Summer 2010 Edition

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Systems Engineering:

Managing Technology Integration — Delivering Life Cycle-Balanced Systems Solutions

Systems Engineering Is a Foundation for Our Collective Work

This issue of *accelerate* marks an important evolution in our development of a Ground Systems Enterprise. The focus throughout this issue is the intersection and underpinning of all we do in this enterprise — systems engineering and integration. Systems engineering has always been the foundation for our collective work and how, as one community, we are dedicated to applying its methods and principles to platform and component development. This community is revolutionizing system-of-systems integration and redefining systems engineering processes for the next generation of ground combat and tactical vehicles.

While this expertise is spread throughout our community, systems engineering is the cornerstone for supporting the U.S. Army Materiel Command and its overarching Materiel Enterprise, the U.S. Army TACOM Life Cycle Management Command (LCMC), U.S. Army Research, Development and Engineering Command (RDECOM) and our Program Executive Office (PEO) and Program Management Office (PMO) partners. Since day one, these respective leader teams have been dedicated to strengthening the community's capabilities to rapidly support acquisition programs and accelerate systems engineering and integration into everything we do for Department of Defense Joint programs, the Army and the Soldiers we support.

To drive that point home, the *Weapon Systems Acquisition Reform Act of 2009* clearly articulates the critical importance systems engineering brings to the acquisition process and how it provides the robust analyses and technical assessments needed for informed decision making. The act reinforces the absolute necessity for systems engineering in accurately estimating a program's operational requirements, life cycle costs and acquisition or production schedules. This system-of-systems engineering approach expertly infuses the necessary analysis for the overall systems affected within the broader context of the corresponding system deployment. It takes a more disciplined approach up front to ask the right questions to determine customer requirements and develop the best solutions based on that information. This time investment at the beginning of the process will result in a better engineered product or system with fewer design or capability challenges later on. It is this iterative analytical exchange between the principle stakeholders, PEOs and PMOs, warfighters' user representatives, technologists, logisticians, testers and business planners that creates the right requirements that, in turn, lead to successful platform and systems development and integration of game-changing ground vehicle technology solutions.

A crucial aspect that will guarantee both the program's and the enterprise's continual success is the synergy provided by networked information gathering systems and centralized data warehousing. In order to fulfill the vision we have, the community created the Joint Center for Ground Vehicles (JCGV). Collaboratively formed by elements within the TACOM LCMC, specifically PEO Ground Combat Systems, PEO Combat Support and Combat Service Support, PEO Integration, RDECOM-TARDEC, and the U.S. Marine Corps PEO Land Systems and Marine Corps Systems Command, the JCGV's goal is to institutionalize systems integration excellence to achieve the best value for warfighters. The JCGV is, in part, a response to the 2005 Base Realignment and Closure report. However, we have formed this Joint Center because we, as the leaders of these organizations, firmly believe it is the right thing to do. Emerging operational requirements and ever-changing threats to our national security compel us to develop conduits for rapid information exchange and engineering solutions. By utilizing standardized systems engineering and integration, common service providers and integrated portfolio analysis, the JCGV will provide better planning information and help align resources and initiatives within the ground community in ways we have not achieved as individual organizations. The same principles that guide physical system development are providing the methods for developing the JCGV's organizational infrastructure elements and business process integration functions because, after all, the enterprise is a system itself.

Our commitment as a community to addressing these challenges from a systems-wide perspective will help us successfully deliver the most advanced ground vehicle technologies possible, ensuring our Soldiers are the most lethal, survivable and sustainable fighting force for generations to come.

Dr. Grace Bochenek
TARDEC Director

Summer 2010

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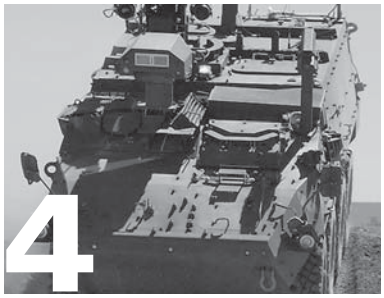
On the Cover: The arrow defines the path that the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) systems engineers follow through modeling and simulation, testing, design, prototyping and the final Integrated Survivability Demonstrator (ISD) on a Family of Medium Tactical Vehicles truck platform. The ISD will test multiple survivability and Soldier-protection and situational awareness technologies. This issue of *accelerate* Magazine is focused on the detailed systems engineering process and the benefits it brings to the Army's research, development and engineering programs. The ISD is one example of the cross-service, cross-command, systems-engineering approach TARDEC and its partners use to integrate technology solutions for Soldiers.

Michael I. Roddin
Editor-in-Chief



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Improving the Combat and Tactical Vehicle Fleet Through Systems Engineering Integration and Force Modernization

The Defense Acquisition University defines *systems engineering* (SE) as "an interdisciplinary engineering management process that evolves and verifies an integrated, life cycle-balanced set of system solutions that satisfies customer needs. It clearly is at the heart of the systems acquisition process, and the Department of Defense [DOD] relies heavily on systems engineers to provide technical support to program managers." That reliance is entrusted to the engineers, scientists and technicians who support the Ground Systems Enterprise.

This edition of *accelerate* Magazine will take an informative look at SE and systems integration (SI) from both a user *and* engineer perspective to highlight the unique tools, methods, metrics and well-engineered processes that systems engineers use to design, build and then sustain highly complex life cycle systems. Several articles discuss the collaborative approach program management teams take for identifying and quantifying system-of-systems goals, creating design concepts, performing design trades and then selecting and implementing the best integrated technology solutions to successfully bridge potential capability or performance gaps in original design specifications or address user-generated requirements. Likewise, this edition explores how systems engineers use modeling and simulation techniques to validate assumptions using warehoused test and design data early in a vehicle system's development process.

Articles of interest you won't want to miss follow:

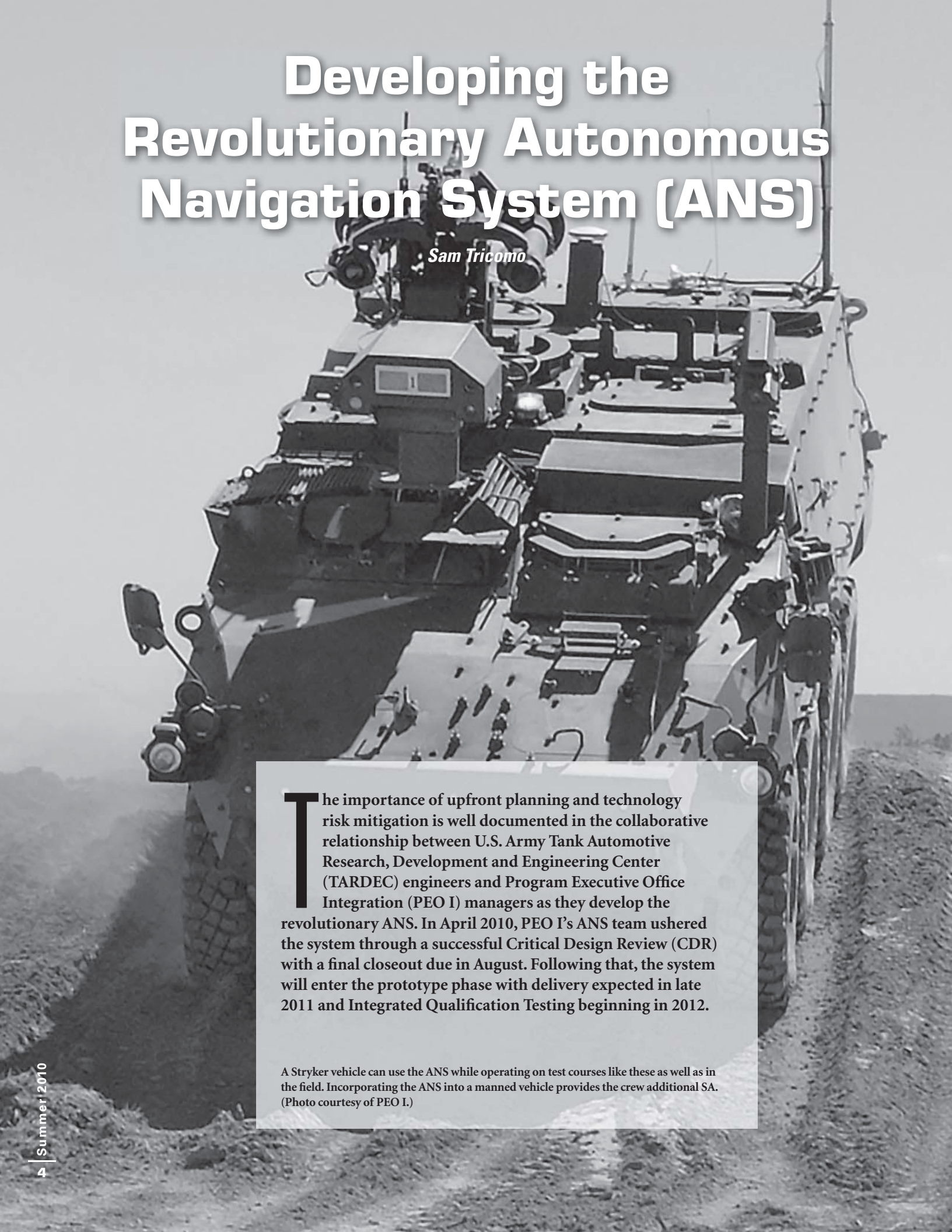
- **The Logistics Modernization Program and Soldier Safety and Security — MG Kurt Stein Makes Warfighters His Top Priority** — U.S. Army TACOM Life Cycle Management Command (LCMC) Commanding General MG Kurt Stein defines the TACOM LCMC's role in the Army's acquisition, logistics, sustainment and technology business. Stein discusses the Army Force Generation process, RESET and future logistics streamlining to better support the Army Modernization Strategy.
- **'Insight, Not Just Oversight' — Following DOD Lead, Embedded Systems Engineering Provides the Framework for Solid Decisions** — TARDEC's Magid "Mag" Athnasios, Executive Director, Engineering, discusses the science behind SE and integration (SE&I) and how and why SE&I is a central part of the U.S. Army Research, Development and Engineering Command.
- **Systems Engineering Panel Convenes at TACOM LCMC** — TACOM LCMC systems engineers held a candid discussion about the values and challenges of using the SE process. This panel, comprised of members from across the Ground Systems Enterprise, offered an insider's view of the Detroit Arsenal's SE processes, challenges and successes.
- **TARDEC is Right on TARGET** — TARDEC's Heather Molitoris explains the new stage-gating process. The process will help TARDEC enforce SE through both the acquisition and science and technology domains.
- **Encounter Avoidance — Protecting and Sustaining the Tactical Wheeled Vehicle (TWV) Fleet** — The Ground System Enterprise's extensive analysis and development of the Tactical Wheeled Vehicle Survivability (TWVS) Army Technology Objective demonstrators incorporated community collaboration, partnership and detailed SE&I to successfully produce more than 50 potential technology solutions to better protect Soldiers and equipment.

This edition's articles focus on the awesome analytical and assessment capabilities the Ground Systems Enterprise's collaborative partners, engineers and program managers are integrating into life cycle systems to improve Soldier safety, situational awareness and survivability, in a fluid, rapidly changing operational environment. Thanks to the people behind the processes, this community is committed to delivering the most technologically advanced and integrated solutions to ensure our warfighters are protected by the best vehicle systems and equipment imaginable.

Michael I. Roddin
Editor-in-Chief

Developing the Revolutionary Autonomous Navigation System (ANS)

Sam Tricomo



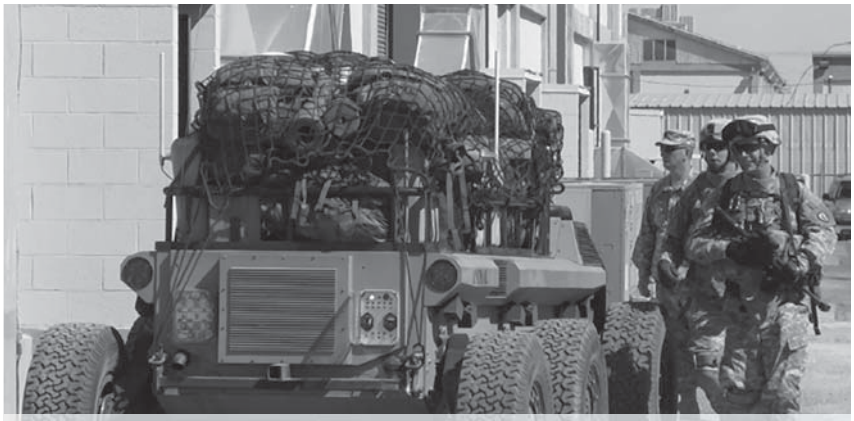
The importance of upfront planning and technology risk mitigation is well documented in the collaborative relationship between U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) engineers and Program Executive Office Integration (PEO I) managers as they develop the revolutionary ANS. In April 2010, PEO I's ANS team ushered the system through a successful Critical Design Review (CDR) with a final closeout due in August. Following that, the system will enter the prototype phase with delivery expected in late 2011 and Integrated Qualification Testing beginning in 2012.

A Stryker vehicle can use the ANS while operating on test courses like these as well as in the field. Incorporating the ANS into a manned vehicle provides the crew additional SA. (Photo courtesy of PEO I.)

"The ANS Team has done a remarkable job in both the development of the system and the conduct of the CDR," remarked LTC Jay Ferreira, Product Manager for Unmanned Ground Vehicles (UGVs) for PEO I. "Autonomous navigation is a very complex and challenging problem. ANS is the only program of record in the Army currently working to address it. The current ANS design is 95 percent compliant. When you put it into context, there are 811 individual requirements for the ANS system. This accomplishment is attributable to a lot of hard work put in by the team. Though approval has been granted to proceed at the CDR, there are some remaining technical issues to close out," Ferreira continued. "The remaining issues do not represent significant risk to the overall system."

"The ANS is an onboard, integrated suite of sensors and technology that enable autonomous navigation, perception, path-planning and vehicle-following capabilities for UGVs, allowing them to move on the battlefield with minimal human oversight," lead ANS Project Engineer Lenny Hennebeck explained. "It is an important addition to the Army's modernization efforts because it serves as the primary sensor and navigation system for the Army's XM1219 Armed Robotic Vehicle/ [ARV] Assault-Light [ARV-A-L] and the robotic Multifunction/ Utility/Logistics and Equipment [MULE] vehicle."

Under the system, vehicle sensors are located in perception modules, each one a cluster of three daylight, infrared and low-light cameras. Platforms such as the ARV and MULE will be equipped with four perception modules, one on each side of the vehicle. The front and rear modules are augmented with light detection and ranging systems to map the terrain directly ahead of and behind the vehicle. The ANS also features a millimeter wave radar on the front of the robot to track moving vehicles and approaching objects. Additional features include global positioning systems and inertial navigation capabilities. The ANS computer manages the robot's path planning, video processing, object processing, sensor processing, and speed and curvature controls.



Soldiers of the Army Evaluation Task Force at Fort Bliss, TX, test the MULE, a 3-ton unmanned ground system designed to support dismounted, mounted and air assault operations. The ANS system, an onboard, integrated suite of sensors and technology that enable autonomous navigation, perception, path-planning and vehicle-following capabilities, will be the primary sensor and navigation system for the MULE. (U.S. Army photo.)

