolated from the known phenomena at the atomic level to dream up things like teleporters. (Graphic by Getty Images)

SMALL
IS THE NEW BIG

ANGELA ARWOOD-GALLEGOS

COMMAND/ORGANIZATION: Small Business Programs, U.S. Army Mission and Installation Contracting Command

TITLE: Procurement analyst and small business professional

YEARS OF SERVICE IN WORKFORCE: 12

DAWIA CERTIFICATIONS: Level III in contracting; Level II in small business; Level I in purchasing

EDUCATION: MBA, Webster University; B.S. in business management, Colorado State University – Pueblo

AWARDS: Army Office of Small Business Programs Small Business Professional of the Year; Commander's Award for Civilian Service; Army Achievement Medal for Civilian Service; U.S. Army Materiel Command Recognition Certificate; Fort Carson Garrison Commander's Award

Angela Arwood-Gallegos would like you to know that there's nothing small about the work of a small business professional. From the number of tasks she juggles and the amount of information she needs to know to the economic impact, small business is a very big deal.

As a small business professional and procurement analyst for the U.S. Army Mission and Installation Contracting Command (MICC), Arwood-Gallegos provides counseling and training sessions to small business owners on individual procurement opportunities and helps prepare small business owners for federal contracts. She primarily supports three organizations: MICC – Dugway Proving Ground, Utah; MICC – Fort Carson, Colorado; and MICC – Fort Polk, Louisiana. She has also supported the Small Business Program offices at MICC – Fort Riley, Kansas, and MICC – Fort Hood, Texas.

"One common misconception of a small business professional is that all we do is review and sign DD2579s, the small business coordination form. That's definitely not the case," said Arwood-Gallegos, who served as a contracting officer for 10 years before transitioning to the small business career field two years ago. "I'm busier than I ever thought I would be. That's another misguided perception of working for the government—that we have lots of free time on our hands. It's the furthest thing from the truth. [When I started in acquisition] I knew I would find work to keep me challenged and busy; I just didn't know that I would be this busy."

Her work includes ensuring compliance with relevant sections of the Federal Acquisition Regulation, the Defense Federal Acquisition Regulation Supplement and the Army Federal Acquisition Regulation Supplement, and assisting each installation with the development and performance toward annual and quarterly small business goals. She also plays a role in acquisition planning, developing market surveys and conducting market research, participating in source selections and reviewing acquisition strategies. Additionally, Arwood-Gallegos coordinates small business outreach events at MICC installations she supports, assists small businesses with payment issues, and works with the Office of Small Business Programs and the U.S. Small Business Administration in performing procurement management and surveillance reviews.

In May, Arwood-Gallegos was named the Small Business Professional of the Year by the Department of the Army Office of Small Business Programs as a result of the exceptional support she provided to MICC – Fort Carson and the 418th Contracting Support Brigade. Her implementation of the Army Small Business

Program enabled MICC – Fort Carson to significantly exceed four of its five goals for FY17 and increased the small business vendor base for MICC activities at Fort Carson, Fort Polk and Dugway. As a result of her efforts, MICC – Fort Carson received the U.S. Small Business Administration Region VIII Administrator's Small Business Advocacy Award. While serving remotely as the small business professional for MICC – Dugway, she worked closely with office personnel to set aside approximately $11.4 million in construction actions for small business vendors in Utah. As a result of that organization's improvement in supporting local small businesses, it was named the Small Business Administration's Contracting Office of the Year for 2017.

"Most vendors that I counsel are overwhelmed with the amount of work it takes to get registered to do business with the government," said Arwood-Gallegos. "It is my job to help them find the right resources."

If she were queen for a day, Arwood-Gallegos would make a couple of changes. "First and foremost, I would ease some of the stress by hiring more qualified people to assist in accomplishing the mission. Then, I would increase communication throughout the process—all the way up to the contracting officer for award—so that everyone involved has a good understanding of the requirement, documents get submitted with sufficient time and the information provided is complete," she said. "It's great when this happens, and I wish it could happen more often, particularly for the more complex requirements."

Arwood-Gallegos, an Army spouse, got her start in the Army Acquisition Workforce after learning about it from a friend who was accepted into the Air Force Copper Cap Internship Program. "I researched the Army internship program and was fascinated with all it had to offer," she said. She started her first acquisition post in 2006 with MICC and has been with the command ever since. "The more I learned along the way, the more I came to love the acquisition career field. I enjoy the challenges and the constant changes, and it does a great job of keeping me on my toes and energized."

The biggest challenge that she faces in performing her job "is that there is too much of it and not enough people to keep up with it all." Prioritizing, organizing and multitasking are keys to getting things done, she said, as are solid communication skills and being prepared for what's next. "I integrate with the acquisition teams as early as possible so I have a good idea of what is coming before it gets here. When I can get involved in the acquisition early on, I have a better understanding of the requirement, and I'm able to foresee any potential challenges it may present. It also helps to reduce my review time." When it comes to communication, she said, "all of the different forms are critical in this career field. It's important to stay informed, to know the right time for soft skills versus hard skills, to be responsive, to be clear and concise when sharing information with others and to always keep an open mind."

It's easy to become overwhelmed with the constant changes of the acquisition career field, Arwood-Gallegos conceded. "Two quotes really help me: 'A bend in the road is not the end of the road unless you fail to make the turn,' and 'Try not to become a person of success, but rather a person of value.' "

—*MS. SUSAN L. FOLLETT*

SMALL BUSINESS SUPPORT SQUAD
The MICC – Fort Carson team gathers for a picture March 20 at Colorado Technical University. The team hosted a Small Business Acquisition Forecast Open House at the university to educate small business vendors on the contracting process and the requirements that Fort Carson is looking to fill this year. (U.S. Army photo by Amber Martin, Fort Carson Public Affairs)

FIELD KITCHEN OPEN FOR SERVICE
Soldiers prepare locally contracted food for U.S. personnel executing bilateral training overseas. Food preparation is just one of the many services that operational contracting support personnel can procure for troops on deployment or in the field for joint exercises. (Photo by the author)

PLAN
for better PLANNING

For better contracts and better support to the warfighter, integrate operational contract support personnel into the same education system that trains the operational personnel.

by Maj. Kasandra B. Tharp

Imagine you're a contingency contracting specialist supporting an exercise in the Philippines. Having arrived in the country, you receive a list of requirements from the operational units participating in the exercise and have limited time to get vendors on contract. The requirements that vendors will supply range from basic life support to some that are more mission-specific. In any case, you have a strict time limit to make the mission happen.

So, the requirement for 200 portable toilets at a Philippine exercise range doesn't raise any red flags for you as you execute the process to compete the requirement for quotes. When the unit arrives a week later, however, an issue pops up. These aren't the typical Western portable toilets U.S. personnel might expect to find at U.S. training sites. These are the local version, designed for squatting instead of sitting—clearly a difference between what the planners intended and what the contracting personnel executed.

Over the past decade, with the Army and other service components supporting large-scale contingency operations in Southwest Asia, a distinct disconnect has become evident between operational contract support (OCS) planners and the joint operational planning effort blending contractual support with the services' built-in logistical capabilities. This disconnect surfaces commonly during joint bilateral exercises, where basic contracting principles like defining requirements—not just any kind of portable toilet—are executed poorly because of the lack of OCS perspective.

LOGISTICS AND CONTRACTING GO TOGETHER
Spc. Yulin Ge, a watercraft operator with the 545th Transportation Company, briefs attendees at the Joint Senior Enlisted Logistics Forum, which was held Jan. 31 at Joint Base Pearl Harbor – Hickam, Hawaii, to help enlisted logistics leaders better organize joint capabilities. Including the perspective of operational contracting support personnel into logistics planning and training would make contingency operations and joint exercises run more smoothly, the author argues. (U.S. Army photo by Sgt. 1st Class Michael Behlin, 8th Theater Sustainment Command)

> **The experience of learning with a diverse group of other Soldiers produces better planners.**

Evaluations of contracting over the last 15 years of contingency operations have shown repeated proof of this disconnect. Even up to August 2011, with the release of the final report from the Commission on Wartime Contracting, analysis of contracting operations showed that ill-conceived projects, no matter how well-managed, are wasteful if they do not fit the cultural, political and economic norms of the society they are meant to serve. The report went further, stating that poor planning and oversight repeatedly resulted in costly outcomes and misspent money that could be used for other mission objectives. Clearly, a gap needed to be filled in the contracting

efforts for contingency operations, and the contracting community's answer was OCS.

Since the 2003 invasion of Iraq, and particularly the release of the Gansler Commission report on contracting in October 2007, the Army's OCS planners have improved their understanding of the joint planning process and their proper roles as an integral part of operational planning for all of the services, such as defining requirements and understanding units' needs. However, the various military services' planners have shown no intent to expand the involvement of the operational contracting community in the joint

operational planning process, despite the ongoing requirements for contracting support.

The need for contracting support is likely to persist or to grow, given the Army's current and expanding logistical needs for a wide variety of operations worldwide in different geopolitical environments. For instance, deployed troops continue to receive support through contractual requirements such as the Logistics Civil Augmentation Program (LOGCAP), a program that uses civilian contractors to augment the Army force structure. LOGCAP is currently on its fourth contract, awarded in 2007.

This contracting support is so necessary to operational units that troops actually train to use it. When units go to the National Training Center at Fort Irwin, California, to prepare for a deployment, a LOGCAP contractor is part of the training rotation, replicating the numerous services contractors will provide to the unit in theater. This reliance will continue for as long the military maintains a high operations tempo, allowing little time for planning and increasing the reliance on contractors. This underscores the need to incorporate OCS into the planning community.

CONTRACTING ON THE GROUND
An OCS Soldier in civilian clothes provides final payment to a first-time local Philippine vendor. (Photo by the author)

LOGISTICS MULTIPLIER

Military OCS planners are the Army's best-equipped personnel, based on their training and experience in contracting operations, to identify how to fill gaps between the Army's logistical requirements for products and services and what its supply system can provide. Consequently, it falls to OCS planners to initiate, coordinate and execute the contracts needed to sustain the warfighter.

Typically, they are integrated with the Army's traditional logistics personnel and units, working directly with units in the field to help organize and fill logistical requirements through all phases of an operation. Contracting support personnel do not replace logistics planners; rather, their skills are complementary, and OCS personnel help to streamline the procurement of capabilities from outside the military supply system—like the portable toilets for a joint exercise, in the example above. As a part of the acquisition community, OCS planners are well-versed in compliance with the Federal Acquisition Regulation and Defense Federal Acquisition Regulation Supplement regardless of the operational location.

As critical as contracting is to the success of an operation, OCS planners would logically seem to require the same level of training in the art of operational planning as those service members assigned to other operational branches, such as infantry, armor or logistics. But they are not afforded the same level of training as their operational counterparts.

STOVEPIPED TRAINING

Post-command officers, senior captains and noncommissioned officers E-7 or higher in most of the combat arms and combat support branches have a solid understanding of support to current operations and can identify needs and capabilities based on their experiences. In addition, they receive education to develop their abilities to plan at the operational and strategic levels.

The Army schools that officers attend—the U.S. Army School of Advanced Military Studies, Air University's School of Advanced Air and Space Studies, and Marine Corps University's School of Advanced Warfighting, for example—bring together service members from diverse backgrounds within a narrow array of job fields, to provide them with a broad base of planning knowledge, including new processes and how to integrate the perspectives of various military occupational specialties and branches.

The School of Advanced Military Studies, part of the U.S. Army Command and General Staff College at Fort Leavenworth, Kansas, provides a 10-month course that prepares officers to lead a plans team. The school aims to build innovative, adaptive

IT STARTS WITH EDUCATION
Offering operational contract support personnel training and education similar to the training that their operational counterparts receive would benefit all involved, the author argues: Planners would gain a better understanding of the kind of contract support units will need once on the ground—including how much it will cost and how to write the requirements—and OCS personnel would refine their ability to keep contracting costs down and avoid project missteps. (Photo courtesy of the author)

leaders who excel at operational art and are willing to experiment and accept risk.

The experience of learning with a diverse group of other Soldiers produces better planners. Thus, a graduate of the school, say, an AH-64 Apache pilot subsequently assigned as a brigade S-3, or overall unit planner, knows how to build an operations plan that incorporates the ground-level perspectives of infantry, armor and artillery units along with Army logisticians' perspective on when and where they can provide munitions and fuel. In theory, the S-3's understanding of contracting support comes from having worked and studied with logistics branch officers; in reality, these officers may not possess the contracting knowledge they need to be effective because of a lack of practical experience.

Unfortunately, the School of Advanced Military Studies and similar schools run by other services to develop plans officers are not open to contracting personnel, so contracting personnel may never learn how contract types and requirements can impact operations, positively or negatively, nor appreciate the necessary level of coordination in operational planning.

The only training OCS personnel receive in planning is through the Joint OCS Planning and Execution Course (JOPEC), during which they receive instruction on how to support staff estimates, identify methods to integrate OCS into joint training and exercises, and estimate support requirements to develop plans and orders. Those contracting personnel who receive the JOPEC training are better prepared to participate in joint planning, but they still must rely on the limited operational experience they received

before becoming acquisition personnel. Similar to the operational planning community, they are "stovepiped" within their own specialty and are not developing the skills necessary to work with their operational counterparts.

THE LAST-MINUTE APPROACH

As a practical reality, contracting often ends up being more an instrument to meet last-minute needs for supplies, construction or services than a focus of operations planning. Just as the demand for an item increases its value, this creates problems—inflated prices, unmet requirements, failed projects—in procuring items that are needed immediately. The last-minute approach rarely considers the necessary contract size and scope to fully support an operation.

For example, inadequate planning for equipment—whether light forklifts, heavy cranes or container handlers—to off-load ground vehicles to be used in a mission will likely lead to profound difficulties for the warfighter. By not planning adequately, this materiel may be left sitting on a tarmac, waiting to be moved and essentially useless. In addition, having to hire contractors who are both certified and readily available can exact an unexpectedly high, budget-straining cost.

> **Clearly, a gap needed to be filled in the contracting efforts for contingency operations, and the contracting community's answer was OCS.**

CONCLUSION

In the end, planners across the force must be in sync in order to provide the most effective efforts. The operational contract support planner needs to understand what the warfighter needs. In turn, the warfighter and those who plan their missions need to understand what it takes to clearly define and execute operational requirements.

Only a fundamental change in the culture of operations planning will be sufficient to fix this disconnect, instilling the need

to include the intricacies of contracting in the full spectrum of planning considerations. The goal of this overall culture change should be to create a new generation in the planning community, one prepared to apply a multidisciplinary perspective to the various factors that influence the operational environment.

This cultural transformation can begin with education, specifically at the advanced schools that develop plans personnel. A step in the right direction would be to integrate guest instructors from the School of Advanced Military Studies and JOPEC into the corresponding planning and contracting courses. However, the best, though more costly, solution would be to let OCS personnel attend the School of Advanced Military Studies and its counterparts in the other services, and include contracting as a formal part of the curriculum.

The ultimate objective should be to better integrate OCS personnel into operational environments to implement contracting earlier in the operation, thus avoiding the conflicts arising from last-minute contracting. Finally, advanced military schooling would better prepare operational contracting personnel to provide the services that the planning community requires for the Soldier.

The necessary culture change begins with the education infrastructure that already exists. Attendance at these schools by OCS experienced personnel will be of immense benefit to all students and the planning community at large. If the Army continues its current lack of integration of warfighting and OCS planners, then operational inefficiencies and excessive costs will persist. Proper integration of OCS will result in better-defined requirements, lower costs and improved schedule and performance. Ultimately, enabling the warfighter is why Army contracting exists.