For planned missions, the software interprets commands from an external operator. Using geospatial data, the ANS computes the best path through waypoints provided by the operator. Using its sensors, an ANS-equipped vehicle will avoid obstacles while navigating to the waypoints. The system continuously revises routes to find the easiest path to an objective and provides position data and motion commands to the vehicle in the autonomous mode. Incoming sensor data is processed by the onboard computers and software to detect, avoid and track obstacles, people and other vehicles. The system also provides Soldiers with a situational awareness (SA) virtual presence for vehicle survivability and precision weapons aiming and pointing systems for the ARV's armament.

"Think about when you drive your car," Ferreira mused. "You perceive and gauge traffic density, speed, distance, obstacles, terrain and weather to navigate a route that is or is not familiar. Imagine the number of computations and decisions the human brain must make in an instant. They determine your body's responses, which results in the safe operation and navigation of your car. Now, imagine a system that must replicate that active decision making and situational awareness capability," he explained. "All of it being done in a real-time, dynamic environment to safely control an unmanned vehicle. It's pretty remarkable and challenging."

The ANS program took a holistic approach to the system's development with program building and testing done in increments. In 2004, TARDEC's Near Autonomous Unmanned System (NAUS) Army Technology Objective (ATO) built on the

The ANS is an onboard, integrated suite of sensors and technology that enable autonomous navigation, perception, path-planning and vehicle-following capabilities for UGVs, allowing them to move on the battlefield with minimal human oversight. (Photo courtesy of PEO I.)

concept of semiautonomous leader-follower technology to achieve dynamic robotic movement in tactical formations. This technology is identified as important to the fight Soldiers will face in the future as the Army continues to seek technological solutions for protecting its fighting force. More than 10,000 robotic systems are presently serving Soldiers, with a majority deployed to Iraq and Afghanistan. Of these systems, UGVs are often used in explosive ordinance disposal, route clearance and reconnaissance missions.

This TARDEC ATO was focused on addressing (then) Future Combat Systems' (FCS's) risks associated with local SA, tactical behaviors and self-security for the ARV system. The ATO also addressed risks for the FCS MULE and the FCS ANS related to ANS robotic platform integration as well as UGV safe operations.

In 2006, the Army reorganized its research structure to combine similar efforts under broader categories. As part of this effort, ARV robotic technology was combined with an advanced UGV perception program at the Army Research Laboratory and a UGV armament program at the Armaments Research, Development and Engineering Center.

This new combined effort was titled the NAUS ATO. The NAUS ATO became the single program of record for U.S. Army Research, Development and Engineering Command technologies being developed for the FCS UGV community with a primary focus on the ARV. In FY07, the FCS ARV program was deferred and sent to science and technology (S&T) for further S&T refinement. This new S&T effort was titled the Robotic Vehicle Control Architecture (RVCA) and was staffed through TARDEC. To support this new S&T objective, TARDEC refocused its portion of the NAUS ATO toward advancing key enabling technologies in the areas of UGV Formation Control (FC) and Self-Security (SS). FC and SS are both underdeveloped UGV capabilities that were high on the FCS ARV list of technological risks.

Most recently, the RVCA helped PEO I by testing ANS on a large platform and by examining bandwidth constraints. "Working with PEO I, RVCA has integrated a suite of system control, display and sensing hardware and software onto the Autonomous Platform Demonstrator (APD) that allow it to be controlled real-time by a Soldier, or operated in an autonomous mode," said TARDEC RVCA Program Manager Chris Mocnik. "We have been able to prove the system at much higher speeds than ever before."

The APD is a 9.6-ton, 6-wheeled, hybrid-electric (HE) robotic vehicle with an advanced HE drivetrain that can achieve speeds of more than 50 miles per hour. When equipped with ANS, the APD is configured with GPS waypoint technology, an inertial measurement unit and computer algorithms that enable it to move autonomously while avoiding obstacles in its path.

An APD maneuvers over concrete blocks outside of a TARDEC building at the Detroit Arsenal. The APD is helping TARDEC engineers develop, integrate and test next-generation UGV mobility technologies. (U.S. Army TARDEC photo by Carolyn Baum.)

Additional equipment on a Stryker gives its operators enhanced SA. PEO I and its partners provide research into this new equipment to support Soldiers and Marines and assist them in making more informed decisions in the field. (Photo courtesy of PEO I.)

"The ANS program significantly benefitted from this S&T collaborative effort. TARDEC's work through development, experimentation and data collection using prototypical ANS hardware and software really helped us mitigate technical risk. It is one of the better relationships I've seen between the S&T and program communities," Ferreria said.

Prior to using the APD, ANS concepts were proven on the Crusher, a 6-wheeled, HE vehicle weighing 14,000 pounds. "While Crusher really helped us test and prove several concepts, we really could not get the kind of speed required out of it," Mocnik explained. "With the APD, we are very able to test at those higher speeds."

Other accomplishments TARDEC's RVCA program has helped PEO I achieve within the ANS sphere include:

- Developing and refining battle command ANS software.
- Leveraging warfighter machine interface components and transitioning architecture to follow-on programs.
- Conducting a Soldier operational exercise to gain valuable user feedback on system performance during mission scenarios conducted on relevant terrain.

According to PEO I Deputy Product Manager for UGV Development Dan Folk, the ANS program's next step will be integrating the ANS onto the ARV. The ARV's CDR is scheduled for October 2010. For the next six months, the ANS and ARV teams will work together to ensure that their requirements are synchronized. After the ARV CDR, the program will begin building prototype platforms on which the ANS system will be integrated and tested in early 2012.

When the ANS is incorporated into a manned vehicle such as a Stryker, the cameras and sensors add to the crew's SA by providing a wide-angle view through onboard monitors. The vehicle's driver can navigate by looking at the screen rather than the vehicle's periscopes.

Some tasks the system already performed in RVCA tests include move-on-route, obstacle detection and avoidance, and leader/follower capabilities under both day and night conditions. Designated by the Army for integration on the ARV-A-L, the ANS has also been tested on vehicles including Strykers, MULE Engineering Evaluation Units and Light Medium Tactical Vehicles (LMTV).

"The ANS system can be integrated on virtually any manned platform in the Army and United States Marine Corps inventory, as demonstrated with the integration on the Stryker, Family of Medium Tactical Vehicles and LMTV platforms," Ferreira continued. "The key is integrated. It isn't a strap-on system. Each platform requires some unique modifications to the steering, braking and acceleration to enable robotic operations. This is commonly known as converting a vehicle to drive-by-wire. Once that is done, ANS can be integrated on the vehicle to operate it in a teleoperated or semi-autonomous environment," he concluded.

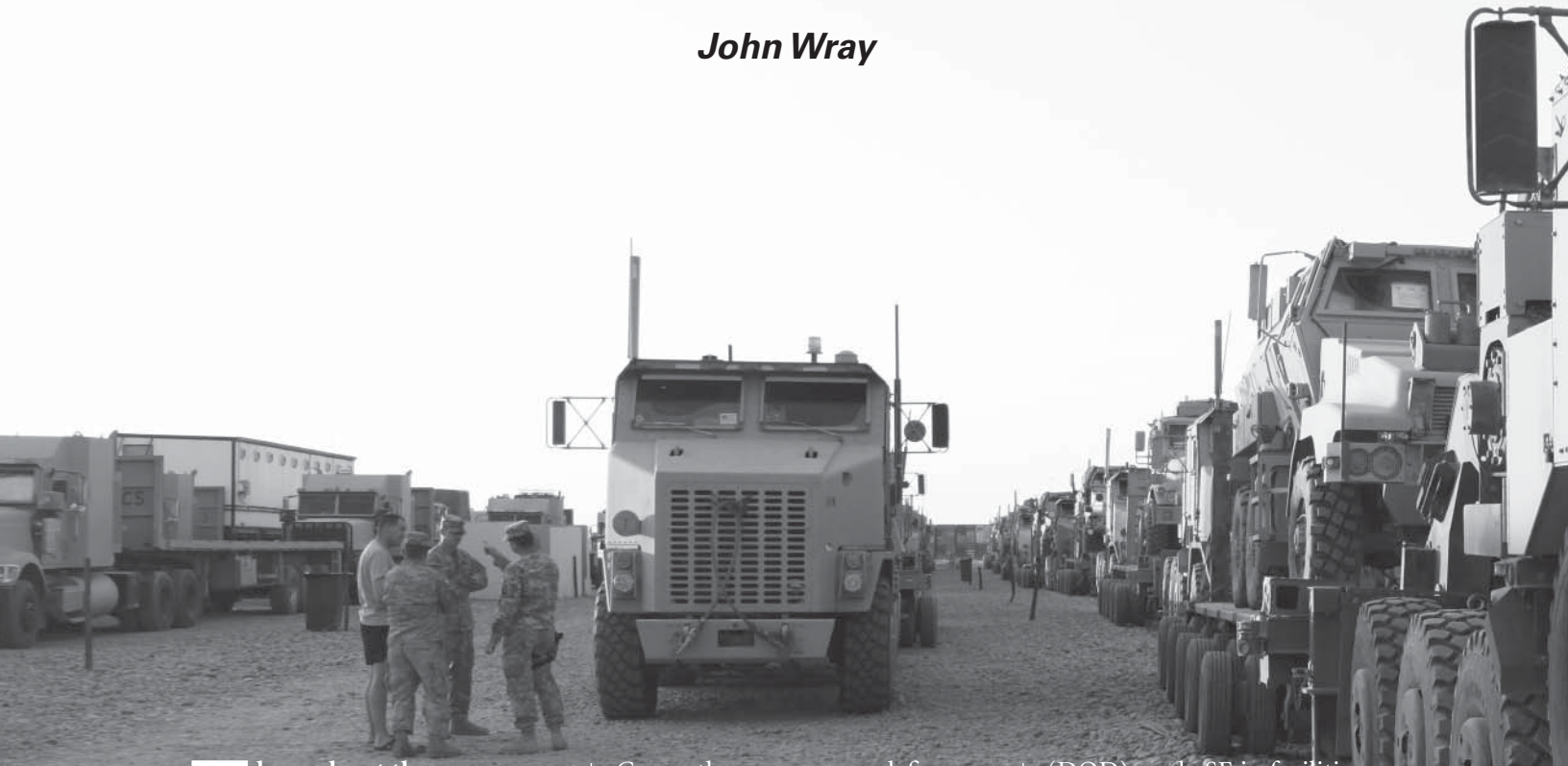
"TARDEC's work through development, experimentation and data collection using prototypical ANS hardware and software really helped us mitigate technical risk. It is one of the better relationships I've seen between the S&T and program communities."

Sam Tricomo is a contractor supporting strategic communications for PEO I. Prior to joining PEO I, he worked as an investigative and automotive reporter in Michigan. He holds a B.S. in public relations and crisis communications from Western Michigan University.

‘Insight, Not Just Oversight’ —

Following DOD Lead, Embedded Systems Engineering Provides the Framework for Solid Decisions

John Wray



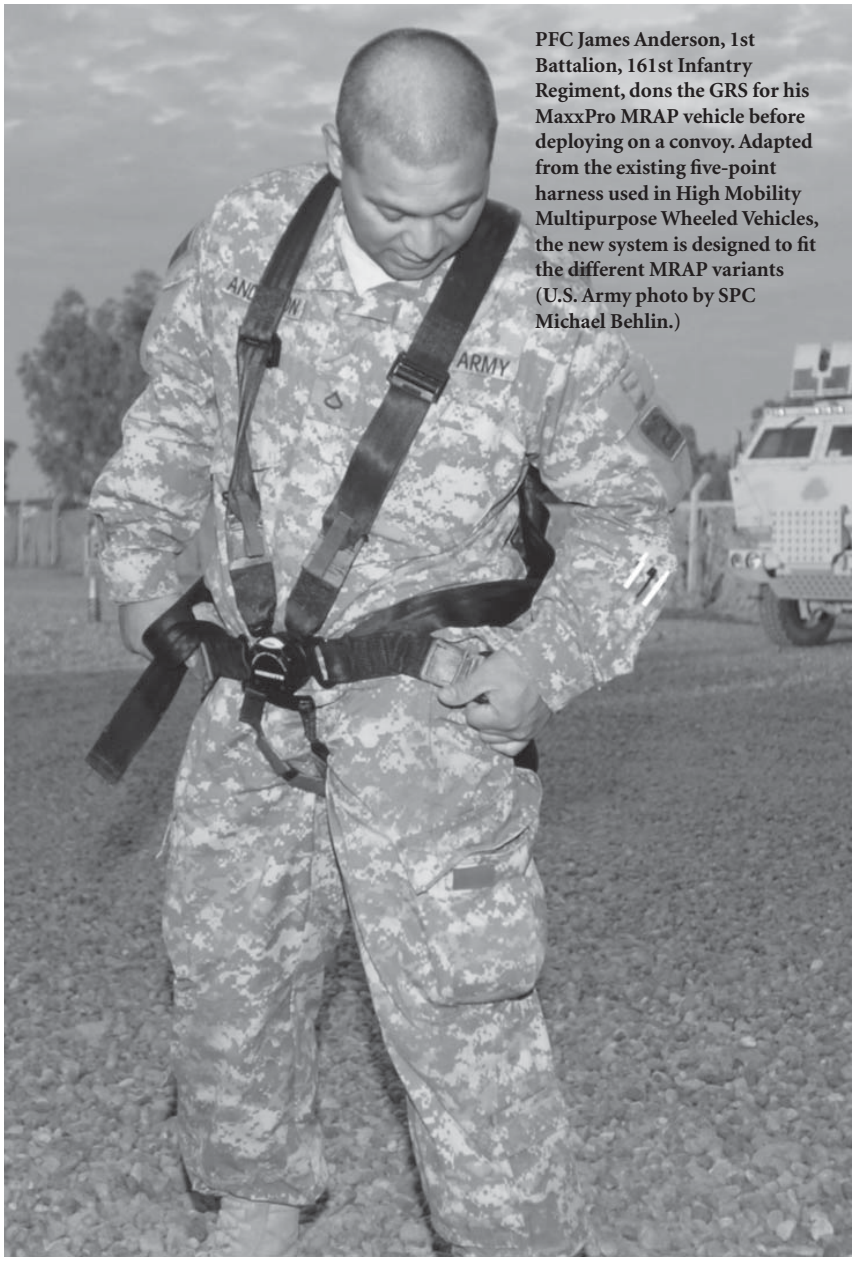
Throughout the manufacturing and business communities, the term systems engineering (SE) has been defined in a variety of ways. In 2004, the International Council on Systems Engineering (INCOSE) defined SE as, “An interdisciplinary approach and means to enable the realization of successful systems.”

Three years later, renowned British SE Professor Derek Hitchins published this definition — “The Art and Science of creating effective systems, using whole-system, whole-life principles.”

Currently, *answers.com* defines SE as, “The design of a complex interrelation of many elements (a system) to maximize an agreed-upon measure of system performance, taking into consideration all of the elements related in any way to the system, including utilization of worker power as well as the characteristics of each of the system’s components.”

While no one definition can possibly capture all the components or benefits of SE concisely, each provides a clue as to how systems engineers within the Department of Defense (DOD) apply SE in facilities around the globe. The U.S. Army Tank Automotive Research, Development and Engineering Center’s (TARDEC’s) Executive Director for Engineering Magid “Mag” Athnasios suggests a definition that views SE as an underlying set of ideas and tools. “As TARDEC followed the lead from DOD and the U.S. Army Research, Development and Engineering Command [RDECOM], SE works best for us as a framework for the ground systems domain to align science and technology objectives to meet the mission needs of the warfighter,” explained Athnasios.

National Guardsmen from the 1483rd Transportation Company, 541st Combat Sustainment Support Battalion, Taji, Iraq, prepare for the transport of MRAPs to Joint Base Balad, April 14, 2010. The Gunner Restraint System, specifically designed for MRAP vehicles, is a major RDECOM SE collaboration success story. (Joint Combat Camera Center – Iraq photo by SGT Jason Stewart.)



PFC James Anderson, 1st Battalion, 161st Infantry Regiment, dons the GRS for his MaxxPro MRAP vehicle before deploying on a convoy. Adapted from the existing five-point harness used in High Mobility Multipurpose Wheeled Vehicles, the new system is designed to fit the different MRAP variants (U.S. Army photo by SPC Michael Behlin.)

Business Reform Leads to Positive Change

The revitalization of SE for RDECOM can be traced directly back to 2004 and the Under Secretary of Defense for Acquisition, Technology and Logistics' issuance of SE policies that were directly aimed at the acquisition community. In April 2007, RDECOM issued a policy applying SE to all science and technology (S&T) programs. In September, TARDEC formalized its SE policy. To view the policy, visit: **https://acc.dau.mil/CommunityBrowser.aspx?id=153117**.

"SE works best for us as a framework for the ground systems domain to align science and technology objectives to meet the mission needs of the warfighter."

In accordance with this policy path, the *Weapon Systems Acquisition Reform Act of 2009* was created to amend the way in which the Pentagon contracts and purchases major weapons systems and was signed into law May 22, 2009. President Barack Obama called the act "a very important step in creating a government that is more efficient, more accountable and more responsible in keeping the public's trust." The bill, which passed both the House of Representatives and Senate unanimously (411-0 and 93-0, respectively), puts more emphasis on testing technologies before they enter production and aims to save billions of dollars in wasteful projects and potential cost overruns. "Following that direction, we were able to both stand up an SE control hub and embed that thinking and resource across our organization," said Athnasios. "Now, SE is truly part of who we are and how we do business. It plays a role in all corners of TARDEC and across lab entities. For example, there is a Life Cycle Management Command [LCMC] SE integration team in which we play a role," Athnasios continued. TARDEC has SE and Integration directors at multiple program executive offices (PEOs), including PEO Ground Combat Systems, PEO Combat Support and Combat Service Support, and PEO Integration.

Developing a Customer-Focused Approach

At TARDEC, there is a strong and growing SE group founded by TARDEC Associate Director Edward Andres and now led by Associate Director Tony McKheen. The group is divided into three parts:

- SE Process Team
- SE S&T Support Team
- SE Program Support Team

This entire assembly is a member of national organizations, including INCOSE, and is

fostering SE awareness and knowledge at events such as the 2010 National Defense Industrial Association's Ground Vehicle Systems Engineering and Technology Symposium — a forum for the convergence of DOD, industry and academic expertise — at which TARDEC hosted an SE mini-symposium to delve deeper into SE issues. Further participation includes the NASA/Army Systems and Software Engineering Forum at the University of Alabama and the Army Systems Engineering Forum at Fort Hood, TX. Athnasios noted that, with each team, SE begins and ends with the customer. "When properly deployed, SE enables discussion, lends analysis to decisions and lays a foundation for accurate decisions," he explained. "Instead of oversight from an after-the-fact evaluation, SE gives the insight to make the right decisions."

"Now, SE is truly part of who we are and how we do business. It plays a role in all corners of TARDEC and across lab entities."

When asked for a TARDEC SE success story, Athnasios quickly pointed out the Gunner Restraint System (GRS). In one weekend, an Army enterprise collaboration team pulled together its resources to deliver a Mine Resistant Ambush Protected (MRAP) vehicle GRS to warfighters in the field. That group included warfighters, Project Manager MRAP, the U.S. Army TACOM LCMC, TARDEC, Edgewood Chemical Biological Center, Aberdeen Test Center, Blue Grass Army Depot and MRAP vendors. With a multipoint

The MRAP GRS, shown here strapped to a Soldier, improves the turret gunner's safety in MRAP vehicles. TARDEC engineers and collaborative enterprise and industry partners designed and developed critical solutions to meet operational requirements in record time for DOD's fleet of MRAP vehicle variants. GRS technology is also being factory installed on all MRAP All Terrain Vehicles being deployed to Southwest Asia. (U.S. Army photo.)

restraint harness and retractor, the system increases safety and security for Soldiers in a battlefield environment. While turnaround on that project was extremely fast — it was urgently reported Sept. 26, 2008, and the product shipped to theater Oct. 2 — Athnasios emphasized that SE principles were still applied and were beneficial. "SE, as a set of tools, can be modified and tailored," he remarked. "It doesn't have to slow anything down and should never be perceived as an obstacle."

Is SE here to stay at TARDEC? "SE was a paradigm shift for TARDEC," Athnasios remarked. "Before we were wrapped up in performance perspectives — now we know what goes into building a system and how it really works. Every advanced technical objective has an SE plan. SE is part of what we do and who we are, and that way of work is here to stay. Not only is the work here to stay, but SE has emerged as one of the best jobs to have in the U.S."

A recently released study by Focus, a California-based research and analysis group, determined that "systems engineer" is the best job when evaluated against positions that will achieve growth in demand by 10 percent or more over the next decade, according to U.S. Bureau of Labor Statistics estimates. Focus excluded positions that did not require at least a bachelor's degree and two to seven years of experience.

"SE is part of what we do and who we are, and that way of work is here to stay."

"For the right mindset, SE really is a rewarding field in which to work," Athnasios continued. "At TARDEC, we have a list of desired skills that includes knowledge of manufacturing, logistics, maintenance, operations and support concepts. But, above all, we're looking for 'systems thinkers' with excellent communication and interpersonal skills," he concluded.

John Wray is a Media Relations Manager with BRTRC and provides contract support to TARDEC's Strategic Communications team. He holds a B.A. in communications from Michigan State University.

Achieving True Systems Integration

Understanding the scope of an integration problem before beginning is critical when using robust systems engineering (SE) processes to achieve systems integration (SI). If a step is missed, all the work that follows will be suboptimal.

In the current Army, we have established both our fighting and force generation focus on Brigade Combat Teams, which:

- Are the set piece of Army force projection.
- Were converted to a modular structure to make them interchangeable with similar architectures and capabilities (plug-and-play units).
- Flow through Army Force Generation (ARFORGEN), which sets the ready and contingency force pools.

From this, we can deduce that we must concentrate on integrated unit capabilities. By doing this, we can field a complete capability package to units through ARFORGEN and can assure the brigade commander that the equipment has been engineered together, tested together, fielded as a package and is ready to take into collective training.

Often we use an extended metaphor where we assume that building a unit is analogous to building a house. For both, you need to understand the top-level requirements and constraints. For the unit, this is in the form of required unit capabilities, concept of operations and extant systems and architectures. For a house, it is family requirements translated into blueprints, lot size, existing furniture sizes and city building rules and limitations.

To begin the process for the unit, though, you must use SE to decompose and allocate requirements, publish the architecture views and define the systems-level specifications and interfaces. For the house, you hire a general contractor who interprets the blueprints and establishes subcontractor and material requirements.

In execution for the unit, you need system-of-systems (SoS) engineering oversight to ensure that the development of individual systems stays aligned and to make trades when and where problems are discovered. This effort will also work with system providers to integrate pieces in a build-up fashion (design integration through models, SI Laboratory integration and field integration and test). For the house, the general contractor ensures that the subcontractor's efforts stay aligned and makes trades and adjustments as problems occur. He or she coordinates key points along the process for building inspectors to validate that individual contractors (framing, electrical, plumbing, heating/cooling, etc.) have completed work to standard.

Until recently, the Army contracted for all systems individually with limited standards and knowledge of interfaces. The result was patchwork integration and, in some cases, units that were allowed to live with suboptimally integrated systems that could potentially inhibit the performance of other systems. If you took the same approach with the house, you'd hire all the trades separately and would stand a good chance of having the drywall installed before the electrical or plumbing was complete.

Scott J. Davis, Program Executive Officer
Program Executive Office Ground Combat Systems

A convoy of U.S. Army tactical vehicles drives through a sandstorm in Iraq. Employing a disciplined systems engineering and integration (SE&I) approach early in a program's development and acquisition cycles can help shorten those cycles and get important vehicle technologies to Soldiers faster. (U.S. Army photo by SSG Luke P. Thelan.)

Systems Engineering Panel Convenes at TACOM LCMC

Teresa Gonda

For this SE-focused issue, accelerate *Magazine convened a panel of experts from across the newly formed Joint Center for Ground Vehicles (JCGV) to discuss the importance of SE to the ground vehicle community, what, precisely, SE means and entails, and how it differs from SI. Panelists included members from the Joint Enterprise Development and Integration Advisory Council, the JCGV's key advisory council tasked with establishing policy and strategy with respect to SE&I issues. Members include: Bobbe Desmond, Assistant Program Executive Officer, SE and Technical Integration, Program Executive Office (PEO) Combat Support and Combat Service Support (CS&CSS); Tony Desmond, Director, SI/G7, PEO Ground Combat Systems (GCS); Clifton Boyd, Associate Director (AD), SE&I, PEO Integration (PEO I); Mike Burnett, Integration Engineer, U.S. Marine Corps (USMC) PEO Land Systems; John Phillips, Director, Strategic Initiatives, U.S. Army TACOM Life Cycle Management Command (LCMC); Ed Andres, outgoing Director, U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) Ground Domain Planning and Integration (GDPI); and Tony McKheen, AD for SE, TARDEC. Strategic Transformation Director and TARDEC JCGV Development Lead Teresa Gonda moderated the panel discussion.*

Q: What do you think the defining differences are between SE and SI?

Bobbe Desmond (BD): From the PEO perspective, what we think SE and SI are may be different from what other people think they are. SE is a whole functionality, and SI is the actual doing.

Teresa Gonda (TG): So, SE is a function, and the application of that is SI. In other words, you apply SE to do SI.

BD: The execution. Not just to the end of putting a widget out the door — it's to the end of putting a program out the door. You'll get arguments that logistics, support and testing are all separate functions, but they aren't. They all feed into how you design what you have to design, where the requirements are. … We've come to look at logistics as just one more specification requirement.

TG: So it's the difference between integrating a thing versus integrating a capability. If you're going to integrate a capability, you're forced to ask the questions some people may automatically ask when integrating a thing, but if you're integrating a capability into a system, you've really got to understand a lot more.

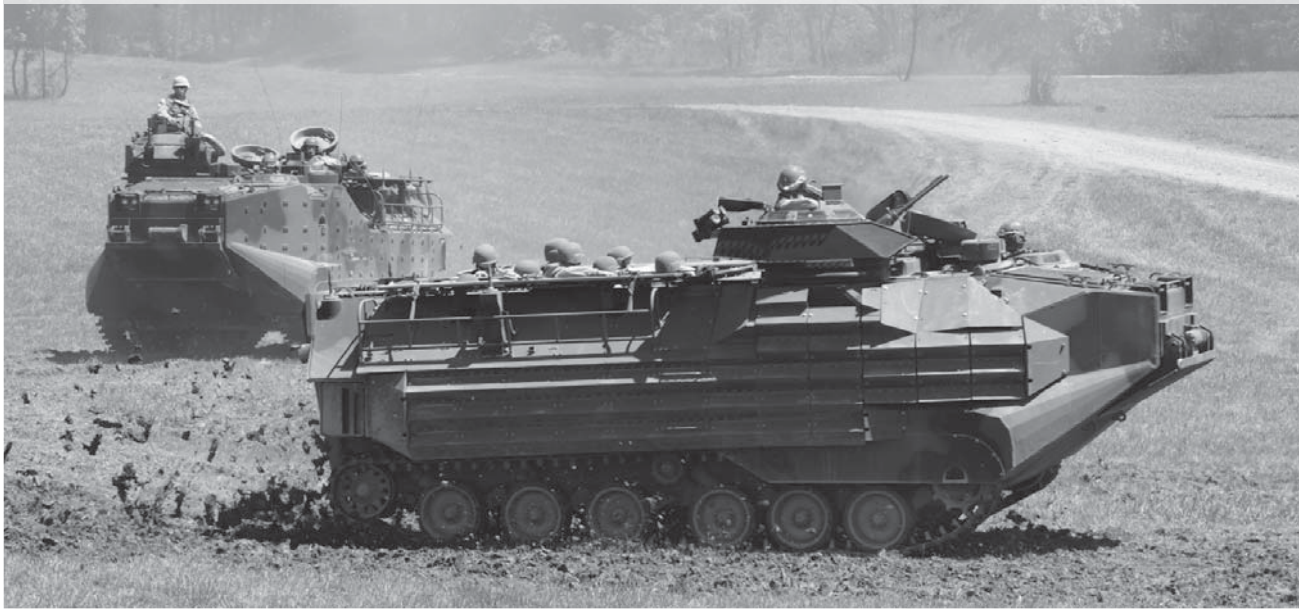
Tony Desmond (TD): I won't dispute what you're saying in terms of the definition. I will simply say that over the last couple of years, we've blurred the lines between engineering and integration. Integration is broader because it joins several processes that result in the overall capability. SE is, in my mind, all of the things I need to do. It is the technical process walk-through plus the technical management process in order to facilitate that whole series of additional integration functions.

SI includes coordination between two pieces of acquisition. The reach back with the U.S. Army Training and Doctrine Command [TRADOC] to ensure that you have tight coupling of concept and requirements generation and all of the supporting operations analysis, as well as the movement forward in the life cycle to make sure you have all of the necessary links for logistics, production and sustainment. Plus the links upward into the budget process and the Joint Capabilities Integration and Development Systems process.

BD: We agree on that. That's all part of the SE process, and integration is the implementation of that.

TD: The problem is that we keep trying to define one term over the other. SE is the process, and SI is the execution of the process. I'm not sure I agree with that.

There is a renewed emphasis on the importance of SE&I to the success of DOD ground combat and tactical vehicle programs. TACOM LCMC and USMC PEO Land Systems are working jointly to ensure an SoS approach is applied to all ground vehicle systems, such as the Amphibious Assault Vehicles shown here. (USMC photo by LCPL Jahn R. Kuiper.)



BD: You really can't separate the two. There are a lot of products that come out of the SE process. But, the end product is the integrated product, the integrated thing. They're one and the same.

Mike Burnett (MB): I'd define SE as the process and discipline that should and could be applied to the integration problem space. We've got to start doing that.

John Phillips (JP): I agree with everything I've heard. The reason we'd say we were systems integrators was because we didn't live in just one commodity area. We were responsible for integrating all aspects of all commodities, all aspects of the program from top to bottom. We always referred to that as SI and would refer to SE as the process that allowed us to do it, whether it was a single commodity or across all commodities.

Tony McKheen (TM): Integration means you're introducing a capability to the entire fleet, that you're doing more than just the engineering tasks or individual tasks.