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Dr. Philip Perconti
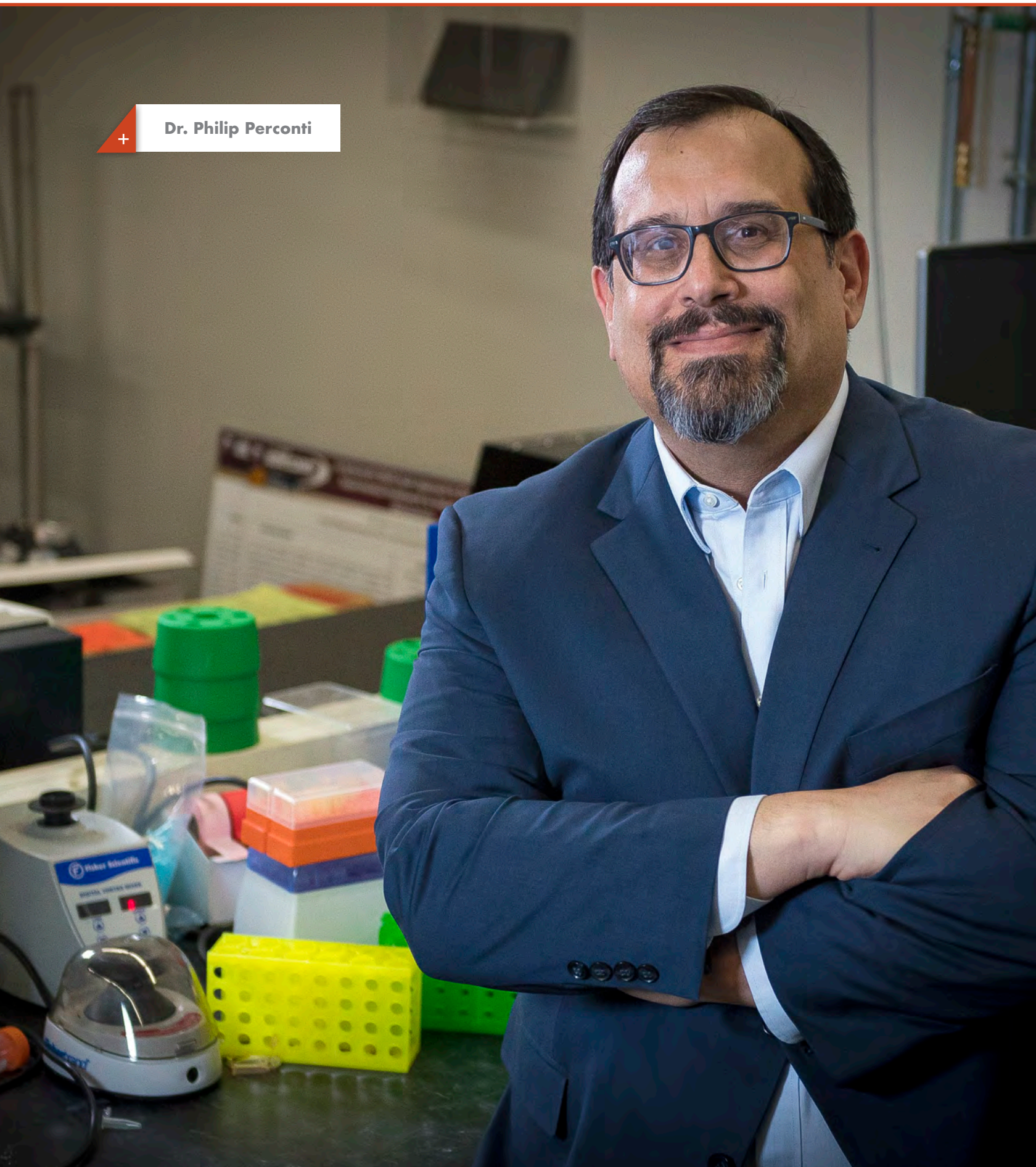
RESEARCH
WITH A
DIFFERENCE

Dr. Philip Perconti leads the Army's "corporate lab" with the intimate involvement of warfighters, businesses, academia and other labs in a high-stakes, high-risk, no-time-to-waste environment focused on finding and developing blockbuster disruptive capabilities.

by Mr. Michael Bold

When Philip Perconti was 8 or 9, he discovered technology in the back of a television. Peeking into the back of his parents' big color TV, he was spellbound by the glowing tubes. "It made me very curious about how things worked," he said.

When the TV stopped working, he discovered how: "I noticed that one tube stopped glowing. My father and I took the tube to the drugstore, put it in the test stand (yup, they had those in drugstores back then), and found that it was defective. We bought the replacement tube, put it back into its slot, turned the TV on, and it worked again! I was hooked."

That hook, and hard work, led him all the way to the directorship of the U.S. Army Research Laboratory, some 45 years later.

After graduating from James Madison High School in Brooklyn, New York, Perconti joined the Navy. After one year in the Navy, Perconti knew he wanted to get a college degree. He not only got his bachelor's, but followed that up with a master's and a doctorate, all in electrical and computer engineering.

Since then, he has spent nearly 30 years working for the Army. "After the Navy, I co-opped with the Army at the night vision lab, and the rest is history," he said. Perconti started

out at the U.S. Army Communications-Electronics Research, Development and Engineering Center's Night Vision and Electronic Sensors Directorate (NVESD), eventually becoming branch chief for imaging technology. In 1996 he became director of the Electronics and Photonics Technology Office at the National Institute of Standards and Technology. He returned to NVESD in 2000 as director of the Science and Technology Division, then moved to ARL in 2013 as director of the Sensors and Electron Devices Directorate before becoming acting director of ARL in April 2016. In June 2017, "acting" was removed from his title.

> **" Technology transfer is truly a contact sport, and it is through a close coordination and collaboration among government, industry and academia that we are able to rapidly accelerate technologies and capabilities to the warfighter. "**

ARL, based in Adelphi, Maryland, is the Army's premier laboratory for basic and applied research and analysis. With primary laboratory sites at Aberdeen Proving Ground, Maryland; Raleigh-Durham, North Carolina; Orlando, Florida; and White Sands Missile Range, New Mexico, as well as dozens of other sites throughout the U.S. and in three other countries (see Figure 1, Page 102), ARL researches weapons and materials, sensors and electron devices, computational and information sciences, human research and engineering, vehicle technology, and survivability and lethality analysis. The laboratory consists of about 2,000 civilian and military employees with an annual budget of over $1 billion.

Among Perconti's accomplishments at ARL are:

- Modifying its use of cooperative research and development agreements (CRADAs). CRADAs allow Army and private sector researchers to set the terms for who does what research, who gets intellectual property rights, and who gets to develop what and for how long, while involving no exchange of funding. The new CRADA model has significantly lowered barriers for cooperation, enabling ARL researchers to more effectively transfer intellectual property to their partners, and has boosted the number of active CRADAs from 20 in 2014 to now more than 400.

- Expanding ARL's Open Campus, begun in 2014 by his predecessor, Dr. Thomas P. Russell, now the deputy assistant secretary of the Army for research and technology. Open Campus was designed to create a science and technology (S&T) ecosystem emphasizing interdependent collaborative research. Under Perconti's leadership, ARL has leveraged more than $70 million in in-kind

contributions for Army-focused research through Open Campus initiatives.

- ARL Extended, with hubs at ARL West, at the University of Southern California; ARL South, at the University of Texas at Austin; ARL Central, at the University of Chicago; and ARL Northeast, at Northeastern University in Boston. ARL has also established CRADAs with regional universities and partners around each hub; ARL, for instance, has one CRADA that covers the entire University of Texas system.

- Development of technology transfer, with small businesses licensing ARL intellectual property.

In an email exchange, Army AL&T asked Dr. Perconti about the future of ARL and its role in the Army.

Army AL&T: Everything we're hearing about Army acquisition is about making it faster and more responsive. How does this new emphasis, along with the Futures Command, change ARL's mission, if at all? Will you have to adjust Army S&T efforts to ensure quick transition of scientific knowledge and development of a rapid prototyping capability?

Perconti: ARL's mission still remains the same. We're the corporate laboratory for the Army, and our mission is discovery, innovation and transition of science and technology knowledge and capabilities that address the Army modernization priorities. We have strategically developed research programs that align with the Army's priorities and are aggressively looking to develop disruptive technologies in those key areas.

The Army vision states the Army will be ready to deploy, fight and win decisively, against any adversary, in a joint,

SHOP TALK

Perconti speaks with Gen. Daniel B. Allyn, then-vice chief of staff of the Army, during Allyn's April 2017 visit to ARL. ARL was established in 1992 to focus on gathering and generating land warfare technologies needed by the Army. With the recent stand-up of the Army Futures Command, ARL will focus on high-risk, high-payoff research to support S&T across the new command and represent its S&T interests worldwide. (U.S. Army Research Laboratory photo)

multidomain, high-intensity conflict, and will maintain its ability to conduct irregular warfare while simultaneously deterring adversaries anytime, anywhere, by 2028; ARL is looking at 2028 and beyond. ARL has a plenoptic view of science and technology: We look at our research through many lenses across time. ARL researchers focus on the future, while simultaneously looking to exploit breakthroughs for nearer-term innovation—for example, to address excessive wear in large-caliber gun tubes.

Recently, ARL connected long-running materials research in tantalum "cold spray" technology with collaborative partners to form the basis for new gun-tube material improvement programs. Tantalum is a high-temperature- and wear-resistant material that provides longer service life and is the only material tested that can

withstand the higher temperatures of advanced propellants. Cold spray is the only technique developed that can apply a tantalum bore coating for large-caliber cannon tubes.

We always look for opportunities to roll out disruptive technologies as they emerge. If we have an S&T breakthrough with the potential to change the way the Army fights and wins our nation's wars, then it is our responsibility to rapidly work to get that innovative technology pushed toward a transition partner. Early-onset partnering is a method ARL uses to quickly transition knowledge, ideas, information and technology. To effectively apply the science and technology ARL develops, it's important to understand the capability gaps and how S&T can be used to meet the need. This is where partnering early with

academia, industry, RDECs [research, development and engineering centers] and innovation hubs becomes crucial in order to develop a comprehensive partnership that is capable of delivering a product from a theoretical concept to a disruptive technology.

Army AL&T: How would you define "disruptive"?

Perconti: Disruptive is a term used to describe a drastic improvement to the way a technology is produced, enhanced or performs. The improvement is so great that it disrupts the linear incremental process in the advancement of a technology.

Army AL&T: In a speech you gave to the Federal Laboratory Consortium in May, you discussed the need for early involvement of the warfighter, academia and industry when developing new capabilities. Talk about that.

Perconti: The problems we face today are way too complex to solve either in isolation or sequentially. Early and intimate collaboration between warfighters, large and small businesses, academia and government labs is a must in the 21st century and a major objective of the Army Futures Command. In the current global environment, we no longer are afforded years of lead time in developing new capabilities for the Army. By bringing all parties together early in a collaborative environment, we can foster and accelerate new concepts, ideas and capabilities through an Army innovation ecosystem focused on delivering new capabilities as quickly as possible.

Army AL&T: ARL needs to respond to immediate needs from the field; to build capabilities needed in the next 10-25 years; and to look to the future for capabilities that will be required 30-50 years from

now. How does the laboratory respond adequately to such a wide-ranging mission, and how does that affect the laboratory's research priorities? How does the lab incorporate new strategic thinking about the way the Army of the future will fight? Talk about the long view versus quick capabilities.

Perconti: As the creators and custodians for the Army's far-term S&T, ARL's mission is to understand and translate cutting-edge science into actionable knowledge that will enable future Army capabilities. Often risk of failure is high in research, because project outcomes are uncertain. However, we learn from every experiment, and we use this knowledge to reduce the uncertainty in S&T options and to identify and quantify technology risk, so that our leadership has the knowledge necessary to make informed decisions.

Army AL&T: Where do you see ARL doing its most important "revolutionary" work in the near term? How about the most important evolutionary developments? Discuss incremental versus disruptive technologies.

Perconti: Disruptive innovation is our sweet spot. We seek to change the way the Army fights and wins our nation's wars by moving trajectories of technologies off the existing path and into new directions with the potential for greater warfighting capability—we want the U.S. Army to own technological surprise.

Take, for example, the Generation II Advanced Combat Helmet fielded to warfighters last spring. It's 22 percent lighter than the legacy Advanced Combat Helmet, based on the use of ultra-high-molecular-weight polyethylene and other materials. ARL developed the manufacturing science for this helmet as part of foundational research with academic and industry partners. ARL is working with its partners—PEO [the Program Executive Office for] Soldier, NSRDEC [the U.S. Army Natick Soldier Research, Development and Engineering Center], industry, academia—on further enhancements in helmet technology to provide greater

protection from ballistic threats and less burden for the warfighter.

Our next disruption will be in Soldier protection systems that use 2D materials, such as graphene and other lightweight materials. ARL researchers are focusing on designing new polymers for superior protection capabilities by unraveling the complex relationship between polymer chemistry, microstructure and energy absorption and, by doing so, increasing the materials' ballistic protection properties to stand up against tougher threats that are certain to be developed by adversaries. If successful, this technology will set the precedent for protection with extremely light weight.

Army AL&T: What role do you see the lab playing in the new Futures Command? Does the work of the new Futures Command influence ARL's funding?

Perconti: ARL was established in 1992 to become a world-class laboratory focused on gathering and generating land warfare technologies needed by the Army. Now,

We look at our research through many lenses across time. ARL researchers focus on the future, while simultaneously looking to exploit breakthroughs for nearer-term innovation.

as the Army Futures Command [AFC] prepares to lead the Army's future force modernization enterprise, ARL will emphasize its role as the Army's corporate research laboratory by strengthening its focus on high-risk, high-payoff research, providing broader support for S&T across AFC, and representing AFC's S&T interests across the worldwide scientific community.

ARL is further refining the way we look at S&T in support of the Army and how to quicken the transfer of knowledge that will lead to increased capabilities. The essential research programs focus our efforts to pursue the Army's vision beyond 2028.

Army AL&T: Part of the Army's efforts to speed acquisition include more collaboration with industry and academia. ARL's Open Campus initiative has been successful in doing this. What can Army acquisition learn from ARL's Open Campus?

A BIGGER BOOM
Researchers from ARL and Washington State University have discovered a new type of energetic material that could triple the energy content of well-known explosives such as the ones pictured here. ARL has discovered that engagement with academic and industry partners at the early stage of development is crucial to technology transition and transfer because it allows the Army to better understand the partner's technology and, in turn, helps the partner to better understand the Army's requirements. (U.S. Army photo)

Perconti: Through Open Campus, ARL has been successful in dramatically increasing the number of partnerships with industry and academia. These partnerships include CRADAs, CAs [cooperative agreements], licensing, joint publishing, joint development of IP [intellectual property], staff exchanges and the sharing of facilities. ARL has discovered that engagement with partners at the early stages of development is crucial to technology transition and transfer. The early engagement allows the Army to understand the partner's technology and manufacturing capabilities while the partner better understands the Army's unique requirements. This early mutual understanding shapes the opportunities for rapid acceleration of capabilities to the Soldier.

Army AL&T: Talk about CRADAs. You've greatly expanded the use of CRADAs at ARL.

Perconti: A cooperative research and development agreement is an agreement between a federal laboratory and a nonfederal party to perform collaborative research and development in any area that is consistent with the federal laboratory's mission. CRADAs are the most frequently used mechanism for formalizing interactions and partnerships between private industry or academia and federal government laboratories.

Under the statute that authorizes CRADAs [15 U.S.C. 3710a], a federal laboratory may provide personnel, services, facilities and equipment, but no funds, to the joint research and development effort. A nonfederal party may provide funds, in addition to personnel, services, facilities and equipment to the joint research and development effort.

ARL uses CRADAs with academic institutions or industry to maximize collaboration, minimize bureaucracy and yield mutual benefit by taking full advantage of our Open Campus efforts. The changing pace of science and technology around the country has necessitated that ARL transform and adapt its business practices and be proactive about identifying game-changing S&T across the country. ARL has stood up business-related efforts to improve business acumen, information technology and strategy management.

Moreover, ARL Extended is ARL's effort to create strong, enduring S&T partnerships by co-locating Army research and development personnel in close collaboration with academia and industry. In this aspect of the Open Campus initiative, ARL Extended leverages regional expertise and facilities to accelerate the discovery, innovation and transition of science and technology. Close collaboration with universities, startups and established companies working in regionally specific technical subject areas will directly benefit the Soldier and ensure our nation's future strength and competitiveness.

Army AL&T: The CRADA that ARL has with Uber sounds fascinating and a little off the beaten track. How is it going to make for quieter aircraft? How did that come about?

WHERE TO NEXT?

ARL researchers used this small unmanned Clearpath Husky robot to develop a new technique to quickly teach robots new behaviors with little human oversight. While having robots interpret commands the same way that humans do is noteworthy, Perconti noted, overmatch would require developing a robot that can anticipate what needs to happen next. (U.S. Army photo)

REDEFINING STEALTH

ARL is collaborating with Uber to develop a quieter rotor system for vertical takeoff and landing vehicles that could improve aeromechanic performance and advance the capabilities of unmanned aircraft systems. The organization has increased its use of CRADAs and other instruments to quickly transition research products to industry, RDECS, PEOs and the requirements community as soon as they show promise. (SOURCE: Defense Advanced Research Projects Agency artist concept)

Perconti: The research from the ARL-Uber collaboration will potentially deliver unprecedented capability for quieter rotor systems in a unique stacked rotor configuration, which involves two rotor systems stacked on top of each other and rotating in the same direction. This rotor concept may enable vertical take-off and landing vehicles to be quieter, while maintaining or improving aeromechanic performance. Partnering was initially conceived when Uber engineers met the Army researchers at the American Helicopter Society Aerospecialist meeting in January 2018 and, soon after, three months of discussions began about a potential collaboration. This is a win-win partnership because Uber is looking for technology to enable its urban transportation (the air taxi, Uber Elevate) and the Army is utilizing connections to Uber and its top industry partners to accelerate enabling silent operations as a capability for the future unmanned aerial vehicle fleet for the Soldier.

Army AL&T: How do we accelerate developing capabilities in electronic warfare, cyber and artificial intelligence (AI)?

Perconti: Future warfare will see a rise in autonomous systems, and the U.S. Army could face a major threat from weaponized autonomous platforms, ranging from human-in-the-loop to full autonomy, that use rules of engagement that are less restrictive than current U.S. policy permits. The future will see the emergence of adversarial AI, which will lead to machine-on-machine warfare that infiltrates human decision-making timelines. Success in this battlefield intelligence race will arise from increasing AI

FIGURE 1
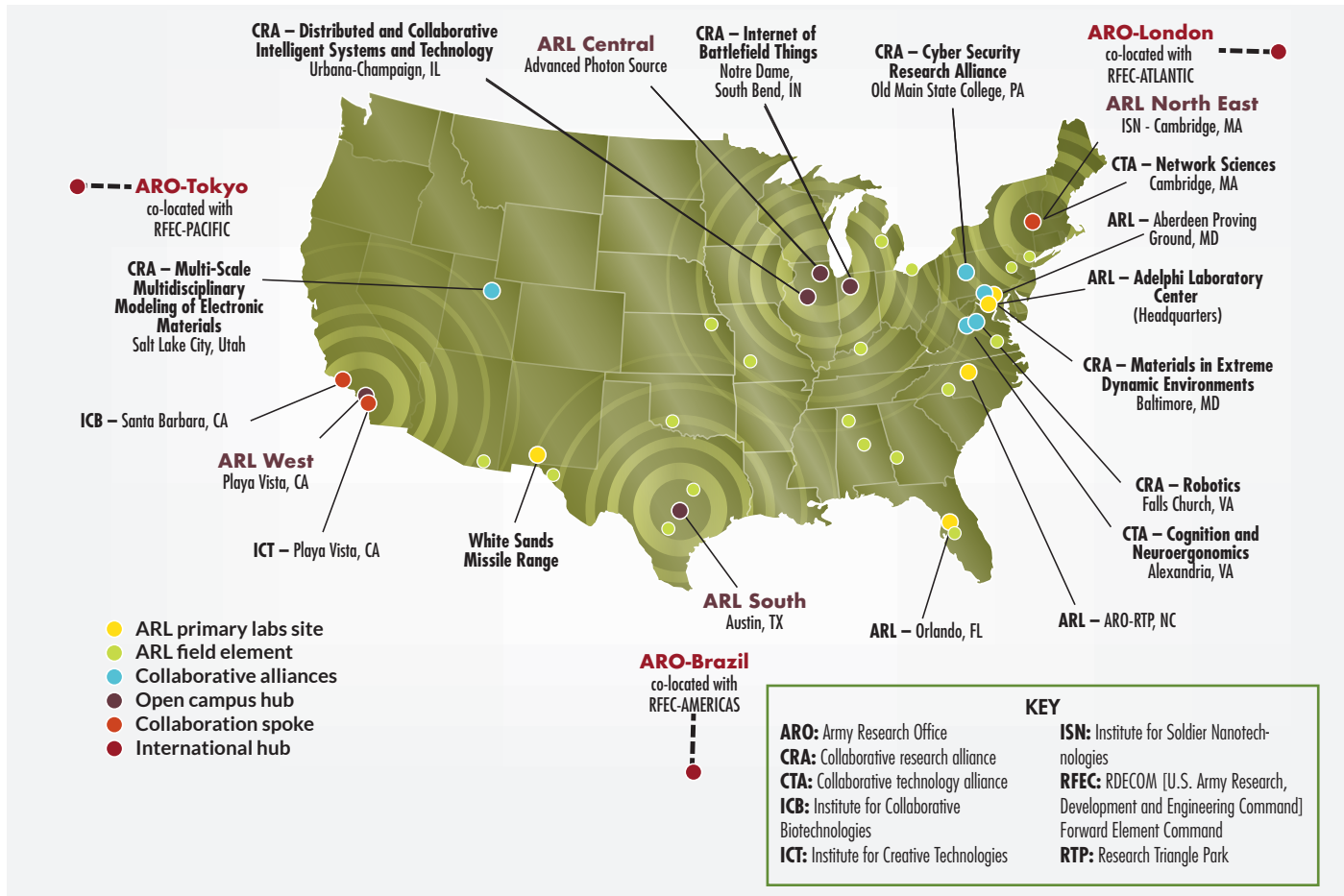
ARL'S WEB

ARL is based in Adelphi, Maryland, with primary laboratory sites at Aberdeen Proving Ground, Maryland; Raleigh-Durham, North Carolina; Orlando, Florida; and White Sands Missile Range, New Mexico, as well as dozens of other sites throughout the U.S. and in three other countries. Its efforts include collaborative research alliances (CRAs), collaborative technology alliances (CTAs) and other collaboration research entities, such as the Institute for Collaborative Biotechnologies (ICB) and the Institute for Creative Technologies (ICT). (SOURCE: ARL)

capabilities as well as uncovering unique and effective ways to merge AI with Soldier knowledge and intelligence.

In particular, ARL's efforts in human-agent teaming look at both how humans—Soldiers—interact with agents—robotic entities—and how those agents can be used to interact with humans. Part of that interaction involves developing an understanding of how humans communicate with robots and vice versa. The ability to have robots interpret commands the same way that humans

interpret them is huge, but a game-changing technology would be having the robot anticipate what needs to happen next. This level of adaptive behavior will provide an overmatch capability in this battlefield space.

The Army requires adaptive AI—AI that will learn with little or no supervision using small data sets collected organically, that will quickly and easily adapt to new tasks that will provide context

and understanding in unstructured environments, and will defeat attacks from adversarial machines.

The U.S. Army AI Innovation Institute [A2I2, which will officially start in 2020] seeks to rapidly advance adaptive AI capabilities to enable fully autonomous maneuver. Adaptive AI will provide our warfighters with *coup d'oeil*—the ability to recognize with one glance the tactical advantages and disadvantages on the battle-field using a heterogeneous mix of unmanned ground and aerial platforms that rapidly learn, adapt and reason faster than the adversary in a complex environment.

ARL also sees an important connection between AI and cyber and electronic warfare (EW), because effective conduct of cyber and EW battle is becoming increasingly difficult without AI-based intelligent agents. ARL executes research in developing such intelligent agents. These would assist Soldiers in defensive and offensive tasks that often unfold in fractions of a second, too fast for a human cognitive cycle.

Army AL&T: What is technology transfer, and why is it important?

Perconti: Technology transfer at ARL is the process by which existing knowledge, facilities or capabilities developed under federal R&D [research and development] funding are used to fulfill public and private needs. Every year, millions of taxpayer dollars go into funding research and development, with the intent to have a return on investment and move innovations from the laboratory to the hands of the Soldier or the commercial marketplace. Technology transfer from ARL spurs the genera-tion of small business startups or spinoffs. Technology transfer may also spin in viable technologies that meet the warfighters' requirements.

Technology transfer is truly a contact sport, and it is through a close coordination and collaboration among government, industry and academia that we are able to rapidly accelerate technologies and capabilities to the warfighter. From the start of the Open Campus initiative and through the advent of the Army Futures Command, ARL embraces an agile and entre-preneurial mindset to be expeditious in transition of research products to RDECs, industry, PMs [program managers] and PEOs, and the requirements community as soon as they show promise. With this in mind, we are aligned and ready to support AFC and the cross-functional teams in the pursuit of mid- and far-term capabilities.

> **"The problems we face today are way too complex to solve either in isolation or sequentially. Early and intimate collaboration between warfighters, large and small businesses, academia and government labs is a must in the 21st century."**

Army AL&T: Talk about academic entrepreneurship. Why is it important?

Perconti: Academic entrepreneurship is a major force in the U.S. economy. A large fraction of U.S. startups, including those that resulted in creation of some of the world's largest corporations, originated at universities, inspired by academic research results and started by professors and students who saw a business opportunity in the research. The U.S. Army S&T enterprise, including ARL, seeks to make greater use of this major intellectual and economic force. This can be—and is already being—done in a number of ways. Army scientists and engineers often work with academic entrepreneurs, both before and after the creation of a new business, thereby benefit-ing from ideas and research that underpin a budding company. Furthermore, collaborative research between academic entre-preneurs and ARL can result in novel ideas that the academic entrepreneurs translate into tangible products. These, in turn, may contribute to the security needs of the United States.

For more information, go to the ARL website at **https://www.arl.army.mil/**.

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SEE THE UNOBVIOUS

Modeling and simulation is a PM's friend.

by John T. Dillard, Col., USA (Ret.)

EXPANDING HORIZONS
Spc. Olivia Silver, assigned to 1st Armored Brigade Combat Team, 1st Cavalry Division, scans for targets at the Gunfighter Gymnasium shooting simulation drill during the 2018 European Best Warrior Competition at Grafenwoehr, Germany, in August. (U.S. Army photo by Kevin S. Abel, 7th Army Training Command)

One thing I always felt pretty confident about during my acquisition career was the ability to see the obvious. That may not sound like much, but believe it or not, you'll encounter a lot of people who don't have this skill. However, seeing the unobvious … Ah, now that was the ability of only clairvoyants and psychics, I thought.

But guess what: The right investment by the program manager (PM) in modeling and simulation (M&S) can help you do just that. How can this be? After all, the primary weakness of all models is the same as their strength—simplicity.

Seems a real balancing act. Philosopher William of Ockham (see Ockham's Razor, or Occam's Razor) advised us to keep things as simple as we can. Einstein voiced the same caveat with, "Things should be as simple as possible, but no simpler." It was mathematician Norbert Wiener who said, "The best model of a cat is another, or preferably the same, cat," while statistician George Box advised, "Essentially all models are wrong, but some are useful."

These fellows weren't telling us not to model or simulate. They were simply warning us against excessive elaboration or build-out when modeling or simulating a product or system, since no system can be exactly represented by a simpler model.

So, how can a model that is not too complex and not too simple give us additional information we need to make technical or financial decisions?

I'll provide some examples. But you should know upfront that modeling and simulation can support you in your management decisions through all phases of the acquisition life cycle. In the main, M&S will likely do this by reducing your sample size

of test articles, saving you money, as well as providing early discovery of technical anomalies. And yes, just like the modeling and simulation evangelists tell us, M&S will help you reduce time and risk as well, while increasing the quality and readiness of the fielded system.

Those are the expected payoffs to your investment. Still have some doubts? I don't blame you.

If done right, it's going to help you see the unobvious before disaster strikes—and save you time and money as well.

QUANTIFYING THE UNKNOWNS

There are any number of models across various knowledge domains: cost or financial models, models for spare parts and usage of consumables and, of course, the technical components of your developing system. Focusing herein mostly on the latter, it often became apparent to me how many "unknown unknowns" were always lurking out there during any particular phase of development.

It is often said that complexity is best defined as many, different, interconnected parts and their interactions. A key component of complexity is the uncertainty of those interactions, and that's where modeling and simulation gives us a hand. If we build our models right, with just enough

granularity or detail, these efforts can actually save us from some misery.

We're probably all familiar with flight simulators, helping to train pilots in the operation of their systems. But along the development path, we have no finished system to emulate or simulate. So that's when the benefit of M&S can seem a little vague. And when you're having trouble achieving some key performance parameter, the last thing you want to hear is that

more research, development, test and engineering (RDT&E) money is needed for some model when you know that even the actual system probably doesn't have enough funding. We have to see our investment in M&S as a risk-handling technique, since the worst we can do is proceed into uncertainty with a ready-fire-aim approach.

For example, during development of the Javelin anti-tank missile, engineers were uncertain as to whether the early design of the gimbaled seeker (the rotating assembly up front of the missile that "sees" the target) would be able to hold on to the target view throughout its climbing and diving flight pattern for autonomous top attack. Using a scale model of the eventual missile's front end, the engineers literally

BACK TO THE DRAWING BOARD
Originally the outer breakwater of Dubai's Palm Jumeirah Island was designed as a continuous barrier. But this prevented natural tidal movement, and the seawater within the crescent breakwater became stagnant. A 2009 retrofit created gaps on the sides of the breakwater, connected by bridges, that allowed tidal movement to oxygenate the water and prevent stagnation. (SOURCE: Getty Images)

mounted a gimbaled seeker contraption on the skids of a helicopter and flew a simulated path to determine whether there were enough degrees of freedom for the seeker's movement.

It might have been an extra expenditure of funds not anticipated. But it was the best approach before having a finished missile to integrate, allowing the project team to go forward with design of other components.

And during the downrange initial operational test of the Army Tactical Missile System, when the very first of only 15 missiles to be fired didn't hit the target and was scored a failure, it was our "hardware-in-the-loop" software model back at Redstone Arsenal, Alabama, that told us it flew right where it was supposed to—but had the wrong targeting data for the gunners to input.

History is replete with examples of people who failed to adequately model before they began construction, including the Tacoma

Narrows Bridge collapse of 1940 (unexpectedly swaying wildly in the wind and recorded on film), and the retrofitting of Dubai's Palm Jumeirah Island in 2009, with breakwater crescent openings (a bit of an afterthought) to prevent internal water stagnation. The problem is no different with weapon systems.

M&S THROUGH THE WICKETS
During the materiel solutions analysis phase of the acquisition process, it's common for PMs to invest in force-on-force modeling to predict combat value using key performance parameters of the new system. Other concept studies include such modeling to aid the analysis of alternatives effort.

Later on, during technology maturation and risk reduction, our prototypes will be early design models to demonstrate technology readiness levels and reduce risk by means of technical and operational discoveries during simulations. M&S efforts during both of these phases inform us as well as the user community.

With uncertainty resolving over time, we enter the engineering and manufacturing development phase, where M&S investments are still required as we learn more about our more mature "engineering design models." Computer-assisted design and manufacturing are invaluable as we refine requirements and design while using developmental testing to validate maturing models. These operational models also help us better realize the logistical support plans that previously had been conceptual.

At this point there is likely a divergence of models: the real-world mission kind (test articles) that can fly, roll or swim throughout the multidomain battlefield, and the hardware (and software)-in-the-loop models. The latter are typically being run within computers to predict performance in a huge variety of conditions and scenarios via Monte Carlo simulations (multivariate probability distributions).

Both serve to inform project stakeholders, especially you, the PM. Often, we have to cut a deal with the operational testers to let us use something less than a full-up system for destructive testing. No sense firing a .50-caliber machine gun at a nuclear submarine—just use a panel (skin) from the side of one. (Sound crazy? Just read the account in "The Pentagon Wars" of the time some folks wanted to fire a tank main gun round at a combat-loaded Bradley Fighting Vehicle, just to see what would happen.) PMs must negotiate the use of models instead, to reduce the costs of test articles.

SAVE THE BACON

Another bacon-saving episode—in this case, in the evolution of the Javelin missile project—was an engineering and manufacturing development field simulation that we felt would probably be more to satisfy bureaucrats' demands than to learn anything new about our system. How wrong we were! With immature models and prototypical hardware and software, we found out unequivocally that our FLIR (forward-looking infrared) sensor sensitivity specification was validated—and there would thus be zero room for design trades on that aspect of the system.

With the production and deployment phase drawing near, and as stereolithography technology is advancing now to 3D printing, output models will still be used to prove out production planning and manufacturing processes using factory simulations. Low-rate initial production test articles will no longer be models, but production-representative—the real thing. And, as with the example above of the Army Tactical Missile System initial operational test and evaluation, M&S can still save the day by revising the test score as successful that was initially thought to be a failure. In that same three-month major operational test event on the very eve of system deployment to the Persian Gulf War, we were able to use over 1,000 simulated fire missions, done solely by computer model, to convince testers and other stakeholders to support the full-rate production decision.

Of course, during the operations and support phase we will be getting user feedback to help us elaborate evolving ideas for more capability through modifications, tech insertion and so on. Here again,
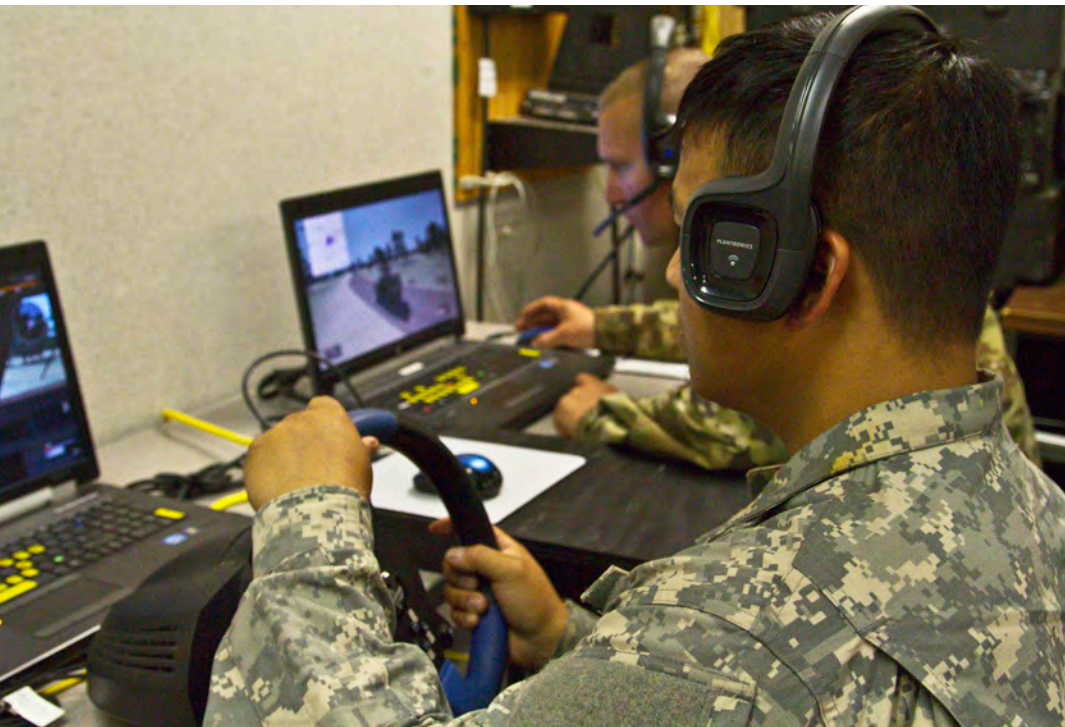
TRAIN HERE FIRST

Soldiers practice convoy operations on virtual battlespace simulators. Training simulators go hand in hand with rigorous modeling as tools supporting the optimal design and use of warfighting systems, especially if the number of actual systems available to train is limited. (U.S. Army photo by Staff Sgt. Anaidy G. Claudio, 368th Public Affairs Detachment)

Just like the modeling and simulation evangelists tell us, M&S will help you reduce time and risk.