Q: What is the particular importance of the roles of SE&I in the ground vehicle community in terms of developing the ground vehicle fleet?

TM: The *Weapons Systems Acquisition Reform Act* [*WSARA*] *of 2009* has certainly put it at the forefront. It has gone from something we knew we had to do to something we must be doing and doing it earlier. We must be doing this up front; we must do more of it. We must do it in-house — we must consider all of this.

"We need to manage our risk better and allow ourselves to have the flexibility to be more innovative."

— Teresa Gonda, Strategic Transformation Director and JCGV Development Lead, TARDEC

Now there is more of an awareness that we need to plan these things out better. We need to get better at thinking of everything up front, not just for a vehicle development program but for our fleet. It's making sure we have the plans in place for how we're going to do this so that these programs don't end up in dead ends. It means that the SI of a capability into the fleet is well thought out, has a good plan. You're doing the good SE of managing requirements creep, trying to freeze requirements and trying to keep it at a baseline so that it can support integration into the fleet.

TG: What I noticed about *WSARA* is that it tied all of the analysis to cost, and that makes sense because we don't do SE just to be disciplined for its own sake. There's a payoff. Like Tony said earlier, we want to avoid scope creep. If we really want to be able to finish an acquisition program these days, especially larger ones, we need to do our homework up front and use this analysis so that we get our costs right and really understand what we're going after.

Clifton Boyd (CB): Scott Davis, [Program Executive Officer, PEO GCS], is fond of using the analogy of building a house. If you're doing SI ahead of time, it's not just the plumber putting his

"SI includes coordination between two pieces of acquisition. The reach back with TRADOC to ensure that you have tight coupling of concept and requirements generation and all of the supporting operations analysis, as well as the movement forward in the life cycle to make sure you have all of the necessary links for logistics, production and sustainment."

— Tony Desmond, Director, SI/G7, PEO GCS

plan together and the electrician putting his plan together and then they both go into the house. Someone has to have an integration role to ensure the plumbing isn't running through the same holes the electrical is trying to go through before all the walls have gone up.

TM: You need to do the work up front and early in the process to make sure the plans are out there, and when a vehicle platform is introduced into the fleet, all the other items that go along with it are ready, as well. It's not just the platform but the training that's needed for that platform and the support tools.

It's making sure the plans are followed so that the plumbers and the electricians show up when they're supposed to and do what they're supposed to in the manner they're supposed to and the plans don't keep changing.

CB: SE is analogous with the architecture of the house. The SI function is more aligned with the general contractor who looks at the blueprint the architect puts together and determines how things are going to work. It's the general contractor's job to make sure everyone shows up at the right time and can implement the plan that the architect put together.

Q: The TACOM LCMC SE&I team identified three goals to look for commonality across programs: (1) a common requirements management and analysis process and language; (2) common risk management; and (3) data configuration management. What role do you see the chief systems engineers playing in achieving those goals, and why are they important to the community?

Vehicle testing is a key component service that TARDEC provides to the TACOM LCMC and its respective PEOs and PMs. Testing results provide crucial information necessary for decision makers to make informed engineering and integration decisions. Here, an MRAP vehicle is tested on TARDEC's Reconfigurable N-Post Simulator. (U.S. Army photo by Carolyn Baum.)

TD: A common requirements language is important because of the Army's strategy to field by the ARFORGEN model and fielding by brigade. Those brigades are comprised of systems from all of our PEOs. If you don't have a common way to do the technical processes and the technical management processes, you're going to be unable to do the common SE necessary to ensure that you can field an integrated brigade capability.

TM: All these pieces that are supposed to come together originate from all these different places. It would be great to have a consistent way that we all do things so when all those pieces do come together, it's easily understood. Everyone knows what the process was. That goes beyond ground vehicle people.

TD: It does go beyond the ground vehicles. The platforms that will house all of the equipment are an integral part of that to a certain extent. Since the buck stops with us in terms of final integration, we have to make sure we're in lock step.

MB: Cross-platform and cross-systems — definitely.

TM: I think requirements is a great thing to focus on because a lot of people have things going on there. If you want to talk about requirements analysis and requirements engineering, the problem we've really been fighting a lot of years now is requirements validity and requirements creep.

"I'd define SE as the process and discipline that should and could be applied to the integration problem space."

— Mike Burnett, Integration Engineer, USMC PEO Land Systems

BD: From the data management aspect, we've been working with PEO GCS on data management and cost management concerns that we're about to bring over to TARDEC from a PEO level. We want to make sure we are positioned to handle the *WSARA* changes to manage technical data packages and other items.

TG: So, at the PEO level, at least two PEOs are getting together to

U.S. Soldiers ready their Bradley Fighting Vehicle (BFV) before beginning live-fire operations. The BFV, among other Army ground vehicle platforms, receives support from the Concepts, Analysis, Systems Simulation and Integration (CASSI) group's Powertrain Modeling and Simulation (M&S) Team. The work that CASSI does is an integral part of the SE&I the JCGV provides the community for better decision making for current and future combat vehicle platforms. (U.S. Army photo by SGT Erik McCulley.)

look at their concerns and bring them to TARDEC so that you can help affect that change so that we can work it together.

Q: It has been said that SE turns raw data into information that enables project managers to make decisions. If this is true, how does the ground SE community do this for successful ground vehicle integration? What are some of this community's success and not-so-successful stories within SE?

"A large part of the entire JCGV effort we are pursuing together is coordinating our SE&I capabilities and strengthening them."

— Teresa Gonda, Strategic Transformation Director and JCGV Development Lead, TARDEC

BD: Battle command and network is a perfect example of both. We're discovering all kinds of issues associated with installing network and battle command hardware and software because we didn't plan for it and do the right SE at the beginning.

TG: So it's kind of a success and not at the same time. We didn't do it at the beginning, and now we're seeing issues, but we're using the process and working things through.

BD: And trying to resolve them.

Q: There are people who imply that the SE&I processes are at odds with innovation. Is that true, or are they complementary?

TM: I think you can come up with innovative ways of doing things even in SE&I. It doesn't keep you from being innovative. It just means once you come up with a method, you have to be disciplined when you apply it.

BD: Exactly. The whole process, in and of itself, is meant to be changeable and flexible, and as new technologies are developed you could insert them at any time. For example, the testing is what kills a lot of time in the Army. There's nothing in the SE process that says you can't use M&S to do that. It's the regulations imposed on the process from outside of SE that force us into longer development times.

TD: Let's be very precise, and let's remember our history. The reason we are where we are is because, in the past, the Army has made the decision to accept risks that were extremely high and, in retrospect, not necessarily prudent with respect to modernization. A litany of programs can be examined. As a result, our ability to tailor acquisition category [ACAT] I

"The reason we'd say we were systems integrators was because we didn't live in just one commodity area. We were responsible for integrating all aspects of all commodities, all aspects of the program from top to bottom."

— John Phillips, Director, Strategic Initiatives, TACOM LCMC

Major Defense Acquisition Programs has been eliminated. Implementation of *WSARA*-like regulations and restrictions on smaller ACAT programs takes away all the flexibility that's inherently available within the Department of Defense [DOD] 5000. That is the piece that has to be lived with and worked. Until we show the ability to categorize and systematically manage risk as a community, we won't be able to get those restrictions lifted.

"Let's be very precise, and let's remember our history. The reason we are where we are is because, in the past, the Army has made the decision to accept risks that were extremely high and, in retrospect, not necessarily prudent with respect to modernization."

— Tony Desmond, Director, SI/G7, PEO GCS

BD: I agree with everything you said, but the question had to do specifically with the SE process because it imposes discipline and that it's inflexible. That's not the case. It's our own imposition of exterior requirements and regulations [that's the problem], not the SE.

TD: *WSARA* takes lock-step, heel-to-toe SE and almost locks it into being a particular method of doing SI.

TG: How so?

TD: I'm mandated that I go pretty much technical demonstration to engineering and manufacturing design. I don't have an ability to tailor. I'm mandated to do competitive prototyping whether it makes sense or not, regardless of the type of effort I have. I'm mandated to do, on the acquisition side, full and open competition even where it may or may not make good sense. I know the counter-argument is that the cost/benefit analysis will drive that out. In practical implementation, though, we are being told we need to go and do all of the ACAT I-type things that make it impossible for us to quickly procure and field things that would otherwise be accomplished quickly and with minimum risk.

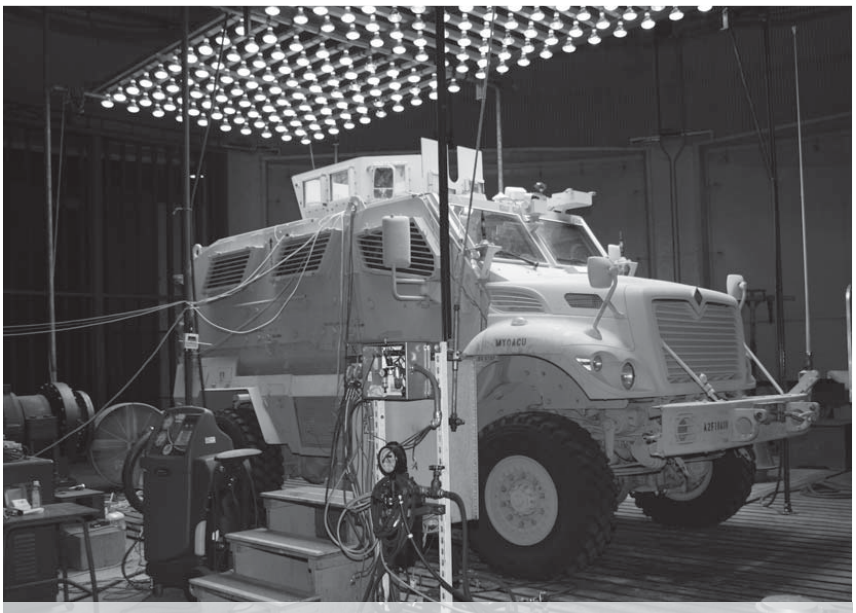
TG: What I hear us saying is that part of why we are getting our collective risk management talent and act together is so we can lower the risk of programs, and maybe some of these restrictions that have been put on us may find their way out of the system. In other words, low risk doesn't mean low innovation, and high risk doesn't mean high innovation. We're just saying that we need to manage our risk better and allow ourselves to have the flexibility to be more innovative.

Q: With the JCGV's establishment, PEO I's Capabilities Packages 11 and 12 kits coming out and integration with the Assistant Secretary of the Army for Acquisitions, Logistics and Technology all on the horizon, where do you see the future of SE?

TM: For the future, I see better collaboration based on some of the things that we've done recently that have worked out really well, such as TARDEC's work with TRADOC on the requirements for the Ground Combat Vehicle [GCV]. We were able to show them how the way a requirement is written and the wording used affects the materiel solution. If you change certain words, it changes something else by a certain weight or affects another item in a different way. I think that was very good, and we may be looking at something similar for the Marine Corps Personnel Carrier.

I think we've got to realize that there are areas that lend themselves to collaborating and working together, but there are also some things that are PEO-specific. We can assist them when they need or want us to, but some items they just have to go forth and do. Through certain phases where there's no specific PM assigned yet, we can help them get through the requirements stage with analysis of alternatives and functional decomposition. Once a PM takes over, though, they'll move things forward after that.

Not that everything has to be identical, but hopefully more common approaches to certain things like risk, requirements and configuration will help us be more collaborative in the future since we'll all be approaching things from the same way.



SE&I involves extensive testing and technology validation to ensure system-of-component changes will meet or exceed Soldier and Marine battlefield requirements. TARDEC provides these test capabilities and shares the information obtained with the JCGV. (U.S. Army photo by Carolyn Baum.)

"If you want to talk about requirements analysis and requirements engineering, the problem we've really been fighting a lot of years now is requirements validity and requirements creep."

— Tony McKheen, AD for SE, TARDEC

MB: I agree with that. I think right now our PMs are very platform-focused because of the acquisition process and all the schedules. But, I think there's an awareness now that it could be better if we shared more information, shared more tools and shared some of the expertise across these different platform groups. I think the awareness that that's a good thing is increasing.

It's going to be helpful if we can just give our programs a little bit of freedom to actually explore and use some of that information they've collaborated on.

TG: How does the Marine Corps' SE, Interoperability, Architectures and Technology [SIAT] play in this discussion?

MB: That's their real role in life — to try to make things like that happen. Unfortunately, again, the acquisition process with schedules and everything makes it very difficult.

PMs don't always see the value of the good ideas that SIAT comes up with and how they can help. The awareness is changing, though. I think we're at a point where the old mindsets are changing, and we have an opportunity to start taking advantage of the integration organizations like SIAT.

Ed Andres: Going forward, we need to make sure, from an SoS perspective, across programs, that we're engaging other programs when we're doing analysis of alternatives or making technology decisions and that we're sharing

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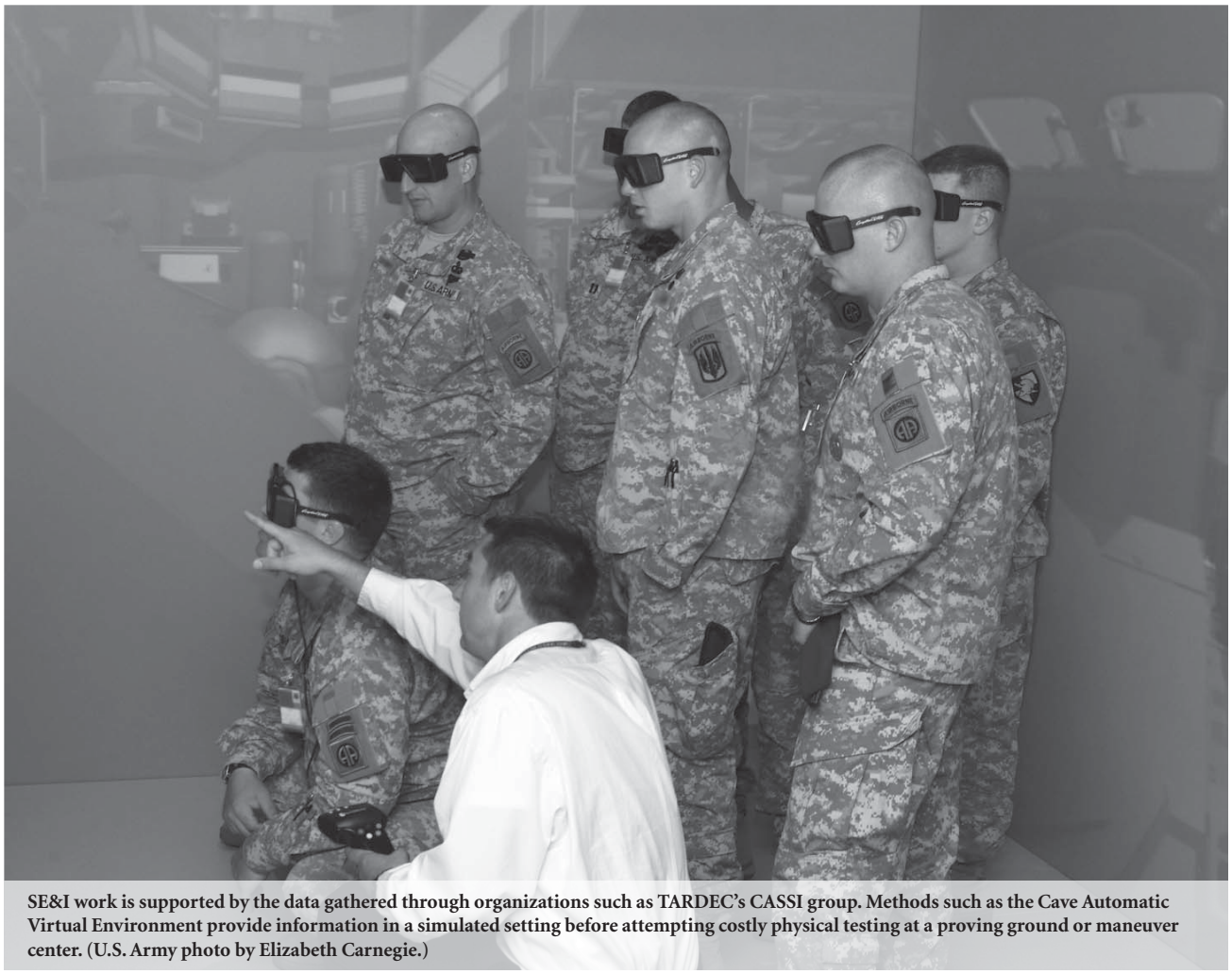


SE&I work is supported by the data gathered through organizations such as TARDEC's CASSI group. Methods such as the Cave Automatic Virtual Environment provide information in a simulated setting before attempting costly physical testing at a proving ground or maneuver center. (U.S. Army photo by Elizabeth Carnegie.)