READY AT LAUNCH TIME

Sgt. Nicholas Maxim, acting as a member of the opposing force, builds and launches a simulated drone swarm during Exercise Dynamic Front 18 at the Joint Multinational Simulation Center, Grafenwoehr, Germany, in March. The right investments in modeling and simulation can save program managers money and time by turning up anomalies and problems early. (U.S. Army photo by Staff Sgt. Kathleen V. Polanco, 7th Army Training Command)

logistical support tracking, reliability, failure modes and corrective analysis will be accomplished by rigorous configuration management, at the heart of which are recorded design drawings that model the actual thing being in the hands of users. And, of course, the training simulators are the devices we have developed in parallel to help users gain proficiency before actual use.

CONCLUSION

So, without having to read a bunch of training material with boring terminology extolling the values of simulation-based acquisition, you have here what I hope is a convincing argument to make the investment when that open hand comes to you for M&S money. If done right, it's going to help you see the unobvious before disaster strikes—and save you time and money as well. M&S will do that principally by making it possible to reduce test article sample size and discover anomalies early. I guarantee it.

It also falls upon you to continue beyond the initial investment throughout the life cycle and keep elaborating your model of the actual system. How much you are able to apportion to whom will be a difficult trade, as there never seems to be enough RDT&E money to go around, even for the actual system effort underway. How thoroughly to build out your model will also be a tough financial and technical trade. This is the stuff management is made of—having to make those decisions about resource allocation, not knowing how much they're going to pay off. Your systems engineers and other technical folks can help here.

But make no mistake—if accomplished to the right degree, M&S will make it possible to tease out things to furnish the information you need. It might just save the day.

For more information, email the author at **_jdillard@nps.edu_**.

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HOW MUCH TO TEST?
The recently developed Armored Multi-Purpose Vehicle, shown here undergoing testing at Yuma Proving Ground, Arizona, has nearly 80 percent more interior volume than the predecessor vehicle, and more power and survivability. The vehicle's project manager is assessing how much contractor test data can replace government tests, which sometimes repeat the tests conducted by the manufacturer. (Photo by Mark Schauer, Yuma Proving Ground)

SHIFT LEFT

Coordinated contractor testing can help accelerate the acquisition process and improve the quality of equipment and programs.

by Mr. Harry H. Jenkins III

Test and evaluation (T&E) is a perennial target of criticism for the time and cost it adds to acquisition programs. But there are ways to minimize this impact. One way is to use contractor-generated test data.

As the acquisition community strives to "shift left"—to accelerate acquisition timelines and thus support earlier decision-making—the use of data derived from contractor testing could be more efficient, save on testing costs and speed fielding of equipment. The project manager (PM) for the Armored Multi-Purpose Vehicle (AMPV), the replacement for the M113 family of vehicles, is exploring the use of contractor testing and its impact on the acquisition process, especially when resources are constrained.

Typically, contractors test an article in accordance with their own test plan to determine broadly whether their design meets intended requirements. This testing is done in isolation with minimal input from the government, generally at the contractor's own facilities. Contractual language added to the statement of work created the conditions for the AMPV contractor to successfully demonstrate the required performance specifications and for the government to obtain valid data to support the evaluation in one test, versus separate tests, saving time and money. The key is for the government and the contractor to share a common cause with the testing, creating advantages for each.

The PM AMPV's effort dates to June 2016, when it described not only how the program office would be conducting contractor-driven developmental and reliability testing, but also the potential for the U.S. Army Test and Evaluation Command (ATEC) to use these test data for evaluation purposes.

PM AMPV's 2016 briefing on the subject gave rise to a white paper, coordinated between the Program Executive Office for Ground Combat Systems (PEO GCS), the PM's parent organization, and ATEC and in collaboration with the Office of the Deputy Assistant Secretary of Defense for Developmental Test and Evaluation. The white paper explored approaches, guidelines, procedures and other considerations that would promote the acceptance of contractor test data to support ATEC evaluation efforts.

Contractor developmental and reliability testing became part of the T&E program for the AMPV in its approved milestone B test and evaluation master plan. BAE Systems developed a detailed plan for its testing, which addressed design, engineering and production of the AMPV. The contractor test, conducted at the U.S. Army Aberdeen Test Center at Aberdeen Proving Ground, Maryland, was a two- to three-month test for each vehicle variant to "shake them down" and discover any design, quality and manufacturing issues early in the program. The contractor test design was to use government test facilities and government testers. It followed internationally accepted test operating procedures and the AMPV system's operational mode summary and mission profile.

The operational mode summary and mission profile describe the test conditions in which the vehicle is to operate and the amount of time that critical pieces of equipment are operational during the mission. For example, the AMPV general purpose vehicle must operate in conditions comprising 34 percent primary road surfaces, 38 percent secondary and 28 percent cross-country and hilly cross-country road surfaces. In a given combat day, the vehicle's mission command equipment will operate for 22 hours, its primary

weapon will fire 387 rounds and its engine operate for 21 hours.

Combining this detailed information on operations tempo with the use of government test facilities, testers and test procedures has enabled the contractor to support the design and development of the

> **In short, bad news does not get better with time. It is always best to test in a robust, realistic way to identify failures early.**

system. For the government, it provides the opportunity to use contractor test data to augment planned government testing, thus enhancing sample size, allowing for longer testing and broadening performance measurements.

A WIN-WIN EQUATION
It is essential to the success of test planning using this expanded approach to create advantageous conditions for both the contractor and the government. This calls for contractually providing both the

PM and ATEC the opportunity to review and comment on the contractor test plan so that they can shape it to fulfill the evaluation needs of the T&E community. The contractor wants to ensure that its equipment meets established performance specifications. The evaluator needs this verification to be performed a certain way for statistical validity.

There are additional conditions to be set in ATEC's system evaluation plan as well, namely the T&E planning, execution and reporting guidelines to follow in order for ATEC to accept any program data provided by a contractor. For AMPV, this data covered primarily the areas of automotive performance, suitability and survivability, as the system has no offensive weapons.

The test planning also has to address where and how the testing is to be performed, under what conditions and for what duration (as described in the operational mode summary and mission profile), and how the data is to be collected and reported, among other factors. (See "Clear and Common Expectations," Page 113.)

Presenting, addressing and approving the concept of the government using contractor data in the program's approved test and evaluation master plan allows the necessary acceptance by T&E stakeholders. For developmental testing, the stakeholders are the PM, the Office of the Deputy Assistant Secretary of Defense for Developmental Test and Evaluation, the Department of the Army, the Office of the Deputy Undersecretary of the Army for Test and Evaluation and ATEC.

The contractor test planning must address issues identified in ATEC's system evaluation plan to justify reducing the government's testing.

Contractually, the PM needs to ensure that the request for proposal and the subsequent contract describe the government's expectations for conducting contractor testing and using contractor data. The contract must allow for review and approval of contractor test plans to enable the government to provide proper guidance.

The government uses various verification techniques (e.g., test, demonstration, inspection and analysis) to ensure that the systems or items being acquired meet performance requirements and the user's needs. The type of verification techniques and the amount of T&E needed should be part of a contractor test plan. The government must ensure that proper procedures are part of the requirements verification portion.

The contract also needs to address an ATEC inspection of any nongovernment test facilities and ATEC monitoring of test execution. ATEC needs to observe contractor testing to ensure that the system operates in the manner that Soldiers will use it.

Contractor testing typically takes two forms. One form involves the contractors testing their systems in a stressing manner that can induce failures, thus causing contractors to resist sharing their test data. The other involves the contractors treating their equipment with kid gloves because they are afraid to break it. These concerns can make the contractor reluctant to release test results to the government that show multiple failures.

Then, when the system enters government testing, which replicates how the Soldier will use the system, testing uncovers a higher number of failures. This leads to delays to make time for redesigns, manufacturing and testing to ensure contractual

CLEAR AND COMMON EXPECTATIONS

Let's say a fuel efficiency test requires operating a vehicle for three hours at a stable speed, on a defined road course, using defined driver procedures. During the test, a tire fails. Clearly, the test must stop to replace the tire.

However, conflicts can arise when trying to restart the test. One agency may want to change the procedure to gather more information about why the tire failed and choose not to complete the efficiency test. Another agency may want to restart the test from the beginning to ensure that it can gather the fuel efficiency data (even though a tire may fail again before completion).

To combine contractor test data with government test data, several fundamental criteria must match: decision support, the data, test procedures, test execution, reporting and test article configuration.

Decision support—Tests are planned for different reasons. Testing by the contractor supports its design, engineering and production decisions (adequacy of drawings, accuracy of output, quality, design performance, reliability, etc.), whereas government testing supports assessment ratings to meet requirements and satisfy mission capability, while also supporting risk assessments of the factors the contractor used to support its test decisions.

Combined testing from the two sources must support both organizations' decision-making. The contractor's decisions weigh the cost and benefit to its bottom line, which means it may benefit the contractor not to address or correct deficiencies, based on the cost. The government's decision-making is based on a separate analysis of cost and benefit, weighing additional factors such as mission effect, attrition of equipment and loss of life.

Data—Data are defined by format, measurement, collection and system-unique requirements. To combine two sources, procedures must ensure that all four factors match and that the instrumentation can collect all data needed. This data authentication process should be relatively easy to establish: Set a standard for data and instrumentation that both agencies will use.

Test plans and procedures—Users of the data (for the AMPV, BAE Systems and, for the government, ATEC and PM AMPV) all should agree on a common test procedure and execution. Each agency has

an objective to accomplish, and the test plans are tailored to meet the data and decision-making needs of all users. A single planning procedure is necessary to ensure that all decisions and data can be combined as well, so as not to mix apples and oranges. Procedures must also incorporate the decision-making process to account for test outcomes that will require modifying future steps in the test process.

Test execution—Both agencies must agree in advance what they will do while executing the testing and, most important, what they will do when testing reveals something unexpected (higher- or lower-than-expected performance, or a failure). For example, the vendor may want to demonstrate a capability such as top speed, whereas the government wants statistical assurance of the same metric, which may require more samples. Additionally, the government may want to look at the top speed as the system gets older to see how time and usage affect this capability.

Reporting—Reporting could be one of the easiest aspects to combine between organizations. But again, how data support the parties' decisions may tailor the reporting of findings. It is possible that test planning does not have to address reporting at all, as long as there is agreement between both agencies. How is the information shared, for example? Is a formal report required, or is a briefing chart sufficient? A spreadsheet with results, or a database?

Test article configuration—This aspect should also be easy to combine. However, the reality is that configuration can change based on how the data support decisions. In particular, it may be desirable to change the configuration for design and engineering purposes, but to keep it stable or fixed for requirements and mission capability assessment.

Take software updates, a frequent example. There should be a plan as to when updates will occur. If testing reveals the need for an unplanned software update, the teams must come together to determine when to insert it into the schedule and how this unplanned "fix" impacts testing: Does it need to start from zero, or can it continue from the cut-in point? If the update adds capability, what is the impact on evaluation of the system?

—MR. HARRY H. JENKINS III

compliance. Depending on the technology's maturity—the technology readiness level—high failure rates may be acceptable. But if the technology readiness level is high (e.g., greater than 6 on the standard DOD readiness scale of 1 to 9), then high failure rates could indicate poor quality or design.

In short, bad news does not get better with time. It is always best to test in a robust, realistic way to identify failures early, providing time for correction if necessary, rather than hiding them by testing in unrealistic ways that pamper the system. Well-designed systems can operate as intended and do not induce delays in testing, thus satisfying requirements and saving test time and money.

KEEPING IT REAL

All parties involved must become comfortable with the risks of realistic testing. Contractors need to overcome the resistance to share data that may be critical of their design, as this early feedback is exactly what the Army T&E community needs. The Army needs to be receptive to early discovery of issues and provide feedback to the contractor to mature the product and achieve the desired end state. Early discovery minimizes the expense of corrective actions or design changes to mature a concept.

The PM and ATEC can accept contractor data from nongovernment test facilities, but no single approved process, policy or overall guidance exists to fit every testing scenario. Audits of test sites and reviews of testing procedures and reporting requirements are necessary to assess each scenario on a case-by-case basis. In some cases in which test data already exist, ATEC will need to assess the pedigree of the data.

Combining government and contractor testing is also important in supporting

reliability growth, the maturation of a system to achieve optimum reliability over its expected operating lifetime. Testing to the expected life of a system can identify "infant mortality," or failures that occur very early in the life of a system and are associated with design shortcomings; steady-state failures, which occur randomly following the infant mortality phase; and wear-out failures, which come at the end of the life cycle.

CONCLUSION

For AMPV, delays in contractor delivery significantly impacted the scheduled test execution. But because of the efforts of the T&E integrated product team in planning the contractor testing, the government was able to simply redesignate the executed contractor testing as government testing and saved several months of schedule, preventing a milestone slippage. Had this planning and these actions not taken place, it was unlikely that the program would have maintained the planned milestone schedule.

The bottom line is that use of contractor data to address test and evaluation requirements for acquisition programs is possible, but it will require cooperation and planning by the acquisition and T&E communities. The T&E community needs more than an agreement about the testing and data. What is needed is an agreed-to process to resolve questions and answers such as in the accompanying example quickly and easily.

In such cases, the T&E community will have to face the reality that its test, although combined with that of a contractor to reduce redundancy, must actually expand in scope to deal with the problems identified. Contractor testing ends up adding things the contractor normally would not do, but the overall benefit is the potential to reduce government testing on the back end. Also, additional testing may be required to determine if a solution was addressed effectively. This acceptance is key when combined testing is necessary for the sake of overall test or schedule reductions and efficiency.

Lastly, the test community must recognize that a combined test may gather more information, with greater cost or scope, than either of the two individually planned tests, as it is collecting data for two agencies. Nonetheless, the test can still reduce overall redundancy and create efficiency compared with two completely separate tests.

With the constant goal of streamlined acquisition and exercising better buying power, the use of contractor testing, with appropriate organizational coordination and planning, is a best practice to adopt.

As the acquisition community strives to "shift left"— to accelerate acquisition timelines—the use of data derived from contractor testing could be more efficient, save on testing costs and speed fielding of equipment.

*For more information, contact the author at 443-861-9608 or DSN: 848-9608; or at **harry.h.jenkins2.civ@mail.mil**.*

DISCLAIMER

While this paper was coordinated with PEO GCS, the views expressed herein are solely those of the author, and do not necessarily reflect the views of PEO GCS, the U.S. Army Test and Evaluation Command or the U.S. Army or the Department of Defense.

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DON'T JUST HEAR—
LISTEN

B. DEAN ANGELL

COMMAND/ORGANIZATION: U.S. Army Mission and Installation Contracting Command

TITLE: Cost and price analyst

YEARS OF SERVICE IN WORKFORCE: 8

YEARS OF MILITARY SERVICE: 13 (eight in the Army and five in the U.S. Marine Corps)

DAWIA CERTIFICATIONS: Level III in contracting; Level I in program management; Federal Acquisition Certification – Contracting, Level II

EDUCATION: Ph.D. in business administration, Capella University; MBA, Bellevue University; B.S. in business administration, San Diego State University

AWARDS: U.S. Army Contracting Command Cost/Price Analyst of the Year; Army Commendation Medal (2); Army Achievement Medal (2); National Defense Service Ribbon; Army Overseas Service Ribbon; Commandant's Award; Navy Achievement Medal; Navy Good Conduct Medal; Navy and Marine Corps Overseas Medal

When Dean Angell says that any person in the 1102 job series, contracting, should be proficient in all areas of the series, he's speaking from experience. Over the course of a career that spans four decades, he has served as a contract specialist, contracting officer, procurement analyst, cost and price analyst and supervisory contract specialist. He has been a Marine and a Soldier, worked for NASA and the Air Force, started and sold one private sector company and worked for another, and, in his spare time, he's a college professor.