The work done in TARDEC's Center for Ground Vehicle Development and Integration (CGVDI) is another method of information gathering and sharing as part of the SE process. The CGVDI works with a number of PMs on programs such as the Mine Resistant Ambush Protected vehicle. (U.S. Army photo by Carolyn Baum.)

that information and sharing the rationale of how we came to those conclusions across programs. Especially if we share the same requirement or have the same capability gap or are considering the same or similar technologies for our solution sets.

TG: I echo that. A large part of the entire JCGV effort we are pursuing together is coordinating our SE&I capabilities and strengthening them. There are some SE&I resources that could not be afforded by an individual PM. Outside of a large, Abrams-type program, not everyone can throw the kind of resources at issues that are actually necessary to do some really strong analysis. But there are M&S tools, for instance, that really give decision makers more information than they could ever have before, and, collectively, we can improve or build new capabilities together. That's the real strength. It's almost like a union with bargaining power because the concept doesn't just mean building it all in-house and sharing. Now, as a facilitated collective, we can take our business to analysis houses and testing centers and make it worthwhile for these places and industry to really bring strong capabilities to bear as well. So this isn't just about building in-house.

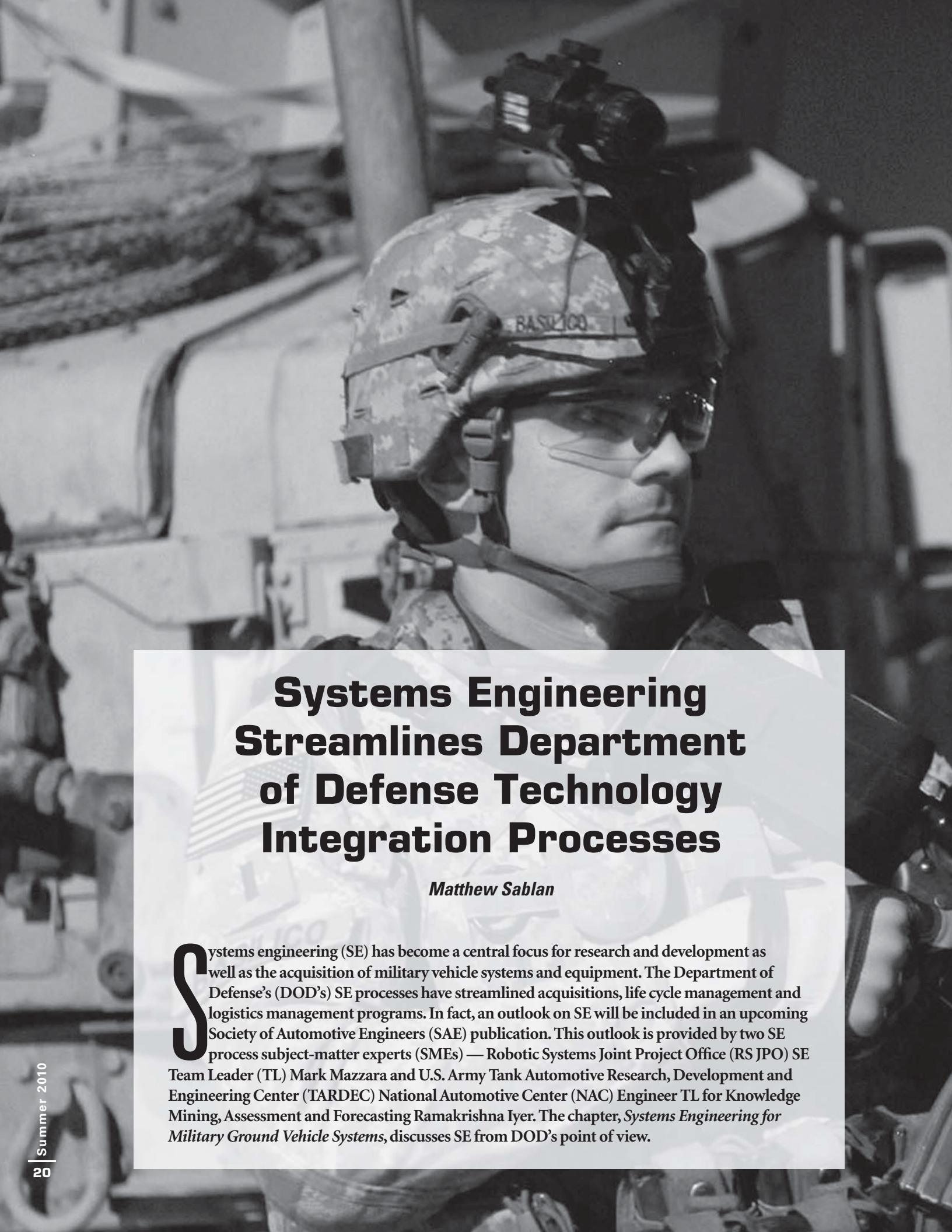
The future better be where we are really leveraging one another, building stronger tools and pooling resources.

"Going forward, we need to make sure, from an SoS perspective, across programs, that we're engaging other programs when we're doing analysis of alternatives or making technology decisions and that we're sharing that information and sharing the rationale of how we came to those conclusions across programs."

— Ed Andres, outgoing GDPI Director, TARDEC

Scott J. Davis is the Program Executive Officer, PEO GCS. He previously served as the Deputy Program Executive Officer for PEO I and was responsible for the organization and management of acquisition programs designed to support Brigade Combat Team modernization. Davis led development, production, fielding and sustainment activities for a wide range of Army ground combat and tactical vehicle systems. He holds a B.S. in mechanical engineering from Michigan Technological University and an M.S. in industrial engineering from Wayne State University. An Army Reserve officer, Davis is also an Acquisition Corps member. For a more complete bio, go to **www.peogcs.army.mil**.

Teresa Gonda serves as the Strategic Transformation Director and JCGV Development Lead, TARDEC. In addition to strategic planning for the organization, she is shepherding a major multi-organizational transformation initiative to create an integrated enterprise based on a common operating architecture of interdependent business processes, SE principles and a continuous improvement culture. The JCGV is based on an operating construct for collaboratively working technology insertion developed during a 2-year master black belt Lean Six Sigma (LSS) initiative she led for the TACOM LCMC. Prior to that, she was a senior researcher and the Army's lead for vehicle thermal signature modeling for 20 years, chairing a NATO research panel on synthetic imaging and camouflage and managing the development of a commercially successful dual-use thermal modeling tool in cooperation with the Ford Motor Co., Navy and Air Force. She is an LSS Master Black Belt and holds a B.S. in computer science from Oakland University with specialized training in infrared technology and modeling.



Systems Engineering Streamlines Department of Defense Technology Integration Processes

Matthew Sablan

Systems engineering (SE) has become a central focus for research and development as well as the acquisition of military vehicle systems and equipment. The Department of Defense's (DOD's) SE processes have streamlined acquisitions, life cycle management and logistics management programs. In fact, an outlook on SE will be included in an upcoming Society of Automotive Engineers (SAE) publication. This outlook is provided by two SE process subject-matter experts (SMEs) — Robotic Systems Joint Project Office (RS JPO) SE Team Leader (TL) Mark Mazzara and U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) National Automotive Center (NAC) Engineer TL for Knowledge Mining, Assessment and Forecasting Ramakrishna Iyer. The chapter, *Systems Engineering for Military Ground Vehicle Systems*, discusses SE from DOD's point of view.

"A number of SAE members have an interest in systems engineering," stated Oakland University Professor Dr. Subramaniam Ganesan, chief editor of the upcoming SAE publication, as he explained why he approached the two to write a chapter covering the latest advances in SE. "DOD and NASA are involved with complex and large systems, and less complex products will follow the same practices. Government, DOD and NASA are the leaders in SE."

Understanding SE

In their chapter, Mazzara and Iyer define SE as "disciplined technical planning and management" or "the process by which a stated user desire is transformed into a tangible product that is optimized in terms of affordable operational effectiveness."

The Army — with its vast array of products, vehicles, equipment and systems — benefits from an SE approach. The Army's current acquisition and design processes are complex and multifaceted, requiring multiple complicated and detailed wall charts to guide its many phases:

- Materiel solution analysis.
- Technology development.
- Engineering and manufacturing development.
- Production and deployment.
- Operations and support.

Mazzara and Iyer write that the "wall chart depict[s] how a required operational capability is transformed from a stated user desire to an affordable, operationally effective, tangible, fielded and sustainable product or capability." SE assists requirements management and development by ensuring adequacy and maintaining integrity between the different levels of requirements. Requirements management is critical to a program and properly addressing it is one of the largest benefits that proper SE provides.

SE Yields High Returns

Proper SE identifies risk factors early in a program or product's life cycle, allowing for development of timely solutions to account for and mitigate risks. The sooner problems are identified, the easier and less costly it is to build in solutions or avoid the risks entirely with different, less risk-intensive solutions. "The more that's done upfront, the greater the probability of ultimate success," Mazzara noted. "This keeps risks from blindsiding you."

Disciplined requirements management also helps DOD identify customers' needs by helping systems engineers identify what they need and recognize how those needs will interact with existing systems that may potentially conflict with other needs or component requirements. Iyer explained this idea using a military bridge as an example of an item for which a Soldier may have many different requirements: durability, weight-carrying limits, location over swift-moving or still water, permanent or temporary status, time needed to deploy, length, weight and portability.

Now consider just two of these factors: length and portability. If the bridge needs to be 20 feet longer, its weight increases proportionally, presenting transportation challenges. In this example — in extremely simplified terms — SE is the process of taking these two requirements and conducting a delicate balancing act between them to develop the technologically feasible solution.

"DOD and NASA are involved with complex and large systems, and less complex products will follow the same practices. Government, DOD and NASA are the leaders in SE."

SE looks at all variables and weighs several possibilities. It then delivers to the customer the best capability that technology currently allows. Work done early in the process to analyze

The Battery B, 2nd Battalion, 12th Field Artillery Regiment Fire Direction Officer, 1LT Matthew Basilico, kneels beside his vehicle while scanning the area below a bridge in the battalion's operational area. Varying vehicle and bridge weight requirements necessitate a detailed SE approach by DOD to best serve warfighters. (U.S. Army photo by PFC Kimberly Hackbarth.)

The 1st Marine Logistics Group (1st MLG) received four Mine Resistant Ambush Protected All-Terrain Vehicles (M-ATVs) Nov. 9, 2009, to train more than 200 operators and mechanics on this new piece of equipment in the USMC arsenal. TARDEC associates were directly involved in SE planning for the M-ATV. (USMC photo courtesy of 1st MLG Public Affairs Office.)

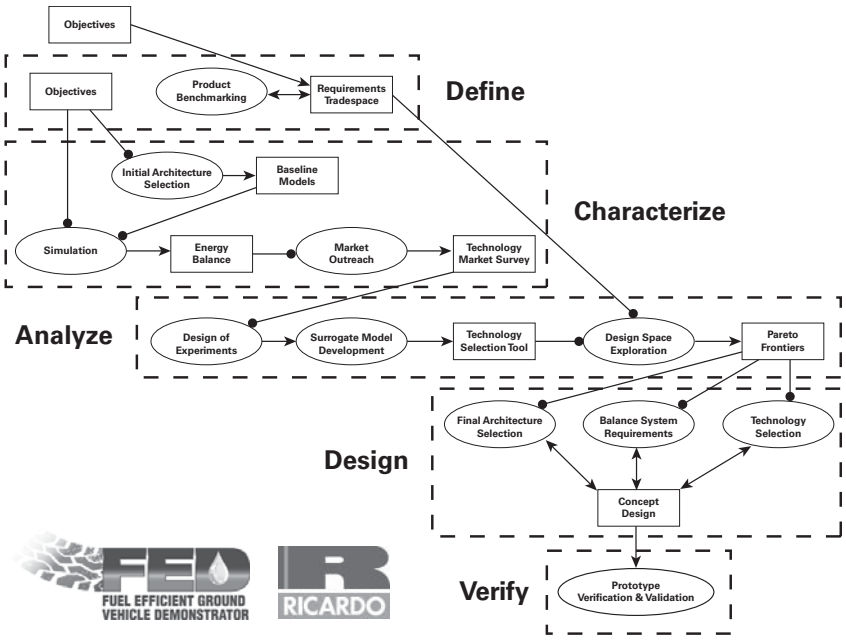
needs and compare them with currently existing systems ensures compatibility and proper prioritization. Continuing the bridge example, it may be determined that the most important factor is weight. After all, the most durable, longest, quickest-deploying bridge in the world is not of much use if it weighs 30,000 pounds and is not easily movable. Other requirements, such as weight-carrying limits are also important.

The sooner systems engineers listen to customers, the sooner requirements information can inform solutions building and balancing requirements. With the bridge, it may be determined that in its destination location, certain chemicals or temperatures may exist that make particular materials better choices than others. Only by listening to the customer and doing the proper upfront research can the systems engineer determine the feasibility of solutions. To find the "voice of the customer," systems engineers go through DOD's Joint Capabilities Integration and Development System (JCIDS) process, by which capability needs are developed and documented. JCIDS also sets up the operational requirements for any new systems or system-of-systems to follow to be successful.

TARDEC has already successfully applied its SE expertise to various programs. These program tests of the program have allowed DOD to refine the process to get the best results possible from the resources available. One program that exemplified TARDEC's SE approach is the Fuel Efficient ground vehicle Demonstrator (FED) program.

FED Program Achieves Results

The SE approach is a versatile tool that can be applied in many ways. TARDEC FED Team Leader Carl Johnson explained that both the FED program's branches used SE approaches to reduce risk. The program's requirements were primarily benchmarked from the High Mobility Multipurpose Wheeled Vehicle (HMMWV) program, creating a set of goal-focused requirements to build toward rather than solutions-focused requirements. By having the goal of a vehicle that met certain benchmarks as opposed to one that used a certain construct,



This chart depicts the phased elements Ricardo used for TARDEC FED concept development. The design concept approach was systems thinking, which focused on system-wide improvements over component optimization. By segmenting the process into multiple steps, the FED used an SE approach with each phase building up to the next in a systematic, disciplined manner. (Image courtesy of Paul Luskin, Ricardo plc.)

This concept drawing of the Ricardo-designed FED offers a designer's rendering of how the vehicle may look upon completion. After thousands of models and countless hours of analysis, the program is proceeding to design and build a vehicle capable of dramatically improving fuel economy in the field. (Image courtesy of Ricardo plc.)

many different combinations could be explored. Ultimately, there were only a few pages of requirements. "We were specific but minimal. We didn't want to be rigid," Johnson remarked.

Data-Driven SE Finds Solution

For the FED program, "The Ricardo Group, one of TARDEC's many industry partners, took a data-driven approach," Johnson explained. Working with TARDEC, Ricardo conducted tens of thousands of simulations at the subsystem level. The modeling and simulation (M&S) process allowed TARDEC and Ricardo to identify the "efficient frontier" of design configurations. This complex SE approach helped determine which combinations of technologies had the greatest chance of meeting TARDEC and DOD requirements. "It helped identify the sweet spots," TARDEC Engineer Rob Berlin noted. "Now, we can validate the models on the back end." Multiple iterations narrowed down the field of thousands to three potential architectures.

Together with two embedded TARDEC engineers, Ricardo documented the SE approach to the FED program. "We wanted a rigorous SE and data-driven approach to select technology and develop architectures," Ricardo Vehicle Engineering Manager Paul Luskin asserted. One area looked at was the vehicle's energy balance, which is the breakdown of how energy leaves the entire vehicle system. By looking at this, the engineers were able to find high-impact areas to focus on. Through their technology market survey of more than 100 different suppliers, the engineers expanded their understanding of various potential components, highlighting the biggest efficiency gains possible with limited resources.

Nontraditional SE Equally Effective

TARDEC, in conjunction with other industry partners, looked at a differing approach unofficially referred to as the "Monster Garage." As TARDEC Engineer Rachel Agusti explained, "It was SME driven. SMEs from academia, industry and government were all in one room." They worked together in groups to rank potential technologies. Initially, they analyzed the technology that was submitted and publicly available. "They drilled down together into concept vehicles," Johnson noted. TARDEC put these six concept vehicles through their paces with M&S tools and used valid drive cycles from theater and developed thorough duty cycle experiments to define each concept's potential duty cycle performance.

By combining industry and academic experts, TARDEC was able to draw on a variety of experience, fostering unique viewpoints and suggestions and allowing each group to view the problem holistically. After the M&S, TARDEC engineers were able to take the concepts that the working groups put forward and select the solution most likely to yield the desired results, saving the expense of having to physically build each demonstrator and test it live.

With Ground Systems Enterprise organizations such as TARDEC and Program Executive Office (PEO) Ground Combat Systems, PEO Integration, PEO Combat Support and Combat Service Support, and U.S. Marine Corps (USMC) PEO Land Systems collaborating with partners from industry and academia, the government will continue to benefit from the process SE affords and demonstrate its role as a leader to innovate and use partnerships to secure new ideas and technologies.

Editor's Note: RS JPO Engineer Mark Mazzara, NAC Engineer Ramakrishna Iyer and FED Engineer Carl Johnson contributed to this article.

Matthew Sablan is a Writer/Editor with BRTRC and provides contract support to TARDEC's Strategic Communications team. He has a B.A. in English and history from Marymount University in Arlington, VA.

TARDEC is Right on TARGET

Heather Molitoris

The U.S. Army Research, Development and Engineering Command's (RDECOM's) Tank Automotive Research, Development and Engineering Center (TARDEC) is implementing a rigorous gated process to ensure its science and technology (S&T) projects align to customer needs effectively, allocating limited resources efficiently to advance the organization's technology capabilities and maintain ground systems superiority. This gated system — the TARDEC Gated Evaluation Track (TARGET) — is a five-phase, five-gated system designed to reduce product development timelines, standardize program management techniques and transition the right technology solutions at the right time to warfighters.

TARGET will provide the operational roadmap for product and technology development by establishing logical work clusters to provide on-demand access to information and leverage community best practices, including:

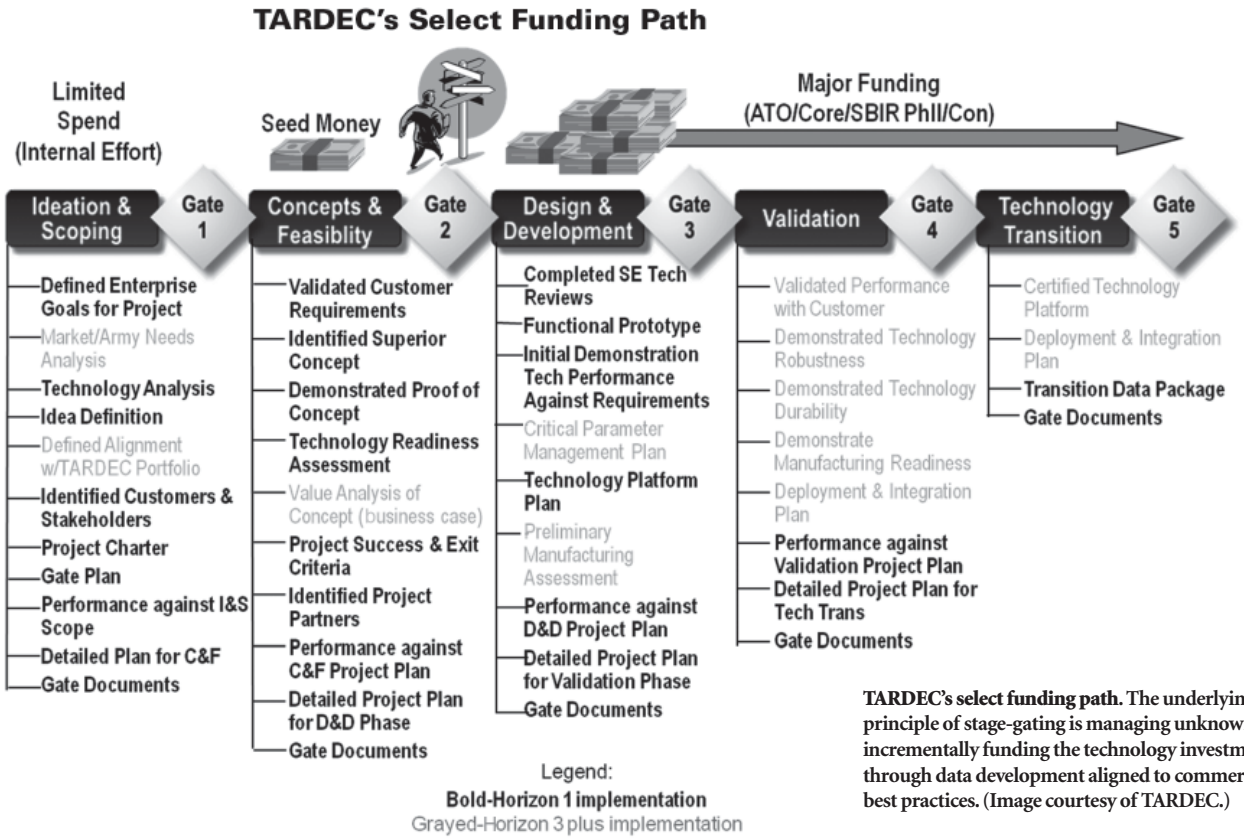
- Shape early product definition (upfront homework).
- Tough go/kill decision points embedded in the process.
- Rolling wave of details.
- Built-in quality through key engineering and program management tool usage to provide data for each deliverable.

The logical clusters of activities will have management reviews incorporated to regulate program risk and review investment decisions made between each work cluster. These decision points are placed at critical increments to verify that a project is meeting customer expectations and technical feasibility requirements.

TARGET: An S&T Development Process

Why does TARDEC need an S&T development process? The simple answer is to provide a common language across the organization to identify project status and alignment, help project leads identify what they do not know and create a structure and environment to make the difficult decisions on project developments. Furthermore, a September 2006 report issued by the United States Government Accountability Office (GAO) Report to Congressional Committees specifically called for developing a gated technology development process to ensure a technology's relevancy, feasibility and transitional readiness, using effective tools to solidify commitment, address transition challenges and gauge project

Mine Resistant Ambush Protected (MRAP) vehicles assigned to the 1st Engineer Battalion, 4th Infantry Brigade Combat Team, 1st Infantry Division, are prepped for an early morning mission. MRAPs and other fielded Army vehicles will benefit from the stage-gate program during their transition phases when engineers systematically analyze technology relevancy, feasibility and transitional readiness for vehicle systems integration. (U.S. Navy photo by CPO Michael Heckman.)



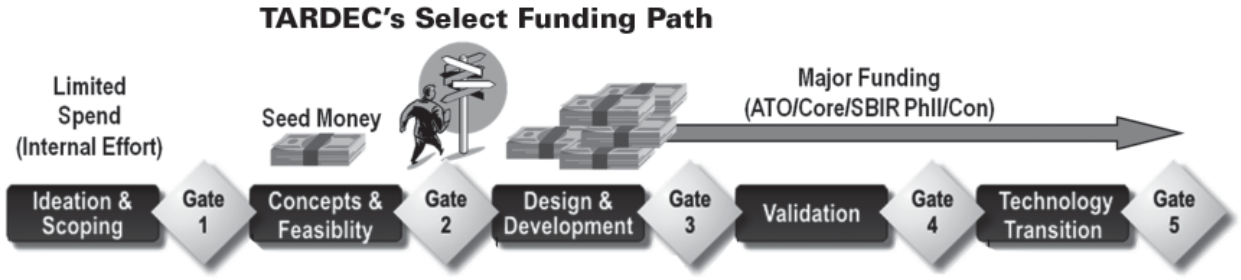
TARDEC's select funding path. The underlying principle of stage-gating is managing unknowns by incrementally funding the technology investment through data development aligned to commercial best practices. (Image courtesy of TARDEC.)

progress and process effectiveness. Additionally, the GAO report highlighted the Department of Defense 5000 series acquisition policy that specifies that technology development should be separated from product development, meaning that technology development should occur prior to product development and precede milestone B, and a separate gating system should be designed to monitor technology development.

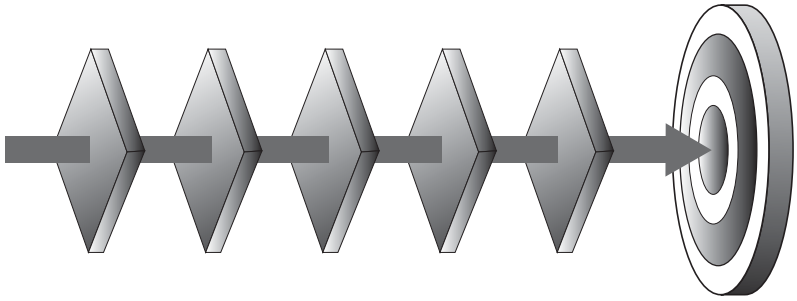
Developing TARGET

The **TARGET** process is the result of a Cooperative Research and Development Agreement (CRADA) between 3M and RDECOM. As part of this agreement, an associate exchange was established between 3M and TARDEC. A 3M associate spent 12 months on-site at TARDEC communicating the critical business processes — goal tree/strategic road mapping, portfolio management and gated system product development system (Stage-Gate). As the TARDEC associate embedded at 3M in St. Paul, MN, I learned 3M's gated evaluation track, New Product Introduction (NPI), through training and actively working two projects within 3M's NPI system. The experience of executing a project within a gated system, attending gate-decision reviews and leveraging on-demand training and information features provided the construct for the **TARGET** process.

The **TARGET** process was developed by a TARDEC task force co-led by the 3M and TARDEC exchange associates. The task force was comprised of representatives from TARDEC's G-5 office of strategy and communications; systems engineering group members;



TARDEC's process is in place to provide a common language across the organization to identify project status and alignment, help project leads identify what they do not know and create a structure and environment to make the difficult decisions on project developments. (Image courtesy of TARDEC.)



TARGET PROCESS

The TARGET process is a five-phase, five-gated system designed to reduce product development timelines, standardize program management techniques and transition the right technology solutions at the right time to warfighters. (Image courtesy of TARDEC.)

Ground Domain planning and integration plans and programs integration team; engineers and scientists from the National Automotive Center; and each Research Business Group (RBG) directorate. The task force was responsible for mapping current product development processes and best practices across the organization onto the TARGET system. The gate-review requirements were determined by interviewing TARDEC leadership — team leaders to directors. The information was enhanced by aligning leadership expectations with regulations to provide a comprehensive listing of expected documentation for S&T product developments. The TARGET framework incorporates commercial best practices, leverages TARDEC's best practices and aligns leadership expectations with key deliverables for each phase.

Stage-Gate Principles

What is a stage-gate system? The term "stage-gate" was popularized by Dr. Robert Cooper, who studied the top innovative companies and found that they had specific product development activities in common and that those companies with specific product development processes had far greater success than their counterparts who did not. Furthermore, he proposed systematically dividing product launches into distinct phases, or stages, to control the amount of capital invested early in a product's development cycle when relatively little data are known on the project's probability of success. The underlying principle of stage-gate is managing unknowns by incrementally funding the technology investment through data development aligned to commercial best practices. The idea is to have the right data to select the right projects and follow a process to execute those projects correctly.

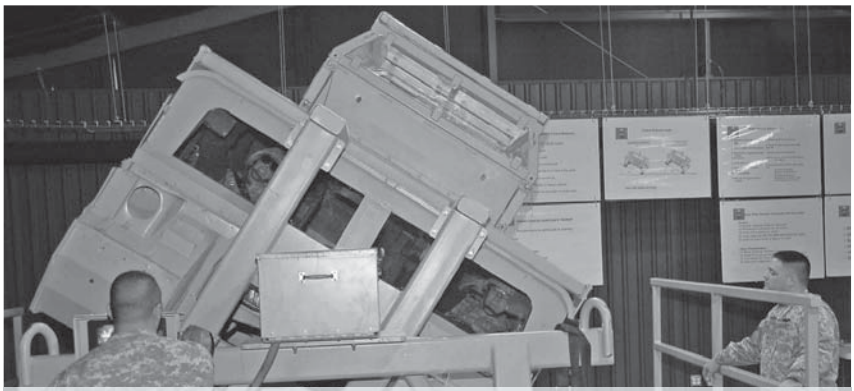
The **TARGET** stage-gate system does just that. It has five distinct phases identified for product development with five major decision review points. The phases are divided and defined such that the first two phases require very little investment and are completed internally to the TARDEC organization, leveraging critical and key core competencies.