"It's a good thing that I love challenging work, because there is plenty of it here," he said. "Here" is Procurement Operations within the headquarters of the U.S. Army Mission and Installation Contracting Command (MICC) at Joint Base San Antonio – Fort Sam Houston, Texas, where Angell is one of two senior cost and price analysts. "We review the actions that have the highest dollar value, are the most complicated and have the highest command interest. To make sure these actions are executed properly, we review enormous amounts of documents and research and correctly interpret laws, regulations, rules and policy. Fortunately, there are some very smart people in MICC, and in Procurement Operations in particular. Assistance is just a cubicle away."

Angell recently led the cost and pricing team on a $4.7 billion contract to provide rotary-wing aviation maintenance services at Fort Rucker, Alabama, in support of the U.S. Army Aviation Center of Excellence. DOD's review of the contract, which Angell noted will save the Army more than $164 million over the previous contract, found many of the team's procurement approaches to be best practices and recommended they be adopted for future procurements.

The $4.7 billion award was complicated and had "very high command interest," said Angell. "The customer wasn't pleased with the service or performance of the previous contract. We met with them many times, over the phone and in person, and toured their facilities. We let the customer describe the requirement—what they needed, what they wanted, what their superiors expected, what their customers expected and why. They explained what was good and bad with the current contract, and would work best to motivate the contractor to produce the desired results that would provide the best value to the Army." When the team began discussions with offerors, the customer described to the MICC team how each offer could or could not help or how it could be improved. "By not just hearing, but listening, we were able to finally execute a contract with terms and conditions that both the

WINNING TEAM
Angell, third from left, stands with his team from Procurement Operations within MICC Headquarters at Joint Base San Antonio – Fort Sam Houston. From left are Raul Guerra; Division Chief Lorraine Massie; Karl Fischer; Karen Edwards; and Dev Gokool. Not pictured are Cynthia Borlinghaus and Johnny Castro. (U.S. Army photo by Ryan Mattox, MICC Public Affairs)

customer and contractor like, with a lower price and higher performance standards than the previous contract."

For Angell, the effort reinforced his belief in the importance of communication. "One of the most important lessons a person can learn—and possibly one of the most difficult to master—is in communication: Don't just hear, listen," he said. "When others are communicating, don't just think about what you are going to say or how you are going to respond. You can learn so much when you finally listen to what people say—and what they don't say."

It wasn't the first time he had learned the lesson. "Many years ago when I was a new contract specialist, I was assigned my first multimillion-dollar acquisition. After I received the purchase request and requirements documents, I contacted the customer to introduce myself. He fired back an email to me and the director of contracting that started out with

'Whenever I have to work with contracting, I just cringe,' and it got worse from there." But by meeting with the customer and listening to what he needed, Angell outlined an approach that met all of the customer's demands.

Angell's federal service started in 1981 when he enlisted in the Marine Corps. After five years as an infantryman, he enrolled in college and joined the Army ROTC program. He was commissioned in the Signal Corps and served for eight years. Angell had a hand in contracting while in the private sector, serving as the final decision authority for local contracts for a cable company and submitting proposals through a print distribution company he and his wife founded.

After selling the company, Angell accepted a developmental position with MICC at Fort Lee, Virginia. He left briefly for opportunities at NASA's Marshall Space Flight Center in Alabama, and Laughlin

Air Force Base, Texas, and rejoined MICC in 2016. He's quick to note that his successes there are largely because of the mentorship and leadership he has received. "It's not practical to mention everyone," he said, "but two people have proven to be superior leaders and mentors for me: Lorraine Massie, Procurement Operations division chief, and Dean Carsello, the contracting officer for the $4.7 billion aviation maintenance acquisition."

When he's not at work, you can find Angell in a classroom—real or virtual—where he teaches MBA students at Bellevue University, based in Bellevue, Nebraska, and Norwich University, in Northfield, Vermont. While Angell was earning his MBA at Bellevue, he struck up a professional relationship with Dr. David Levy, one of his professors who was also the MBA program director. Four years later, when Angell earned his doctorate, Levy offered him an adjunct professor position.

"Every time I teach a class, regardless of the subject, I learn something new," Angell said. He's applying what he learned to MICC, developing online courses in contracting and cost and pricing for analysts and contracting officers. "It's a force multiplier. We can reach more people across the command and provide training cost-effectively," he said. He sees the possibility for scaling the classes beyond MICC, a subordinate command of the U.S. Army Contracting Command (ACC). Angell uses Blackboard, a commonly available platform that's also used by Defense Acquisition University, to develop and conduct his classes. "It's simple to build and navigate, it's portable and it would be easy for other organizations within ACC to take what we've developed and customize it."

—*MS. SUSAN L. FOLLETT*

FORECASTING
SUCCESS

A vigorous talent management strategy keeps the acquisition workforce prepared to tackle future threats.

Predicting the future: It's one of Army leadership's most difficult tasks. But we can't always be a reactive force. Nor can we just defend the nation against current threats. We have to be prepared to defend against future threats. We can't wait. We must be proactive.

One of the ways we work proactively is by managing our talent. We've often talked about career development as having the right person in the right place in the right job at the right time. Succession planning is another way of describing successful talent management.

A strategy that focuses on what type of talent we need within the Army Acquisition Workforce allows us to be synchronized and integrated across, up and down the chain, and across multiple commands. Initiatives focused on talent management allow us to have implementation plans and activities that filter down and are coordinated with individual acquisition commands and organizations.

Talent management initiatives created with the participation of stakeholders and partners across the enterprise help the entire community understand what we're trying to accomplish. Because at the end of the day, we may not be able to do everything we want to do, but if we have to make tough decisions, we know what we're going to do first and why. You have everyone on the team operating from the same playbook.

Visualize a series of concentric circles. The biggest circle is drawn around the entire Army Acquisition Workforce. And then, as people either self-select in some cases, or get thrust into situations in other cases, or rise to a certain grade in yet other cases, you get smaller and smaller circles. It's from these smaller circles that eventually we'll find personnel for key leadership positions:

- Program executive officer (PEO) and deputy PEO.
- Senior contracting official.
- Program manager (PM).
- Deputy PM.
- Chief engineer and lead systems engineer.
- Product support manager (program lead logistician).
- Chief developmental tester.
- Program lead, business financial manager.
- Program lead, contracting officer.
- Program lead, cost estimator.
- Program lead, production, quality and manufacturing.
- Program lead, information technology.

TALENT

Onboarding, mentoring and coaching

Talent identification

Acquisition career field development paths

Civilian and military career models

Enhanced recruitment

Right assignment at the right time

Outreach and employee engagement

MANY PATHS, ONE GOAL

An agile talent management strategy enables the Army to prepare its acquisition workforce to tackle any future threats, and includes a number of vital components, including recruitment, outreach and engagement, and onboarding and mentoring. (SOURCE: U.S. Army DACM Office)

Talent management is a matter of setting the conditions for success. We remove all of the impediments and barriers so that, when we need 25 people with a certain competency or capability, we know right where to find them. We don't wait for the need to arise and then go out and try to build that person.

What would success for talent management look like? It would mean that every time we need an individual or a group to solve a complex acquisition problem, every time we have a technical challenge, every time we need somebody in theater with a particular set of skills, we would already have considered that a possibility and would have developed that capability and talent in our community. We would know who and where they are.

The concepts behind talent management of the Army Acquisition Workforce are:

- Identify high-potential and high-performing employees.
- Develop the talent pool early.
- Reinstate tools to help manage acquisition workforce talent.
- Implement strategies to use skills gained through training and other developmental opportunities.

We are implementing several initiatives to help our leaders identify and develop talent, including:

- Continuing to expand mentoring and fine-tuning our evaluation processes.
- Developing orientation briefings as an onboarding tool to acclimate new members to the acquisition profession.
- Creating civilian career models for every acquisition career field, similar to military acquisition models, and continuing to enhance this tool to provide our acquisition civilians and their supervisors with career guidance.
- Promoting developmental and rotational assignments to provide broadening opportunities for our workforce.
- Encouraging talented and high-potential personnel to apply to our centrally selected positions.
- Ensuring that talent management is nested with talent initiatives managed by the Office of the Secretary of Defense, such as competency development and key leadership position qualification programs.

- Implementing and standardizing a tenure agreement tracking mechanism for critical acquisition positions, including key leadership positions and centrally selected product and project manager and project and product director positions.
- Establishing guidance on the use of the senior rater potential evaluation (SRPE) for all Army Acquisition Workforce members in designated grades or broadbands.
- Developing program management position hierarchy and common nomenclature for use across the enterprise.
- Sustaining and executing the first civilian-only centrally selected product director board, providing opportunities to select high-performing civilians with leadership potential.

For talent management to thrive, you have to establish a methodology by which you can facilitate success. Providing people the necessary tools, such as the individual development plan and the SRPE, allows a much richer discussion about individual potential. Talent management is preparing the seed corn, a feeder population from which future leaders will emerge.

Moving on UP!

Willingness to be mobile is key to career development in the acquisition workforce.

by Ms. Jacqueline M. Hames

In Army acquisition, moving up might mean moving out—out of your comfort zone. Leadership in recent months has been encouraging mobility, or the willingness of workforce members to relocate for work, for one big reason: the development of the employee. "Leadership seems to unanimously find value in a person working in multiple organizations in multiple locations—that brings a wealth of perspectives to that person," said Scott Greene, chief of the leader development branch for proponency and leader development at the Office of the Director, Acquisition Career Management (DACM), Fort Belvoir, Virginia.

Leadership is looking for people with various senior raters—supervisors who rate employees annually on performance and potential—various organizations and, ideally, different locations, Greene said, but for the most part it is looking for willingness to do new things. "Getting people to experience differences grows them," he said, and an employee with a diverse background brings added value to the organization. For example, having all the same senior raters on performance evaluations shows consistency within an organization, but no diversity of thought. Evaluations from different senior raters display a well-rounded perspective on an employee's potential.

WHAT ABOUT BOB?

Sometimes people are just not willing to make drastic geographic relocations because of circumstances—family, ties to the community and so on—but that doesn't necessarily preclude an employee from becoming mobile temporarily or regionally. Say someone named Bob may be a great assistant program manager at Fort Belvoir at the Program Executive Office (PEO) for Soldier, but there's an advancement opportunity a few miles north at the Pentagon, a position that wouldn't require Bob and his family to relocate. Taking that position reflects a readiness to be mobile, Greene said. In other words, Bob is showing his willingness to expand his experience and get out of his comfort zone. However—are you listening, Bob?—workforce members can also show their willingness to leave their comfort zones by accepting promotions in different geographic locations. "Best case, Bob is willing to move from Fort Belvoir up to Warren [Michigan] for

LEAVING THE COMFORT ZONE
Mobility—through geographic relocation or temporary developmental assignments—is important to acquisition careers. It shows leadership the wealth of perspectives an employee has and how they can add value to the workforce at large. (Image by Getty Images)

an opportunity. That's like super mobility. That's wonderful!" Greene said.

LOCATION, LOCATION, LOCATION

Geographic relocation can be daunting; however, if Bob meets his command's requirements for moving, there are some key resources available to guide him through the process and potentially assist him in the move.

Each PEO has the authority to approve relocation incentives for its employees under the criteria outlined in "DOD Instruction 1400.25, Vol. 575, DOD Civilian Personnel Management System: Recruitment, Relocation, and Retention Incentives and Supervisory Differentials," said Cary Cooper, a human resources specialist with the U.S. Army Acquisition Support Center. Bob may be paid relocation incentives—a moving bonus or supplementary pay to cover moving expenses—if he relocates without a break in service to accept a position in a different geographic area that is likely hard to

fill. He'll need to be rated "fully successful" or equivalent in his last performance evaluation to be eligible for an incentive, the instruction states.

After meeting command requirements, workforce members should be sure to research the Joint Travel Regulations (JTR) and the DOD National Relocation Program (DNRP). The JTR governs all permanent change-of-station entitlements, Cooper said. These regulations are applicable to all service members, DOD civilian employees and anyone else traveling at DOD's expense. Chapter 5, Part B lists basic entitlements for current government employees given permanent change-of-station orders.

The DNRP is one real estate assistance option that can be authorized under the JTR, Cooper said. It is designed to assist eligible and authorized civilian transferees, like Bob, to relocate from one duty station to another on orders. The DNRP includes home sale and marketing incentives for DA civilians. These incentives can

be offered to Bob if his move is covered by the mandatory mobility agreement outside of his commuting area, if his reassignment is management-directed or if he is a Senior Executive Service member going to another position. Each DOD agency establishes eligibility criteria for its organizations. Generally, Bob and other employees like him should meet the requirements for permanent change of station, be authorized to use these services by their command and ensure that their residence meets the criteria established in the JTR and DNRP. Cooper cautions that though employees are offered the use of this program, it is not guaranteed that an organization will authorize it. Interested employees should coordinate with their command's human resources office to determine eligibility and receive further instructions.

LATERAL MOBILITY

If Bob's family decides a permanent move isn't feasible, another option for mobility is to take a temporary developmental assignment, Greene said. An employee's

organization can pay for these assignments, which may range from a few weeks to several months. These types of assignments will help employees broaden themselves laterally, he said.

"A focus on development assignments is huge," Greene said. The command can offset the financial burden of developmental assignments with the Defense Acquisition Workforce Development Fund (DAWDF). Many requests for funding developmental assignments came in the past year. "Those are hard to say no to," Greene said. "The board [Defense Acquisition Workforce Development Board] loves seeing those. And sitting on that board for the past handful of years, we've approved those."

The National Defense Authorization Act (NDAA) for Fiscal Year 2008 established the DAWDF, and the NDAA for FY16 made the program permanent. DAWDF is used to recruit, train and retain the acquisition workforce, Cooper said. It can provide funding for developmental assignments and training and education opportunities alike.

There are three categories under DAWDF: retention, recruitment, and training and development. These categories are further explained under 11 line items, which include things like leadership training, acquisition training forums and Defense Acquisition Workforce Improvement Act certification equivalency. The DACM Office centrally manages DAWDF funds, Cooper said. Each command receives an allocation based on what it requests—so if Bob works in PEO Soldier and requested funds to support a six-month developmental assignment, the DACM would transfer funds to PEO Soldier to use, Greene explained.

Information for specific development assignments will be included in the assignment announcement from each deputy assistant secretary of the Army office within the Office of the Assistant Secretary of the Army for Acquisition, Logistics and Technology, Cooper said. The application process for a developmental assignment will vary depending on the organization, she said, but Bob should at least have a first-line supervisor and an organization representative approve the assignment.

Greene recommended that workforce members interested in a developmental assignment speak with their command G-1, even if there is no announcement for a developmental assignment. "I would suggest that individuals self-advocate," he said.

CONCLUSION

Mobility will give employees a larger perspective of the workforce and the wide variety of work it does. Different views of various climates in different organizations, making new contacts and gaining a better understanding of the acquisition community are critical to expanding work experience, Greene said. Mobility shows senior leaders you are willing to go above and beyond the call of duty and be challenged.

*For more information on career planning, go to **https://asc.army.mil/web/dacm-office/**. For more information on the different DAWDF categories and how they break down, as well as program regulations, go to **https://asc.army.mil/web/career-development/dawdf-program/**.*

DAWDF SUPPORTS WORKFORCE MOBILITY
Jason Pitts, chief of the Acquisition Functional Integration Branch at the DACM Office, presents DAWDF financial data to a group of acquisition professionals during the Back to Basics developmental conference in September 2017. DAWDF helps facilitate temporary rotations in other organizations, as well as education and training assignments, to broaden workforce experience. (U.S. Army photo)

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LEADERSHIP PETRI DISH

USAMMDA develops a reputation for growing acquisition workforce leaders.

by Mr. Jeffrey M. Soares

The U.S. Army Medical Materiel Development Activity (USAMMDA) at Fort Detrick, Maryland, is helping to prepare future leaders of the acquisition workforce. USAMMDA cultivates a cadre of acquisition professionals, both military and civilian, who go on to leadership roles in other areas of the Army and DOD. In fact, over the last few years, six former and current members of the USAMMDA team have been chosen from the Army Acquisition Centralized Selection List to serve as leaders in other acquisition commands throughout the country.

"The breadth and depth of our command offer distinct exposure to a wide range of medical materiel solutions," said Col. Ryan Bailey, USAMMDA commander. "From a military perspective, an assignment at USAMMDA offers an opportunity to be part of an organization that is focused on true acquisition medical product development, beginning at the analysis of alternatives, through the entire life cycle process.

"Understanding the acquisition component—the acquisition and sustainment strategy—while also working with stakeholders and users to understand the particular requirement provides true on-the-job, hands-on experience," Bailey said. "It's invaluable."

AN ENVIRONMENT UNLIKE OTHERS

As Bailey suggested, a position at USAMMDA provides a unique acquisition experience, primarily because of the organization's role as a medical product developer. While the Army acquisition system evolved to procure items such as tanks, planes, weapons and other defense equipment, USAMMDA tailors this process to advance military medical products, devices, pharmaceuticals, vaccines and other medical solutions for warfighters. The organization is the Army's lead resource for the advanced development, licensure and fielding of pharmaceutical products for use by the U.S. military.