Phase 1 — Ideation and Scoping

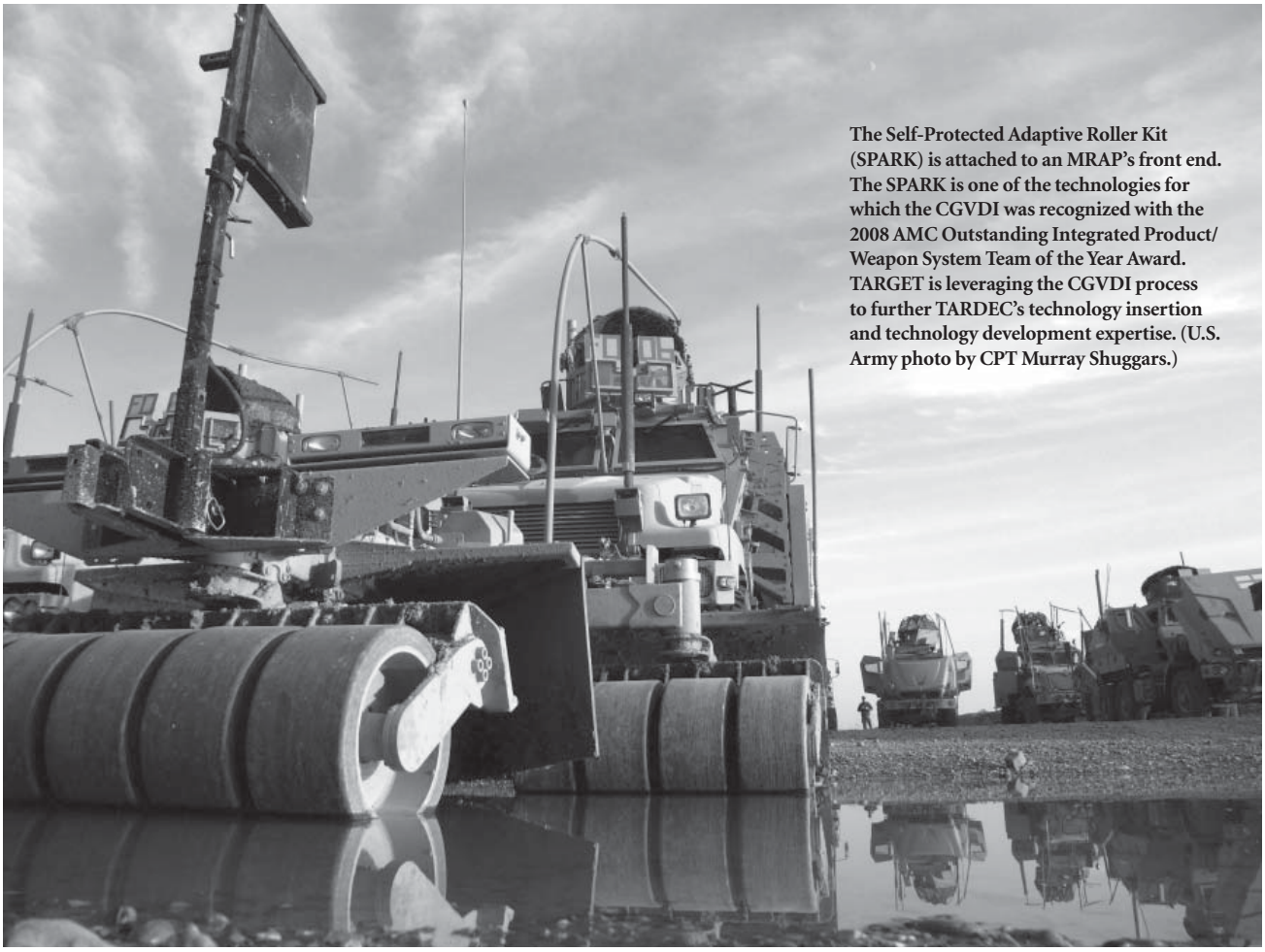
During this initial phase, the main goal is to evaluate the project and its strategic alignment to the customer's needs, and the phase is defined by completing this upfront homework. The activities within this phase identify and qualify how the project aligns with the Army's big picture, TARDEC's needs and strategies, and current technology capabilities. Furthermore, by defining the current technology landscape, the management team will be able to recognize the project's merits based on its technology risk and project magnitude to meet and exceed the customer's expectations.

Phase 2 — Concept and Feasibility

This phase includes building the business case and focuses on understanding customer needs, identifying multiple concepts against those needs and identifying



Students with the Civilian Expeditionary Workforce use the High Mobility Multipurpose Wheeled Vehicle (HMMWV) Egress Assistance Trainer (HEAT) at Camp Joint Maneuver Training Center Jan. 30, 2010. The HEAT is a device that simulates riding in an HMMWV during a rollover and is one of the TARDEC Center for Ground Vehicle Development and Integration's (CGVDI's) accomplishments recognized by the Army Materiel Command (AMC). TARGET is the next evolution of the CGVDI's process development and will leverage its successes for technology insertion to technology development. (Photo by T.d. Jackson, Camp Atterbury Public Affairs.)



The Self-Protected Adaptive Roller Kit (SPARK) is attached to an MRAP's front end. The SPARK is one of the technologies for which the CGVDI was recognized with the 2008 AMC Outstanding Integrated Product/ Weapon System Team of the Year Award. TARGET is leveraging the CGVDI process to further TARDEC's technology insertion and technology development expertise. (U.S. Army photo by CPT Murray Shuggars.)

the feasibility of executing the selected concept. This stage results in selecting the best concept to move the project forward and show its basic feasibility and concept value. This phase also details the project plan for execution, including entrance and exit criteria, product definition, proof of a proposed technology solution, team formation and a validation of customer requirements against the proposed technology development project. At the end of this phase, the funding strategy will be decided to achieve desired capability.

Phase 3 — Design and Development

Defined by prototype development, this is the phase when the product truly builds momentum with identification of a funding strategy, more resources committed to the project and the project lead's making full use of cross-functional teams. This stage's ultimate deliverable is a prototype that is fully functional and meets project performance objectives. The project manager will continue to monitor and control the critical parameters that enable technology success during this phase, through risk mitigation application, project schedule management and earned value management tools. Phase 3 ends with a functional prototype that has demonstrated performance against the requirements.

Phase 4 — Validation

The validation phase combines modeling and simulation, as well as product field testing in a representational environment, to ensure that the product, as designed, meets stakeholder or user needs. Upon exiting this phase, a technology should achieve Technology Readiness Level 6 and have documented its operating range, technology interface and technology robustness.

Phase 5 — Transition Phase

The final phase is defined by successfully transitioning the technology to the customer and includes reviewing the activities and deliverables across the product's development to finalize the customer-required documentation for technology insertion. The technology will be packaged and transitioned for use by the customer and the appropriate documentation regarding its development will be completed.

The five stage-gate phases are grouped into specific phase deliverables and gate documents that are required to provide the necessary data for gate decision reviews. The phase deliverables capture the specific tasks that

are identified by TARDEC and industry best practices. Each phase is followed by a key milestone or critical decision, termed a gate decision review.

The decision reviews are done by a steering committee of gate-decision authorities comprised of the leadership of the resources being executed to support a particular project. The **TARGET** process is documented using the MillWiki software enterprise on Army Knowledge Online. MilWiki provides on-demand training and information. Additionally, there are links to specific training opportunities, and explanations of the deliverable or military handbook/guide are embedded in the instruction to standardize and facilitate information transfer.

The phase deliverables use a rolling wave of detail approach as recommended by the Project Management Institute. This means that the specific activities for the next phase are always defined in the previous phase when the most current and detailed information is known about the project. The gate decision reviews and authorities are scoped by the project itself to push empowerment to the lowest level acceptable by the project magnitude and scope. This is critical in establishing event-driven reviews and decisions scheduled to the project's rhythm by clearly identifying those deliverables, decision points and decision makers needed to review and provide their recommendations for project continuation. Operating in a gated system development is not new to TARDEC or RDECOM — standardizing that operation across the TARDEC enterprise is the critical element that the **TARGET** framework will provide.

As part of a quick reaction force convoy, Soldiers attending the Calvary Scout training school provide covering fire through purple smoke from an up-armored HMMWV, May 19, 2010, at Fort Indiantown Gap, PA. The CGVDI participates in Add-on-Armor kit development, most noticeably having assisted in the development of the MRAP Expedient Armor Kit. TARGET hopes to replicate the CGVDI's successes using an evolved version of the organization's process. (U.S. Army photo by SPC David Strayer.)

TARGET Implementation

TARGET deployment will be incremental with the first wave, focusing on research and development activities within RBG. The two pilot projects that have been selected to participate in the **TARGET** Horizon 1 deployment will exercise the gated system construct and provide valuable lessons learned for process improvement. The first wave of **TARGET** training was completed Feb. 1–5, 2010, and consisted of core members from the two project teams and representatives from across TARDEC.

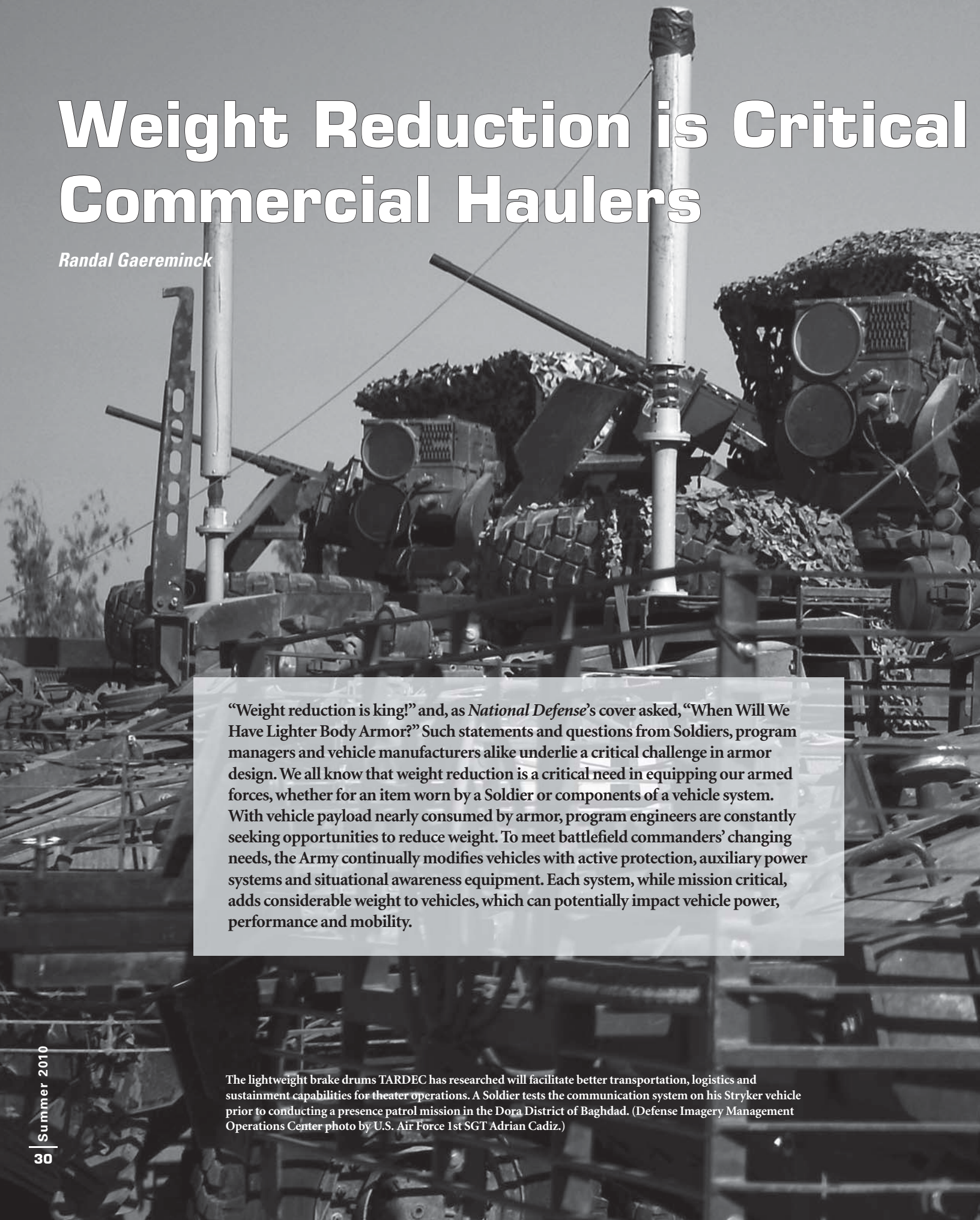
The gated system's Horizon 2 will be deployed in the first quarter of fiscal year 2011 for an initial pilot project across all RBG directorates and initial pilot projects across Product Development and Engineering Business Groups. Horizon 3 implementation in 2012 will be deployed as a regular business practice throughout TARDEC. The incremental deployment allows the system to build off the momentum of previous deployment activities and provides resourced coaches to shepherd the projects through the gated system. Additionally, with each deployment activity, additional project management and engineering tools will be incorporated based on lessons learned from the previous pilot examples. The deployment will transform TARDEC from a reactive product solutions provider to a proactive technology development organization by completing the upfront homework in identifying trends and future needs through standardizing program management techniques to define appropriate development cycle times and, thereby, meet the Army's modernization needs and urgent requirements.

The underlining principle of stage-gate is managing unknowns by incrementally funding the technology investment through data development aligned to commercial best practices. The idea is to have the right data to select the right projects and follow a process to execute those projects correctly.

Heather Molitoris is a Team Leader for Ground System Survivability for TARDEC. She is currently on a special work-industry assignment under the supervision of Jennifer Hitchcock, Acting RBG Executive Director. Molitoris holds a B.S.E. in mechanical engineering, a B.A. in psychology and mathematics from Oakland University and an M.E. from the University of Michigan. She is Level III certified in systems planning, research, development and engineering, and she is an Army Acquisition Corps member.

Weight Reduction is Critical Commercial Haulers

Randal Gaereminck



"Weight reduction is king!" and, as *National Defense*'s cover asked, "When Will We Have Lighter Body Armor?" Such statements and questions from Soldiers, program managers and vehicle manufacturers alike underlie a critical challenge in armor design. We all know that weight reduction is a critical need in equipping our armed forces, whether for an item worn by a Soldier or components of a vehicle system. With vehicle payload nearly consumed by armor, program engineers are constantly seeking opportunities to reduce weight. To meet battlefield commanders' changing needs, the Army continually modifies vehicles with active protection, auxiliary power systems and situational awareness equipment. Each system, while mission critical, adds considerable weight to vehicles, which can potentially impact vehicle power, performance and mobility.

The lightweight brake drums TARDEC has researched will facilitate better transportation, logistics and sustainment capabilities for theater operations. A Soldier tests the communication system on his Stryker vehicle prior to conducting a presence patrol mission in the Dora District of Baghdad. (Defense Imagery Management Operations Center photo by U.S. Air Force 1st SGT Adrian Cadiz.)

for Military and

Weight continues to present challenges to equipping Soldiers and fielding vehicles. Mine Resistant Ambush Protected (MRAP) vehicles were developed for *Operation Iraqi Freedom*, where there are paved roads and relatively flat terrain. However, the Army soon discovered that Afghanistan's terrain is much more rugged. There are few paved roads and more mountain passes, which makes the heavy and tall MRAPs less desirable for Soldiers deployed there. However, the MRAP's protection allows Soldiers to successfully face many of the same ballistic and improvised explosive device threats in Afghanistan that they faced in Iraq. The Army responded by developing the more lightweight MRAP All-Terrain Vehicle (M-ATV) and by innovating new technologies to meet Soldier operational requirements without compromising vehicle or crew safety. The M-ATV has a smaller hull and a lower profile, but weight remains a significant challenge for it as well as other light vehicles, such as the Stryker.