Because of that focus, product and project managers at USAMMDA gain in-depth knowledge in regulatory affairs as they work with the U.S. Food and Drug Administration (FDA) to ensure the safety and efficacy of all pertinent products managed by the command, offering staff members a unique experience within Army medicine.

In this year alone, the command can claim three Army officers chosen to fill leadership roles via the Centralized Selection List process: Lt. Col. Charles Ditusa, Lt. Col. Bryan Gnade and Lt. Col. Kara Schmid. Schmid currently serves USAMMDA as project manager of the Neurotrauma and Psychological Health Project Management Office. Beginning in FY 2019, she will assume the role of joint product manager for Chemical Defense Pharmaceuticals within the Medical Countermeasures Systems Joint Project Management Office at Fort Detrick.

Ditusa recently departed USAMMDA to serve as acting assistant product manager of the Biodefense Therapeutics Antiviral Program under the Joint Program Executive Office for Chemical, Biological, Radiological and Nuclear Defense. As part of his assignment, he is scheduled to assume the role of joint product manager for the Biological Defense Therapeutics office. Gnade, currently chief of the Diagnostics Systems Division of the U.S. Army Medical Research Institute of Infectious Diseases, was selected to serve as a product manager assigned to the Program Executive Office for Simulation, Training and Instrumentation.

CURRENT AND FUTURE LEADERS
The 2018 class of the Program Management – Acquisitions Internship Program, led jointly by USAMMDA and USAMMA, and program leadership celebrated graduation on July 23. From left are Dr. Tyler Bennett, deputy to the commander for acquisition, USAMMA; Col. Lynn Marm, USAMMA commander; Maj. Janessa R. Moyer, Maj. Jeffrey L. Brown, Capt. Efther V. Samuel and Maj. Amber L. Smith, graduates; and Col. Ryan Bailey, USAMMDA commander. Capt. Amanda L. Roth, who also completed the program, was not present for the photo. (Photo by Gregory Pugh, USAMMA Public Affairs)

With two Centralized Selection List positions on his own resume, Bailey knows what the committee looks for when evaluating applications. Candidates for acquisition positions should have the pertinent acquisition certifications coupled with related experience, and they should also have successful leadership experience—all of which are available and highly encouraged during an assignment at USAMMDA.

"I would say that my selection for this particular position was based on my experience as a product manager, and then as a project manager, at USAMMDA as a lieutenant colonel," said Schmid. "These two positions relate closely to what I will be doing as the joint product manager for the Chemical Defense Pharmaceuticals office."

Over the past 12 years, Schmid considers herself fortunate to have remained involved with the Laboratory Assay for Traumatic Brain Injury (LATBI) acquisition program, which has been a prime focus of Army medicine during the last decade. In 2015, she joined USAMMDA as product manager for Traumatic Brain Injury before being named project manager for Neurotrauma and Psychological Health, overseeing the LATBI program.

Schmid noted that her time at USAMMDA helped to prepare her for her upcoming role. "The entire work of USAMMDA is centered on acquisition," said Schmid. "Being a product manager here gives you day-to-day acquisition experience in product development—you are directly responsible for the cost, schedule and performance of your program. But I also gained experience as a project manager, where you're in charge of the oversight and strategic vision of the entire program, much like the joint product manager role that I will be taking on."

"As a project manager at USAMMDA, you're offered valuable experience in making decisions on a programwide level," she said. "Everything you learn on the job, and from other USAMMDA leadership, helps you to understand how to prioritize funding, as well as people and their time, based on the products being developed by the team."

LEVERAGING THE USAMMDA EXPERIENCE
Another unique aspect of an assignment at USAMMDA is that the command has billets coded for medical acquisition that allow officers to attend training through Defense Acquisition University (DAU)—a certification that remains critical for career advancement in Army acquisition and membership in the Army Acquisition Corps. Corps membership is mandatory for all Army acquisition, logistics and technology workforce members who hold key leadership positions. While essential requirements for DAU are satisfied through product manager and assistant product manager positions at USAMMDA, Bailey noted that DAU provides the textbook acquisition training while USAMMDA offers the on-the-job experience that links the process together.

Further, these candidates also gain the required experience in working to transition a product from multiple science and technology partners in the U.S. Army Medical Research and Materiel Command (USAMRMC), moving through the product life cycle to fielding, sustainment and modernization. Additionally, they work with contracting agencies to partner with the necessary commercial entities to complete the advanced development of these products. In doing so, they gain valuable knowledge in working within contracting guidelines such as cooperative research and development agreements and other transaction authorities.

Col. Jeanne Norwood currently serves as the joint product manager for the Joint Vaccine Acquisition Program within the Medical Countermeasures Systems Joint Project Management Office, and much like Schmid, her path to this position includes successful work in product development and acquisition at USAMMDA.

As a product manager within the Pharmaceutical Systems Program Management Office, Norwood, then a lieutenant colonel, led critical efforts to develop diagnostics and therapeutics to treat cutaneous leishmaniasis, a skin infection caused by a single-celled parasite that is transmitted by an insect bite. Along with these duties, she served as chair of an integrated product team that was responsible for the development of medical products to protect warfighters from infectious disease threats.

"During my tenure at USAMMDA," Norwood explained, "I was involved in all phases of the product development process, from supporting early science and technology efforts, to executing Phase III clinical trials, to getting a critical product cleared by the FDA and transitioning it to the U.S. Army Medical Materiel Agency for fielding."

Echoing Schmid, Norwood agreed that the work and training provided at USAMMDA allowed her to grow in the acquisition and advanced development fields. "My experience at USAMMDA helped me to understand and appreciate the importance of functional teams," said Norwood. "Although some of my learning may have been trial by fire, because I was new to advanced development at that time, USAMMDA leadership empowered me to lead my team to advance critical products to the warfighter, and that was really encouraging."

ADDED RESPONSIBILITIES

The breadth of work at USAMMDA will soon increase as the organization absorbed 27 product development personnel from the U.S. Army Medical Materiel Agency (USAMMA) in July. The transition will add many new medical products to USAMMDA's portfolio, which Bailey noted will "help to create even more opportunities for product knowledge and acquisition skill development, and build a much stronger USAMMDA workforce."

With the influx of additional personnel, the need for specialized training will increase as well. Bailey explained that while at USAMMDA, Soldiers may also satisfy their requirements for the Army's 8X Additional Skill Identifier, which remains on their permanent records to show they have successfully completed additional acquisition skills training for an Army Medical Department acquisition officer. Further, both USAMMDA and USAMMA offer the Program Management – Acquisitions Internship Program, which is designed to recruit junior officers to the field earlier in their careers to begin developing acquisition skills for future positions within the workforce.

Schmid praised the internship program as an effective way of creating a large pool of well-trained officers who could one day fill critical acquisition gaps throughout the Army. "Gaining experience in acquisition while you're still a captain will really help you to understand how the USAMRMC does business," she said. "Also, having experiences like this early in your career as an officer will certainly help to prepare you for leadership roles later on."

—MR. JEFFREY M. SOARES

She added that her assignment at USAMMDA "provided my first chance to see a product cross the finish line and go into the hands of the people that really need it. Once you're part of a success such as that, you want to see it happen again."
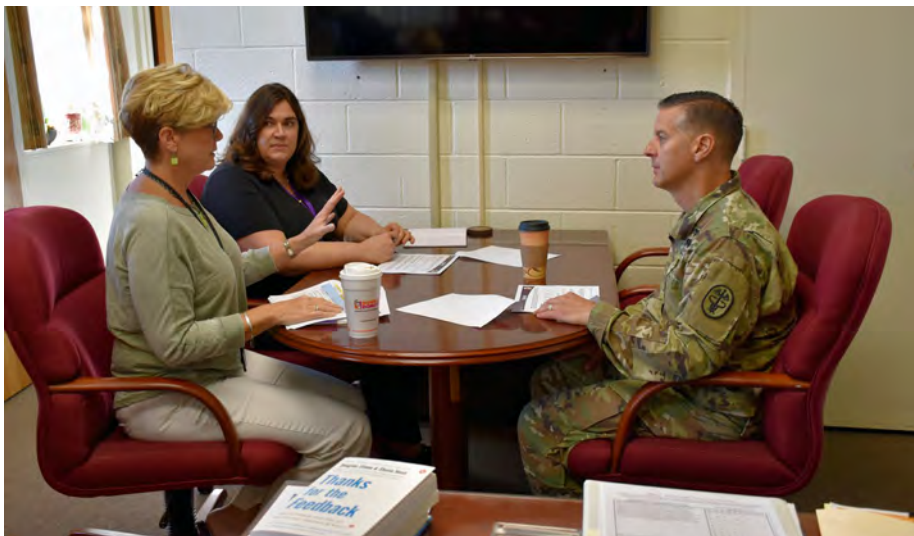
CONCLUSION
USAMMDA has seen its share of success over the years. From critical vaccines and blood products that help to save lives on and off the battlefield, to medical products, devices and treatments that help wounded warfighters returning from battle, USAMMDA's status as a solid training environment to help prepare future leaders is secure.

"USAMMDA truly is a great organization that helps to build the bench of acquisition leaders," said Bailey. "People who join our team obtain the education and experience to develop as professionals in the field, and then rotate out to lead in other diverse acquisition environments."

Schmid and others on the USAMMDA team believe that USAMMDA is one of the most diverse commands under the U.S. Army Medical Command, which supports its status as an effective training environment.

As the USAMRMC is a life cycle management command, USAMMDA has the

entire product development mission under one roof. From infectious diseases to operational medicine, and combat casualty care to rehabilitation, the organization is responsible for developing solutions for everything from basic training to return from battle, which also includes non-battle injuries and diseases.

"Our greatest challenge may actually be the breadth of the work we do here at USAMMDA and throughout the USAMRMC," said Schmid, "but we have all learned to become very efficient at our jobs, and this is something that I truly value from my experience within the command."

Despite her years of experience and training, or perhaps because of them, Schmid realizes she must continue to develop and grow with each new assignment—including the one fast approaching. "I'm starting to brush up on my knowledge of chemical and biological threats, in between my current responsibilities," she explained. "In my new position, I almost feel like I'll be a freshman again. There will be a lot to learn, but I know there's a very strong team already in place, which will help make the transition much easier."

*For more information on the work and mission of USAMMDA, go to **http://www.usammda.army.mil/**.*

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STATUS CHECK

USAMMDA commander Col. Ryan Bailey meets July 20 with Kathleen Berst, USAMMDA deputy for acquisition, center, and Christine Parker, acting project manager for USAMMDA's Medical Devices – Advanced Development Project Management Office. USAMMDA is the Army's lead for pharmaceutical acquisition, so its personnel gain unique experience dealing with the FDA during the acquisition process. (Photo by Ashley Force, USAMMDA Public Affairs)

OUR WORK, IN BRIEF

Lt. Col. Kara Schmid, center, project manager of USAMMDA's Neurotrauma and Psychological Health Project Management Office, briefs Maj. Gen. Barbara R. Holcomb, right, commander of USAMRMC and Fort Detrick, on her office's products and accomplishments during Holcomb's April 23 tour of USAMMDA. Schmid's experience at USAMMDA led to her selection as the next joint product manager for Chemical Defense Pharmaceuticals. (Photo by Ashley Force, USAMMDA Public Affairs)

ON THE

MOVE

U.S. ARMY FUTURES COMMAND

Gen. John M. Murray assumed command of U.S. Army Futures Command during an activation ceremony Aug. 24 in Austin, Texas. Murray, who previously served as HQDA deputy chief of staff, G-8, received Senate confirmation Aug. 20 for promotion to four-star general.

The establishment of Army Futures Command marks one of the most significant Army reorganization efforts since 1973.

Murray, commissioned as an Infantry officer in 1982, has served in leadership positions and commanded from company through division. He is the recipient of numerous awards and decorations.

U.S. ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND

1: FROM CERDEC TO ARMY GEOSPATIAL CENTER

Gary W. Blohm, director of the Intelligence and Information Warfare Directorate (I2WD) at the U.S. Army Research, Development and Engineering Command's (RDECOM) Communications-Electronics Center (CERDEC) at Aberdeen Proving Ground (APG), Maryland, has been promoted to director of the U.S. Army Geospatial Center, part of the U.S. Army Corps of Engineers, at Fort Belvoir, Virginia.

Blohm, who began his new duties Aug. 5, supported CERDEC for 33 years in several key leadership positions, including director of the Space and Terrestrial Communications Directorate and the Command, Power and Integration Directorate before leading I2WD. **Michael Lombard**, I2WD deputy director, will serve as acting director for 120 days or until a permanent replacement is named.

2: S&TC DIRECTORATE GETS NEW LEADER

Michael Monteleone was promoted into the Senior Executive Service (SES) on Aug. 19. As the newest SES for CERDEC, Monteleone will serve as director of the center's Space and Terrestrial Communications Directorate (S&TCD) at APG.

Since 2014, Monteleone had served as chief of CERDEC's Cyber Security and Information Assurance Division. In the two years before his appointment, he held a series of positions in an acting capacity at CERDEC, including chief of the S&TCD Satellite Communications Systems Division and as director and deputy director of S&TCD.

Monteleone, who began his DA civilian career as a GS-07 computer engineer in the Satellite Communications Division at Fort Monmouth, New Jersey, holds a Master of Strategic Studies from the U.S. Army War College, a Master Certificate in Advanced Acquisition from the Naval Postgraduate School, and an M.S. in management and a B.S. in computer engineering from

the New Jersey Institute of Technology. A member of the Army Acquisition Corps, Monteleone is Level III certified in engineering, science and technology management, and program management.

1: CSM DEPARTS RDECOM FOR CECOM

Maj. Gen. Cedric T. Wins, center, commanding general of RDECOM, passed the noncommissioned officers' sword to acting **Command Sgt. Maj. (CSM) Keith N. Taylor**, signifying the relinquishment of responsibility from **Sgt. Maj. Frank C. Gutierrez**, right, during a July 30 ceremony at APG. Gutierrez, who had served as RDECOM's CSM for 11 months, now serves as CSM for CERDEC. Taylor will serve as acting CSM until **Sgt. Maj. Jon R. Stanley** joins RDECOM in September. Stanley is currently the CSM for the Maneuver Support Center of Excellence at Fort Leonard Wood, Missouri. (U.S. Army photo by Conrad Johnson, RDECOM)

U.S. ARMY MEDICAL MATERIEL DEVELOPMENT ACTIVITY

2: PROMOTION CEREMONY AT USAMMDA

Col. William E. Geesey, left, former commander of the U.S. Army Medical Materiel Development Activity (USAMMDA), administered the Army oath to **Col. David L. Saunders** during Saunders' promotion ceremony June 12 at USAMMDA headquarters, Fort Detrick, Maryland. Saunders was a product manager in USAMMDA's Combat Trauma and Acute Rehabilitation Project Management Office, which fields medical devices, drugs and biologics that fulfill the unmet requirements identified by the service end user. He has transitioned to become its medical director. (U.S. Army photo by Jeffrey Soares, USAMMDA Public Affairs)

U.S. ARMY CONTRACTING COMMAND

3: PROMOTION, RETIREMENT AT ACC

Then-**Brig. Gen. Paul H. Pardew** assumed command of the U.S. Army Contracting Command (ACC) on May 31, succeeding **Maj. Gen. James E. Simpson**, who retired after 35 years of service. Pardew was promoted to major general on July 11 during a frocking ceremony at U.S. Army Materiel Command (AMC) headquarters officiated by **Gen. Gustave F. Perna**, AMC commanding general (CG). Pardew, whose daughters, Virginia and Samantha, attached his new rank, previously served as CG of the U.S. Army Expeditionary Contracting Command; director of the Forward Operational Contract Support Integration Cell within the U.S. Central Command, Qatar; deputy chief of contracting management for the U.S. Army Corps of Engineers (USACE); chief of Operational Contract Support and Logistic Services, J-4, Joint Staff; and commander of the 414th Contracting Support Brigade. He has an MBA from Old Dominion University and a master's degree from National Defense University.

Simpson had served as CG of ACC since August 2015. He also had served as director of contracting and deputy to the deputy assistant secretary of the Army for procurement; commander of the U.S. Central Command Joint Theater Support Contracting Command, Afghanistan; deputy chief of contracting management for USACE; and senior contracting official – Iraq for the Joint Theater Support Contracting Command during Operation New Dawn.

During Simpson's command, ACC facilitated nearly half a million contract

actions valued at more than $167 billion. At his retirement ceremony, he spoke about the ups and downs of the last three fiscal years and praised his team for its perseverance. "You are mountain climbers. You've been conquering mountains since this command was formed 10 years ago," he said. "The bad news is, there's always another mountain to climb. The good news is, you are skilled professionals trained in the art of delivering contracting solutions for our Army, and you are the team that will conquer the next mountain." (Photo by Derrick L. Williams, AMC)

4: CHANGE OF COMMAND AT 410TH CSB

Col. Robert McDonald, left, accepted the colors of the 410th Contracting Support Brigade (CSB) from **Brig. Gen. William M. Boruff**, commanding general of the U.S. Army Mission and Installation Contracting Command (MICC), as **Command Sgt. Maj. Charles Williams** looked on during a change of command ceremony July 2 at Joint Base San Antonio – Fort Sam Houston, Texas.

McDonald assumed command of the 410th CSB from **Col. Dariel Mayfield**, who now serves as the deputy for contracting operations for ACC – Redstone at Redstone Arsenal, Alabama. (U.S. Army photo by Daniel P. Elkins, MICC)

5: NEW LEADERSHIP AT 418TH CSB

Col. Joel Greer accepted the colors of the 418th CSB from **Brig. Gen. William Boruff**, MICC commanding general, during a change of command ceremony July 12 at Fort Hood, Texas. Greer, who assumed command from **Col. Lynda Armer**, comes to the 418th CSB from III Corps, where he served as the chief of force management. Armer departed Fort Hood to attend the U.S. Army War College at Carlisle Barracks, Pennsylvania. (U.S. Army photo by Todd Pruden, Fort Hood Sentinel)

6: CHANGE OF COMMAND AT THE 408TH

Maj. Gen. Paul H. Pardew, ACC commanding general, passed the unit colors to **Col. Ralph T. Borja**, right, incoming commander of the 408th CSB, during a change of command ceremony June 22 at Shaw Air Force Base (AFB), South Carolina. Borja assumed command from **Col. Kim M. Thomas**.

Borja comes to the 408th following acquisition assignments with the U.S. Army Aviation and Missile Command, the Program Executive Office for Missiles and Space and the Defense Contract Management Agency. The 408th is one of eight active-component CSBs. Operationally aligned with U.S. Army Central, it maintains operations at Shaw AFB; Camp Arifjan, Kuwait; and Camp as Sayliyah, Qatar. (U.S. Army photo by Sgt. Von Marie Donato, Combined Joint Forces Land Component Command)

7: 409TH CSB WELCOMES NEW LEADER

Col. Freddy L. Adams, commander of the 409th CSB, addressed those gathered for the June 22 change of command ceremony at Sembach Air Base in Kaiserslautern, Germany, where Adams assumed command from **Col. Douglas S. Lowrey**. The 409th provides full-spectrum contract support to U.S. Army Europe. (U.S. Army photo by Elisabeth Paque, Training Support Activity Europe)

8: ACC – WARREN TAPS NEW EXECUTIVE

Daniel J. Gallagher, right, unfurled the Senior Executive Service (SES) flag with the help of **Maj. Gen. James E. Simpson**, center, then-commanding general of ACC, and **Master Sgt. Mark Hirsch**, left, at a ceremony May 14 at Detroit Arsenal, Michigan, to mark Gallagher's swearing-in as executive director of ACC – Warren and his induction into the SES. Gallagher also serves as senior civilian pro-

curement authority for the U.S. Army Tank-Automotive and Armaments Command.

Gallagher, a retired Army colonel, previously was ACC's deputy director of contracting operations at Redstone Arsenal. He has served in a wide variety of command, leadership and staff assignments, including deputy to the commanding general of the U.S. Army Expeditionary Contracting Command (ECC); contracting operations director and chief of staff for ECC; and commander of Defense Contract Management Agency – Huntsville, Alabama. (U.S. Army photo by Ted Beaupre, U.S. Army Garrison – Detroit Arsenal)

U.S. ARMY SECURITY ASSISTANCE COMMAND

1: NEW COMMANDER FOR USASAC
Maj. Gen. Jeffrey W. Drushal, left, accepted the flag of the U.S. Army Security Assistance Command (USASAC) from **Gen. Gustave F. Perna**, commanding general of the U.S. Army Materiel Command, during a July 16 assumption of command ceremony at Redstone Arsenal, Alabama.

Perna thanked **Robert Moore**, USASAC deputy to the commanding general, for filling in as the executive director until Drushal arrived.

Drushal comes to USASAC from U.S. Forces Korea. He earned an M.S. in logistics management from the Florida Institute of Technology, a Master of Strategic Studies from the U.S. Army War College and a B.A. in business management from the University of Tampa. His operational

experience includes three deployments to Iraq, two deployments to Afghanistan and one to Kuwait, as well as support for state and national relief operations in response to Hurricane Katrina. (U.S. Army photo by Adriane Elliot, USASAC Public Affairs)

PROGRAM EXECUTIVE OFFICE FOR AVIATION

2: JETTE VISITS REDSTONE ARSENAL
Dr. Bruce D. Jette, right, assistant secretary of the Army for acquisition, logistics and technology (ASA(ALT)), visited Redstone Arsenal, Alabama, March 29. **Brig. Gen. Thomas H. Todd III**, left, program executive officer (PEO) for Aviation, and other senior leaders in the organization provided program updates. Jette took part in system overviews and a flight demonstration of the AH-64E Apache. (U.S. Army photo by Josh Nichols, PEO Aviation)

3: WHITE TAKES PART IN RAVEN DEMO
Jeffrey White, center right, principal deputy to the ASA(ALT), inspected the small unmanned aerial system Raven during a March 14 visit to Redstone Arsenal. During the visit, White received an update from **Brig. Gen. Thomas H. Todd III**, center left, PEO for Aviation, and took part in a flight demonstration of the AH-64E Apache. (U.S. Army photo by Collin Magonigal, PEO Aviation)

4: NEW LEADER AT AVIATION SYSTEMS
Jimmy Downs, left, acting project manager for Aviation Systems within PEO Aviation, presented the Superior Civilian Service Award to outgoing product director **Tim Vinson** during a June 11 change of charter

ceremony at Redstone Arsenal for the Aviation Networks and Mission Planning Project Office. Vinson, who served as product director for three years, relinquished responsibility to **James Pruitt**. (U.S. Army photo by Tom Voight, PEO Aviation)

5: CARGO AND UTILITY AIRCRAFT LEADER DEPARTS

Lt. Col. Christopher Enderton received an Mi-17 tail rotor blade as a memento during a farewell ceremony May 23 at Campus 805, Huntsville, Alabama, marking Enderton's departure from PEO Aviation's Non-Standard Rotary Wing Aircraft Project Office. Enderton, who served as product director for cargo and utility aircraft, also received the Meritorious Service Medal and the Order of St. Michael Bronze Award for his contributions to Army aviation. He is now with the Defense Logistics Agency in Columbus, Ohio. (U.S. Army photo by Renee Harris, PEO Aviation)

6: RETIREMENT FOR DEPUTY CONTINGENCY OPS OFFICER

Lt. Col. Jay L. Palenapa, right, received a certificate of appreciation for completion of his active reserve service June 1 from **Col. Chad Smith** on behalf of **Lt. Gen. Charles D. Luckey**, chief of the U.S. Army Reserve and commanding general of the U.S. Army Reserve Command, in a ceremony at Redstone Arsenal. Palenapa retired after a 30-year military career, during which he served as PEO Aviation's deputy contingency operations officer. (U.S. Army photo by Daniel Cunningham, PEO Aviation)

7: NEW PRODUCT MANAGER FOR IMPROVED TURBINE ENGINES

Lt. Col. Travis Harris, left, accepted the project office flag from **Col. Roger Kuykendall**, center, project manager for Aviation Turbine Engines within PEO Aviation, as he assumed the responsibility of the Product Manager for Improved Turbine Engines from **Lt. Col. Curt Kuetemeyer**, right, during a change of charter ceremony June 18 at Redstone Arsenal. (U.S. Army photo by Daniel Cunningham, PEO Aviation)

8: PEO AVIATION GETS ITS FIRST SGM

Sgt. Maj. Roy Sullivan assumed responsibility June 1 as PEO Aviation's first sergeant major since the organization's founding in 1987. Sullivan will meet with Soldiers in the field to gain their perspective of aviation capabilities and bring their feedback to the PEO. Sullivan is a member of the South Carolina National Guard with a 30-year military career in logistics and sustainment and a background in Apaches, Black Hawks, Chinooks and Lakotas.

PROGRAM EXECUTIVE OFFICE FOR COMBAT SUPPORT AND COMBAT SERVICE SUPPORT

1: NEW PEO CS&CSS LEADERSHIP

Timothy G. Goddette, right, officially assumed the charter of the Program Executive Office for Combat Support and Combat Service Support (PEO CS&CSS) in a July 10 ceremony at the Detroit Arsenal in Warren, Michigan, hosted by **Dr. Bruce D. Jette**, left, assistant secretary of the Army for acquisition, logistics and technology (ASA(ALT)) and the Army acquisition executive.

Goddette is responsible for a range of systems across the Army's transportation, quartermaster, ordnance and engineer portfolios. With more than 150 programs in active management at all acquisition categories and approximately 100 more in sustainment, he oversees an annual budget of roughly $3.5 billion and a total portfolio budget of nearly $17 billion across multiple appropriations.

Goddette is a retired Army colonel and a member of the Army Acquisition Corps. Before he became PEO for CS&CSS, he served as the deputy PEO for Soldier, where he was responsible for the development, acquisition, fielding and life cycle support for Soldier programs and the Soldier as a System concept. Near the end of his tenure there, he was named acting deputy assistant secretary of the Army for acquisition policy and logistics.

His Acquisition Corps experience began in 1985 with a three-year assignment as research and development coordinator at the U.S. Army Corps of Engineers' Cold Regions Research and Engineering Laboratory in Hanover, New Hampshire. Goddette served three tours at the U.S. Army Tank-automotive and Armaments Command in Warren, Michigan, and has held positions in the Office of the Assistant Secretary of the Army for Research, Development and Acquisition; the PEO for Intelligence, Electronic Warfare and Sensors; and the Office of the ASA(ALT).

Goddette holds a master's degree in industrial engineering from the Georgia Institute of Technology, a master's degree in national security and resource management from the Industrial College of the Armed Forces of National Defense University and a bachelor's degree in engineering from the University of Vermont. (U.S. Army photo by Ted Beaupre, U.S. Army Garrison – Detroit Arsenal)

PROGRAM EXECUTIVE OFFICE FOR COMMAND, CONTROL AND COMMUNICATIONS – TACTICAL

2: LEADERSHIP CHANGE AT TACTICAL RADIOS

Col. James P. Ross, left, passed the charter of the Project Manager for Tactical Radios (PM TR) to **Col. Garth Winterle,** right, in a change of command ceremony July 12 at Aberdeen Proving Ground, Maryland. Hosted by **Maj. Gen. David G. Bassett**, center, head of the Program Executive Office (PEO) for Command, Control and Communications – Tactical (C3T), it also marked Ross's retirement after 28 years of service. **First Sgt. Jeff Litteral**, in background, assisted in the change of command.

Before coming to PM TR, Ross, shown speaking at the ceremony in bottom photo, was director of operations for the PEO for Intelligence, Electronic Warfare and Sensors (IEW&S) and deputy project director for Signals Warfare at Fort Monmouth, New Jersey. He also served as product manager for Prophet within PEO IEW&S and as the military deputy to the commander of the U.S. Army Armament Research, Development and Engineering Center.

Winterle started his military career in 1995 with the U.S. Army Corps of Engineers and spent time in several mechanized combat engineer battalions and as an observer and controller at the Joint Multinational Readiness Center in Grafenwoehr, Germany. He transitioned to acquisition in 2007 with an assignment with the Defense Information Systems Agency and eventually became a product manager for the PEO for Combat Support and Combat Service Support. (U.S. Army photo by Denise Rule, PEO C3T)

PROGRAM EXECUTIVE OFFICE FOR ENTERPRISE INFORMATION SYSTEMS

3: NEW PRODUCT DIRECTOR FOR AHRS

Peter Travis, right, received the charter of the Product Director for Army Human Resource Systems (AHRS) from **Lee James III**, left, during a June 22 ceremony at Fort Belvoir, Virginia, hosted by **Col. James McNulty**, center, project manager for the Integrated Personnel and Pay System – Army (IPPS-A) within the Program Executive Office for Enterprise Information Systems (PEO EIS). Travis has led the Commander's Risk Reduction Dashboard within AHRS since March 2016. (U.S. Army photo by Michael Danko, AHRS)

4: LEADERSHIP TRANSITION AT ATIS

PEO EIS welcomed **Lt. Col. Jim A. Lee**, left, as the new product manager for the Army Training Information System (ATIS) on July 27 in an assumption of charter ceremony hosted by **Col. James McNulty**, right, project manager for IPPS-A, at Joint Base Langley – Eustis, Virginia. ATIS is a defense business system whereby the Army will develop, integrate, operate and maintain an enterprise capability for its training and education communities. (U.S. Army photo by Julie Illes, PEO EIS)

5: GFEBS MARKS CHANGE OF CHARTER

Col. Donald Burton, right, assumed the charter of the Project Manager for General Fund Enterprise Business System (GFEBS) from **Col. William Russell**, left, during a ceremony hosted July 23 by **Chérie A. Smith**, center, program executive officer for Enterprise Information Systems, at the George Washington Masonic National Memorial in Alexandria, Virginia. During the ceremony, Smith presented Russell with the Legion of Merit in recognition of his leadership of GFEBS. Russell remains at PEO EIS as the chief of staff. (U.S. Army photo by Racquel Lockett-Finch, PEO EIS)

6: IPPS-A INCREMENT II WELCOMES NEW LEADER

Col. James McNulty, IPPS-A project manager, welcomed **Lt. Col. Laverne Amara** as the new product manager for IPPS-A Increment II during a change of charter ceremony May 22 in Arlington, Virginia.

During the ceremony, McNulty presented the Meritorious Service Medal to outgoing product manager **Lt. Col. Nicole Reinhardt**, who had led the program since August 2015. (U.S. Army photo by Michael Danko, PEO EIS)

1: P2E CHARTER CHANGES HANDS

Col. Enrique Costas, center, presented the charter of the Product Manager for Power Projection Enablers (P2E) to **Lt. Col. Howard Donaldson**, right, at a change of charter ceremony June 29 at Fort Belvoir. During the ceremony, Costas presented **Lt. Col Gregory Soulé**, left, outgoing product manager, with the Meritorious Service Medal in recognition of his time spent leading the program. Costas is project manager for Defense Communications and Army Transmission Systems (PM DCATS), which includes P2E and three other programs. (U.S. Army photo by James Christophersen, PM DCATS)

2: MC4 MARKS CHANGE OF CHARTER

Tracy Ellis, right, received the charter of the Product Manager for Medical Communications for Combat Casualty Care (MC4) from **Col. James McNulty**, project manager of IPPS-A, during a change of charter ceremony June 26 at Fort Detrick, Maryland.

Outgoing product manager **Matthew Maier** now serves as product manager for Network Modernization within the PEO for Command, Control and Communications – Tactical at Aberdeen Proving Ground, Maryland. Maier, who had served as MC4 product director for three years, received a plaque in recognition of his support of PEO EIS and the IPPS-A mission.

Ellis previously served as MC4's product support manager and chief of the logistics management division. He served in the Army for 26 years as an ordnance officer and retired at the rank of colonel. He has been a member of the Army Acquisition Corps since 2010 and commanded Tobyhanna Army Depot, Pennsylvania, from 2003 to 2006. (U.S. Army photo by Paul Clark, Product Manager for MC4)

PROGRAM EXECUTIVE OFFICE FOR MISSILES AND SPACE

3: NEW PRODUCT LEAD AT IFPC

Lt. Col. Juan R. Santiago Jr., right, was introduced as the new product manager for the Indirect Fire Protection Capability Increment 2 – Intercept (IFPC Inc 2-I) during a change of charter ceremony June
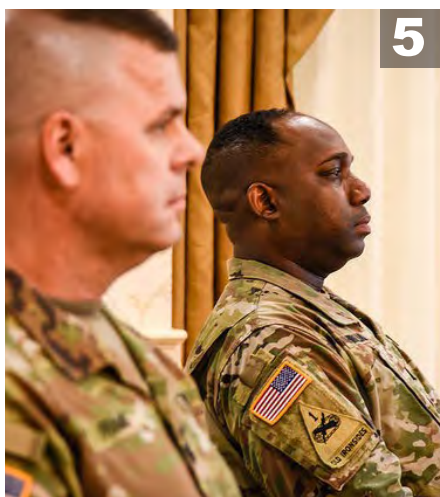
19 at Redstone Arsenal, Alabama, presided over by **Col. Charles Worshim**, left. Worshim is project manager for the Cruise Missile Defense Systems (CDMS) Project Office, which includes IFPC Inc 2-I. Santiago, who takes over from **Michael P. Fitzgerald**, most recently served as the Acquisition Corps personnel policy integrator for the deputy chief of staff of the Army, G-1. (Photo by Boyd D. Collins, CMDS Communications)

PROGRAM EXECUTIVE OFFICE FOR SOLDIER

4: CHANGE OF CHARTER AT SOLDIER MANEUVER SENSORS

Lt. Col. Anthony E. Douglas, left, passed the charter of the Product Manager for Soldier Maneuver Sensors to **Lt. Col. Toby Birdsell**, right, at a June 22 ceremony at Fort Belvoir, Virginia. The office falls under PEO Soldier's Project Manager (PM) for Soldier Sensors and Lasers. Birdsell most recently served as an acquisition career manager at the U.S. Army Human Resources Command at Fort Knox, Kentucky. Douglas is now at the U.S. Army War College at Carlisle Barracks, Pennsylvania. (Photo courtesy of PEO Soldier)

5: SOLDIER PRECISION TARGETING DEVICES HAS NEW LEADER

Lt. Col. Jamal Williams, right, assumed leadership of the Product Manager for Soldier Precision Targeting Devices from **Lt. Col. Michael Frank**, left, at a change of command ceremony June 22 at Fort Belvoir. The organization falls under PEO Soldier's PM for Soldier Sensors and Lasers. Frank, who had served as product manager since February 2015, played an important role in the Joint Effects Targeting System. He is now with the Missile Defense Agency at Redstone Arsenal, Alabama. (Photo courtesy of PEO Soldier)

6: NEW LEADERSHIP AT PM SWAR

Col. Wayne E. Barker, center left, passed the colors of the PM for Soldier Warrior to **Brig. Gen. Anthony Potts**, program executive officer for Soldier, at a change of ceremony Aug. 3 at Fort Belvoir. Potts subsequently passed the PM Soldier Warrior colors to **Col. Troy M. Denomy**, right, who assumed the charter of PM Soldier Warrior from Barker. **Master Sgt. Aaron Atchley**, left, assisted in the ceremony. Denomy comes to PEO Soldier after serving as the executive officer to the principal deputy to the assistant secretary of the Army for acquisition, logistics and technology.

Barker, who served as PM for three years, received the Legion of Merit at the ceremony. He now serves as assistant PEO for Enterprise Information Systems. (U.S. Army photos by Patrick Ferraris, PEO Soldier)

1: CHANGE OF LEADERSHIP FOR AIR WARRIOR

Lt. Col. Bryan Bogardus, second from right, received the colors of the Product Manager for Air Warrior from **Jim Isaacs**, deputy product manager, at a July 20 ceremony at the Marshall Space Flight Center at Redstone Arsenal. **Col. Wayne Barker**, left, then-PM for Soldier Warrior, led the ceremony and presented outgoing product manager **Lt. Col. (P) John Maher**, second from left, with the Meritorious Service Medal and the Bronze Medal of the Order of St. Michael.

The Product Manager for Air Warrior is assigned to PEO Soldier's PM for Soldier Warrior. Bogardus comes to the organization from the Pentagon, where he served as a staff officer for the deputy assistant secretary of the Army for plans, programs and resources, and later as a DA System Coordinator. Maher is now with the U.S. Army Contracting Command at Redstone Arsenal. (U.S. Army photo by Russell Petcoff, PEO Soldier)

2: NEW ORGANIZATION FOR PEO SOLDIER

PEO Soldier has created a new organization—the Assistant Program Executive Officer for Futures and Integration (APEO F&I)—designed to expand the organization's ability to provide adaptive and responsive leap-ahead capability to U.S. land forces. APEO F&I is led by **Col. Christopher Schneider**, who also serves as PM for Soldier Sensors and Lasers.

The establishment of APEO F&I enables PEO Soldier to deliver integrated squad capability to the close combat force, which supports the efforts of the Soldier Lethality Cross-Functional Team as well as other cross-functional teams whose work overlaps with the PEO Soldier portfolio.

APEO F&I is divided into four lines of effort and is making progress on several fronts. The integration team is working with the PM for Soldier Weapons to build interfaces for the Next Generation Squad Automatic Rifle. The innovation team is developing plans to bring together engineers, scientists and experts to work on multidimensional Soldier and squad equipment challenges. The performance team, in conjunction with the Maneuver Center of Excellence and the Joint Readiness Training Center, is planning initial assessments at Fort Polk, Louisiana, to inform future efforts and determine squad performance. The futures team is developing a vision for the squad as an integrated platform.

OFFICE OF THE CHIEF OF STAFF, ARMY ANNOUNCEMENTS

Army Chief of Staff Gen. Mark A. Milley announced the following officer assignments:

Brig. Gen. Robert A. Rasch Jr., deputy program executive officer (PEO) for Missiles and Space, Redstone Arsenal, Alabama, to PEO for Missiles and Space.

Col.(P) Christine A. Beeler to deputy commander, U.S. Army Contracting Command, Redstone Arsenal. She most recently served as deputy director of contracting, U.S. Army Corps of Engineers, Washington.

![THEN & NOW 1970 & 2018 logo with clock]

THEN&NOW
1970 & 2018

BUILDING
BRAND-NEW *SKIN*

Burns are among the nastiest wounds a person can experience, and the Army's Burn Center has been working for more than 70 years to develop treatments that speed healing and recovery.

by Ms. Jacqueline M. Hames

A Soldier sustains devastating third-degree burns over 70 percent of her body when her Humvee is hit with an improvised explosive device. Her excruciating injuries leave her at risk for infection, terrible scarring and death. After being stabilized in the field, she is medically evacuated to the Army's closest burn center, where highly trained surgeons treat her wounds, ensuring that she is protected from infection and organ failure. There, they can even give her brand-new skin to replace what was lost.

This is the future of Army burn treatment at the U.S. Army Institute of Surgical Research Burn Center at Joint Base San Antonio – Fort Sam Houston, Texas.

Renowned worldwide in 1970 for its cutting-edge treatment of thermal injuries—burns—the Burn Center proved the efficacy of a new burn cream, pioneered wound treatment and perfected skin grafts by that year, its 25th anniversary. Now entering its 73rd year, the Burn Center has not only maintained its reputation but continues to innovate with new skin substitutes and replacements, resuscitation techniques and inhalation injury mitigation.

BURN BUTTER

The antimicrobial burn cream Sulfamylon was introduced in January 1964, said Dr. Leopoldo C. Cancio, director of the Burn Center. The sulfonamide drug family, of which Sulfamylon is a member, is used to treat bacterial infections like bronchitis, eye infections and bacterial meningitis. That family of drugs has been around for decades, and the active ingredient in Sulfamylon, mafenide acetate, was not new. But using it as a cream to prevent infections in burn wounds was.

"Surgical Research Institute Enters 25th Year of Burns Research," a February 1970 article in Army Research and Development Newsmagazine, the predecessor to this magazine, detailed how, after extensive laboratory study, investigators at the Burn Center put the drug into a water-soluble white cream to be applied topically to burned areas.

"That is the compound which that article refers to as 'burn butter,' and it is used to this day for the treatment of burn wounds," Cancio said. "Since then, there have been a lot of other products that have come out and that we use for burn wounds treatment, but Sulfamylon was really the first and foremost of those treatments."

In the 1940s and '50s, an otherwise healthy adult with burns over 40 percent of his body had a 50-50 chance of surviving, said Dr. Basil A. Pruitt, former commander and director of the Burn Center. The survival rate improved by 1970; that year Pruitt, then a lieutenant colonel, told reporters that Sulfamylon successfully prevented infection in second- and third-degree burns covering up to 60 percent of the body, and reduced the bacteria count in burn wounds more effectively than any other known topical application.

"Today, if you have an 80 percent burn, you have a 50-50 chance of living or dying, and that's real progress," Pruitt continued. "That's statistically documentable progress." The medical staff at the Burn Center is responsible for that progress.

TREATMENT AND CARE

The delayed approach to surgery at the Burn Center in the 1970s meant leaving a burn wound open and debriding it—removing dead, damaged or infected tissue—daily in hydrotherapy to prepare the patient for a graft. While that approach was sound, it still left patients open to the risk of infection, even when Sulfamylon was applied.

"We don't do that anymore," Cancio said. Now, the center performs excision—the surgical removal of dead tissue—as soon as possible, especially if the patient has deep wounds, before grafting with the patient's own skin or a homograft—donor skin.

Speed of care is a key factor with burn wounds, Pruitt said. If burned and dead tissue remains on the patient, it not only can increase the risk of infection, but also increase the amount of scarring that could occur, particularly if the wounds are deep. "You take it off, it limits any extension of tissue destruction by any invasive bacteria," he said.

Another key factor in burn care is the patient's ability to heal. Accelerating wound healing, particularly in patients with extensive wounds, is a goal of the Burn Center. Two future technologies, ReCell and StrataGraft, are closest to accelerating healing, Cancio said.

"ReCell is a technology in which we take a small biopsy of the patient's normal skin, we scrape off the epidermal cells from that biopsy, we dilute them in a solution and we spray it onto the freshly excised wound bed. And those little skin cells grow and populate the wound bed and replace it with skin. So, sometimes ReCell is referred to as spray-on skin," he said.

NAVIGATING TREATMENT
To avoid giving burn patients too much intravenous fluid, which can create swelling that can cause life- or limb-threatening complications, the Burn Center developed Burn Navigator, manufactured by Arcos Medical Inc. The bedside computer helps guide resuscitation in burn patients. (U.S. Army photo)

ReCell has completed Phase III clinical trials, meaning that the Burn Center is waiting to hear from the U.S. Food and Drug Administration and the manufacturing company that the product is available for purchase and, therefore, clinical use. "As I understand, that will happen pretty soon," Cancio said.
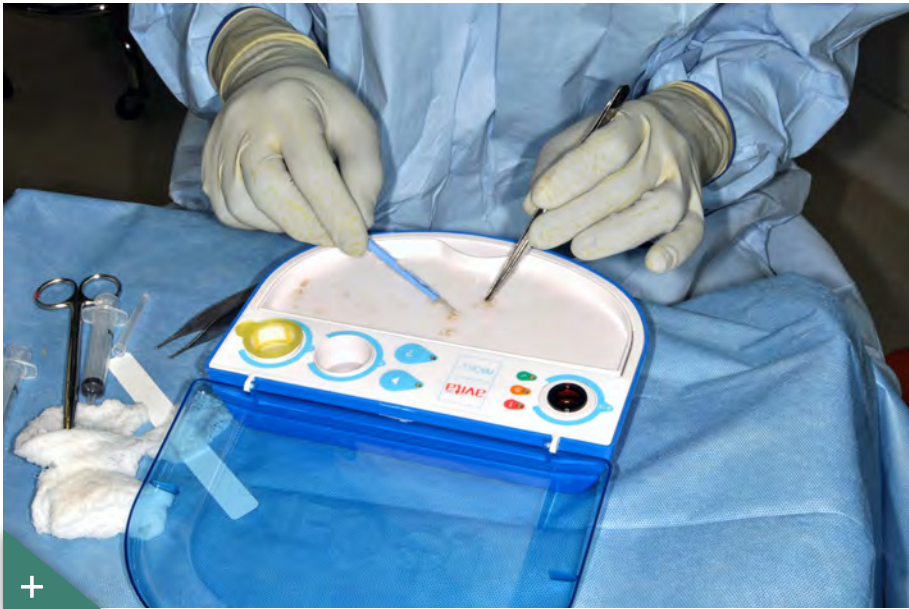
SPRAY-ON SKIN
The Burn Center participated in the clinical trials of ReCell, a technology that deconstructs a small biopsy of a patient's skin and dilutes it in a solution that can then be sprayed onto a wound. From there, the patient's skin cells will populate the wound and regrow skin. (U.S. Army photo)

StrataGraft is a ready-made, off-the-shelf skin substitute comprising two layers. One layer is an epidermal component—the outermost layer—and the other layer is a dermal component, the layer of tough connective tissue beneath the surface. "The epidermal component is derived from an immunologically privileged epidermis from neonates called NIKS cells. Those cells will not be immunologically rejected by the patient, unlike every other type of skin we might transplant from somebody else to a patient," Cancio said.

NIKS, or near-diploid immortalized keratinocyte skin, is made with keratinocytes, cells that make up the vast majority of natural human skin and primarily protect skin from environmental damage, like bacteria.

NIKS cells used in the StrataGraft treatment "are basically a special type of skin cell that comes from somebody else and we put them on the patient's excised wound bed and, ideally, this technology will go ahead and become part of the patient. And then over time, the patient's own skin cells will grow into the product and replace the epidermal cells from somebody else with the patient's own cells," Cancio said.

StrataGraft is still in clinical trials, Cancio said. The Burn Center is participating in two of those trials; one to evaluate the product in patients with partial-thickness (second-degree) burns and another to evaluate the product in patients with full-thickness (third-degree) burns.

UNIVERSAL MODEL
The Burn Center has expanded its mission in the decades since 1970, from focusing almost exclusively on burns to encompassing many aspects of mechanical trauma as well as burn injuries.

"In a very real sense, the burn patient is the universal trauma model," Pruitt said.

"That is, everything that happens in the burn patient, in terms of organ system dysfunction, pretty much happens in mechanical trauma patients." Patients who are shot, for example, experience the same changes that burn patients experience, except that mechanical trauma patients' experiences are accelerated, causing life-threatening changes at a faster rate.

"So, the mission of the unit has expanded to include all of trauma, including combat injury patients, and it has, in the last several years, become the center of combat casualty care research by the integration of all three military services, Army, Navy and Air Force," he said.

The National Defense Authorization Act for Fiscal Year 2017 mandated that the primary mission of the military health system is readiness, Cancio said. The center continuously brings in medical personnel from all over the armed services for team training. "We believe that this burn center contributes significantly to training people to be prepared to deploy to the combat zone and take care of severely injured patients," he said.

The complexity of burn care is not just restricted to a skin problem. Major burns impact all organs and systems of the body, Cancio said, from the psychological, to the heart, lungs, kidneys and the patient's ability to function from a physical and occupational therapy standpoint. "All those organ systems are affected by burn injury, so whether you're a critical care nurse, a surgeon, whether you're an occupational physical therapist or another therapist, respiratory therapist, you get excellent exposure to very critically ill patients at this Burn Center, so we feel that our training mission has only intensified

with the publication of a mandate to focus on readiness," Cancio said.

In recent years, the Burn Center hosted eight Japanese doctors who have gone on to be prominent burn surgeons and trauma surgeons in their home country, Pruitt said. Two Belgian army surgeons came to study, staying for six months each. The center also hosted the surgeon general of Norway, he said.

CONCLUSION

Pruitt, who retired from the Burn Center as a colonel after 27 years there, still teaches surgery at the Burn Center one day a week. He is particularly interested in the research and clinical studies the center

" In the 1940s and '50s, an otherwise healthy adult with burns over 40 percent of his body had a 50-50 chance of surviving. Today, if you have an 80 percent burn, you have a 50-50 chance. "

has expanded into, such as the proper amount of resuscitation (intravenous) fluid for patients, computer-guided resuscitation and the mitigation of inhalation injury. Cancio is active in the management of the inhalation injury and computer-guided resuscitation programs.

During the early parts of the wars in Iraq and Afghanistan, medical staff at the Burn Center noticed some burn patients were receiving too much resuscitation fluid in the first 24 to 48 hours after injury, Cancio said. The fluid is required to replace ongoing losses to the injured tissue and elsewhere in the body. "Some patients received a quarter of their body weight in saltwater over one day. When this fluid leaks into the arms, legs or abdomen, too much swelling can cause life- or limb-threatening problems," he said.

To help avoid over-resuscitation and better guide resuscitation decisions, the Burn Center developed a computer called Burn Navigator, manufactured by Arcos Medical Inc. of Houston. "This product made it through the Army product acquisition process for use in battlefield medical treatment facilities and is also available commercially around the world," Cancio said.

Combat casualties in the same wars experienced smoke inhalation injury rates that were twice as high as those in civilian burn centers because of the use of improvised explosive devices on personnel in vehicles. "To improve the care of patients with these and other severe lung injuries, the Army Burn Center became the home of a new program in adult extracorporeal membrane oxygenation [ECMO]," he said. ECMO uses a pump to circulate blood through an artificial lung, removing carbon dioxide and oxygenating blood cells, which reduces the stress on the patients' organs and helps them heal.

Cancio is quick to say that much has happened in the years since the publishing of the 1970 article and that there are many good burn centers across the country and worldwide; however, "many of the directors of burn centers across the U.S. in fact trained at this burn center throughout the period of time both before and after the article was written, and I think that's one of the big contributions of this burn center to the quality of burn care. It didn't just stay at one center, but it extended to other places through the training efforts of our predecessors," he said.

Pruitt believes the Burn Center has had a demonstrable effect on the survival of many burn patients who otherwise would have died without the advances in clinical care and research the Burn Center provided over the years. In conventional warfare, particularly if there are lots of armored fighting vehicles, the number of burns ranges from one in 20 to one in five casualties, Pruitt said. "That's why the Army has a real reason to continue to be the leader in burn and trauma research … the high incidence of burn injury as related to the type of warfare involved is a real reason for maintaining the support of the Institute of Surgical Research and Burn Center."

*For more information, go to **http://www. usaisr.amedd.army.mil/12_burncenter.html**.*

MS. JACQUELINE M. HAMES is a writer and editor with Army AL&T magazine. She holds a B.A. in creative writing from Christopher Newport University. She has more than 10 years of experience writing and editing for the military, with seven of those years spent producing news and feature articles for publication.

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Dr. Bruce D. Jette
Assistant Secretary of the Army for
Acquisition, Logistics and Technology

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