As the Stryker Modernization Program updates the technology within the Stryker, significant and valuable capabilities are added. Some systems, including the suspension and armor kits, are upgraded, while others, such as those related to command, control, communications, computers, intelligence, surveillance and reconnaissance, are new additions. Most of these systems come with a weight penalty with the vehicle's weight expanding from its original 42,000-pound gross vehicle weight (GVW) to 55,000 or 60,000 pounds GVW.

Advanced Manufacturing Technology Group (AMTG) Delivers Potential Solutions

To help mitigate this added weight, the systems engineers continue to investigate novel ways to make the vehicles more lightweight. To that end, the U.S. Army Tank Automotive Research, Development and Engineering Center's (TARDEC's) AMTG has investigated multiple potential technologies to lessen weight. A

U.S. Army CSM Gregory Frias, 4th Brigade Combat Team, 2nd Infantry Division, points in the direction he wants a Stryker vehicle to stage as the driver navigates a muddy road at a combat outpost in Muquadiah. Through research into composite armor development at TARDEC, Army vehicles can be better protected, lighter and more mobile. (U.S. Army photo by SPC LaRayne Hurd.)

group initiative is to partner with industry to implement new technologies for critical parts manufacturing and technology advancement.

One method the AMTG has investigated involves reducing the weight of an axle or wheel-end component, which has a multiplying effect because there is more than one per vehicle. The Stryker, and similarly the U.S. Marine Corps' Light Armored Vehicle (LAV), has four axles and eight wheels, making it an ideal candidate for weight savings using this method. For wheel-end components, there is further benefit due to the correlation of unsprung mass to sprung mass. For each pound of unsprung mass saved, such as in the wheel, there is equivalent savings of three to five pounds in sprung mass for an average of four pounds of sprung mass.

Composite Materials Reduce Weight

One such wheel-end component is the brake drum, which has been made of cast iron for decades. TARDEC's AMTG developed a technology that enables a conversion from cast iron components to lightweight aluminum composite materials. This produces a military truck-sized brake drum that can reduce the weight of each Stryker brake drum by 45 percent compared to a standard cast iron drum. With a 45-percent weight reduction, a Stryker could remove approximately 250 pounds of unsprung mass from its wheel-ends. Taking into account the correlation to sprung mass, this averages to 1,000 pounds of sprung mass weight savings elsewhere in the vehicle.

The new aluminum composite brake drum designed for use on the Stryker, LAV, Family of Medium Tactical Vehicles and Armored Support Vehicle, has been tested to Federal Motor Vehicle Safety Specification (FMVSS) 121. In addition, the new brake drum has undergone extensive testing by the U.S. Army TACOM Life Cycle Management Command using the Automotive-Tank Purchase Description-2354 test. Successful testing was performed on a dynamometer at Link Engineering Company's Link Testing Laboratories – Detroit. The lightweight drum met or exceeded its cast iron counterpart during testing.

Following testing, the lightweight brake drum was mounted on the front axle of a 26,000-pound GVW vehicle for the FMVSS stopping distance test as well as an additional 10-stop fade test. The stopping distance test was successful. More notably, in the 10-stop fade test, as the liner temperatures continued to rise, the brake pedal force remained consistent. This is in contrast to cast iron drums, which require greater pedal force to stop the vehicle with each successive brake application as the temperature rises.

Another benefit of aluminum-based brake drums may be increased survivability. Based on industry studies, ductile aluminum components are believed to absorb more energy from a mine blast, leading to the conclusion that a blast is further reduced with an aluminum-based brake drum rather than a brittle, cast iron drum mounted inside the wheel rim. Furthermore, the aluminum-based brake drum will dissipate heat three times faster than the cast iron brake drum, bringing the vehicle to a stable temperature more quickly, thereby reducing a vehicle's heat signature faster. With the lightweight brake drums reducing the weight per vehicle, more drums can be shipped per pallet, facilitating transportation, logistics and sustainability requirements.

Metal Matrix Composites (MMC) Provide Next-Generation Solutions

The lightweight aluminum composite brake drum is made possible with the use of MMCs,

which have been in development since the 1950s. The brake drum is made primarily of aluminum except for the braking surface, which is reinforced with ceramic particles. This process is called selective reinforcement — reinforcement of only the area in need of the ceramic material — leaving the remainder of the product as a ductile, low-cost and easy-to-machine aluminum material. The ceramic is introduced to the brake drum as a "preform," essentially a sponge made with ceramic particulates, fibers and a variety of organic and inorganic binders. Depending on the application, the preform is made to a specific volume fraction and density.

Perhaps the greatest challenges to adopting MMCs into mainstream applications are repeatability and cost. Until now, the method to make preforms has been a batch process. Today, the AMTG is working with Century, Inc. to utilize its Century 3+ Ring Extruder technology to develop a highly efficient, continuous mixing method to mass-produce the ceramic preform. Using the ring extruder, the preform material is continuously extruded, formed into shape and thermally processed and machined. The final ceramic preform is then ready to be impregnated with molten aluminum in a squeeze-casting process. After casting, the brake drum is heat treated, inspected with an X-ray and machined to the final size parameters. The entire process can be automated with a very small manufacturing footprint.

This new lightweight brake drum manufactured by Century, Inc. is one of many items being considered for vehicle weight reduction. (Photo courtesy of Century, Inc.)

This technology has broad application across both the Department of Defense (DOD) and the industrial base. DOD's *ManTech 2009 Strategic Plan* identifies "next-generation metal matrix composites" as a critical need for armor and backings. Additionally, this technology will be critical for select commercial truck platforms, especially hybrids and bulk haulers, to meet weight requirements for efficient operation of their vehicles within their respective markets.

Beyond braking components like drums, brake rotors and calipers, engine components are great candidates for MMC reinforcement. The MMC has improved properties over monolithic aluminum at elevated temperatures. For example, MMC cylinder liners allow for tighter cylinder placement, yielding a lighter-weight engine with the same output. Typically, since main bearing caps need to be stiff, steel caps are used for an aluminum block. With steel, there are difficulties due to the large difference with thermal expansion between the two materials. Using stiff aluminum composite bearing caps alleviates this concern with less weight. Another popular engine application for MMC is reinforcing aluminum pistons. In one casting process, the combustion bowl and upper ring region can be reinforced with alumina fiber-based preforms. With a significant increase in stiffness, the upper piston ring can be moved closer to the top of the piston, providing improved combustion and reduced emissions. Overall, the versatility offered by MMC enables an automated process to manufacture MMC-reinforced components of many shapes and sizes.

With the increasing threats to our Nation's military vehicles and warfighters, the need for weight reduction has never been greater. The TARDEC AMTG's technology development efforts will soon pay off for warfighters and America's industrial base. To learn more about this technology and help further its development, military/government organizations can bring their weight reduction challenges to the TARDEC Advanced Manufacturing Team for evaluation. Commercial inquiries, ground vehicle systems concepts, ideas and innovations can be submitted using the electronic form and portal at TARDEC's Ground Vehicle Gateway at: **https://tardec.groundvehiclegateway.com**. All other inquiries should be referred to: **http://tardec.army.mil/contactus.aspx**.

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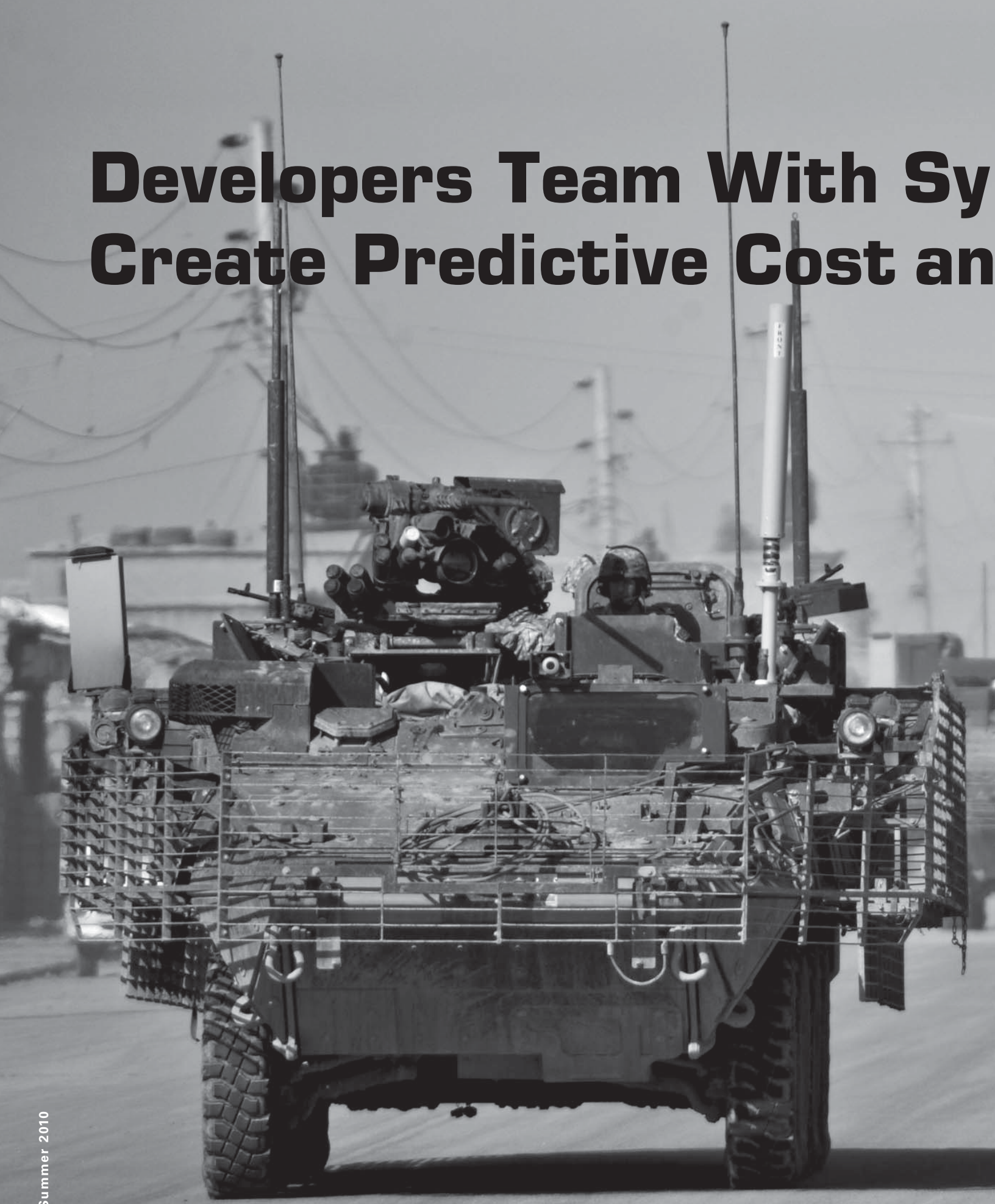
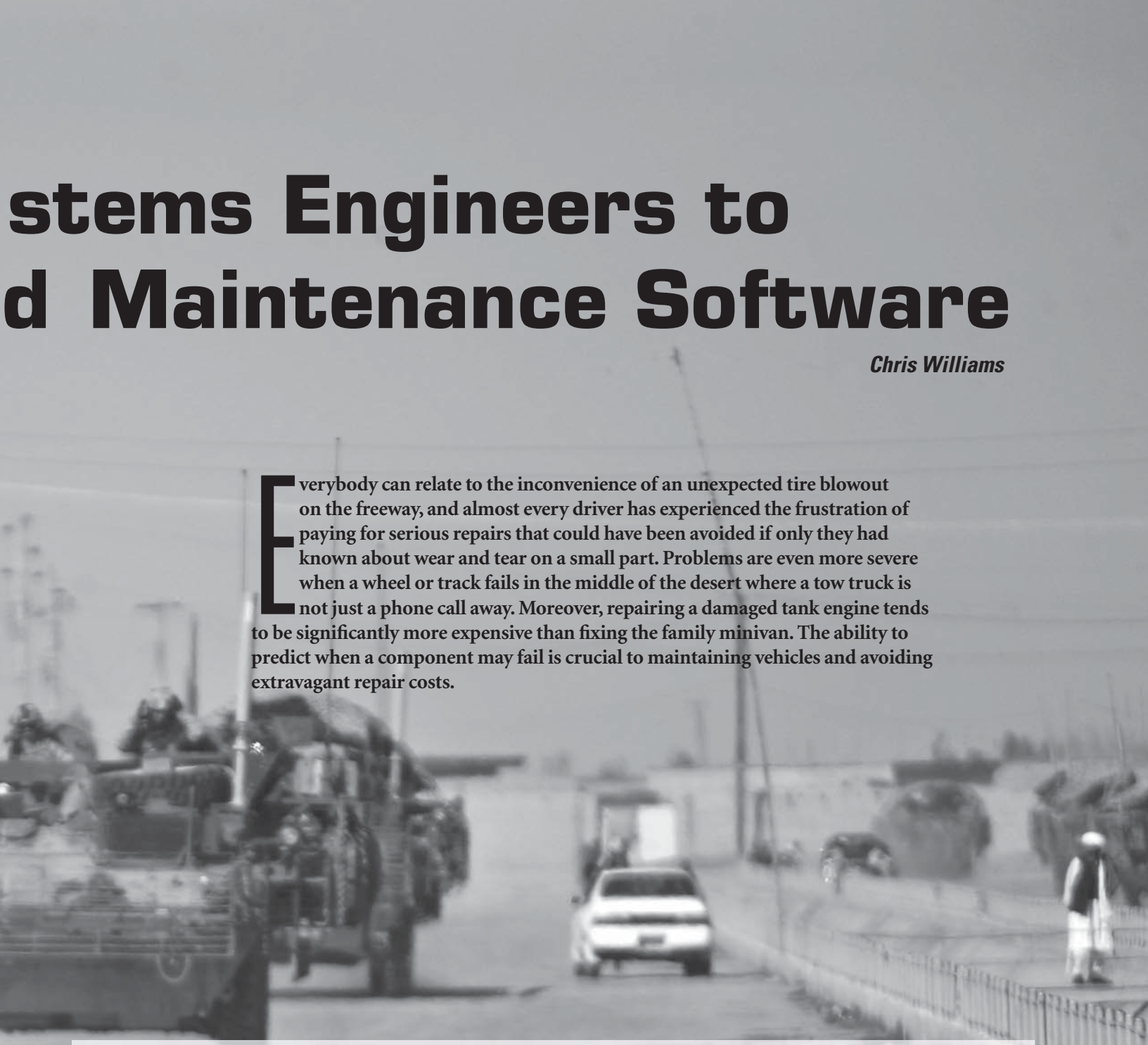
Developers Team With Sy
Create Predictive Cost an



U.S. Soldiers conduct a convoy in Afghanistan. The VEXTEC software can predict component-level degradation, as well as provide an understanding of how component failure and replacement can impact an entire fleet and prevent convoy delays due to breakdowns resulting from predictive component failures. (U.S. Air Force photo by TSGT Efren Lopez.)

stems Engineers to d Maintenance Software

Chris Williams



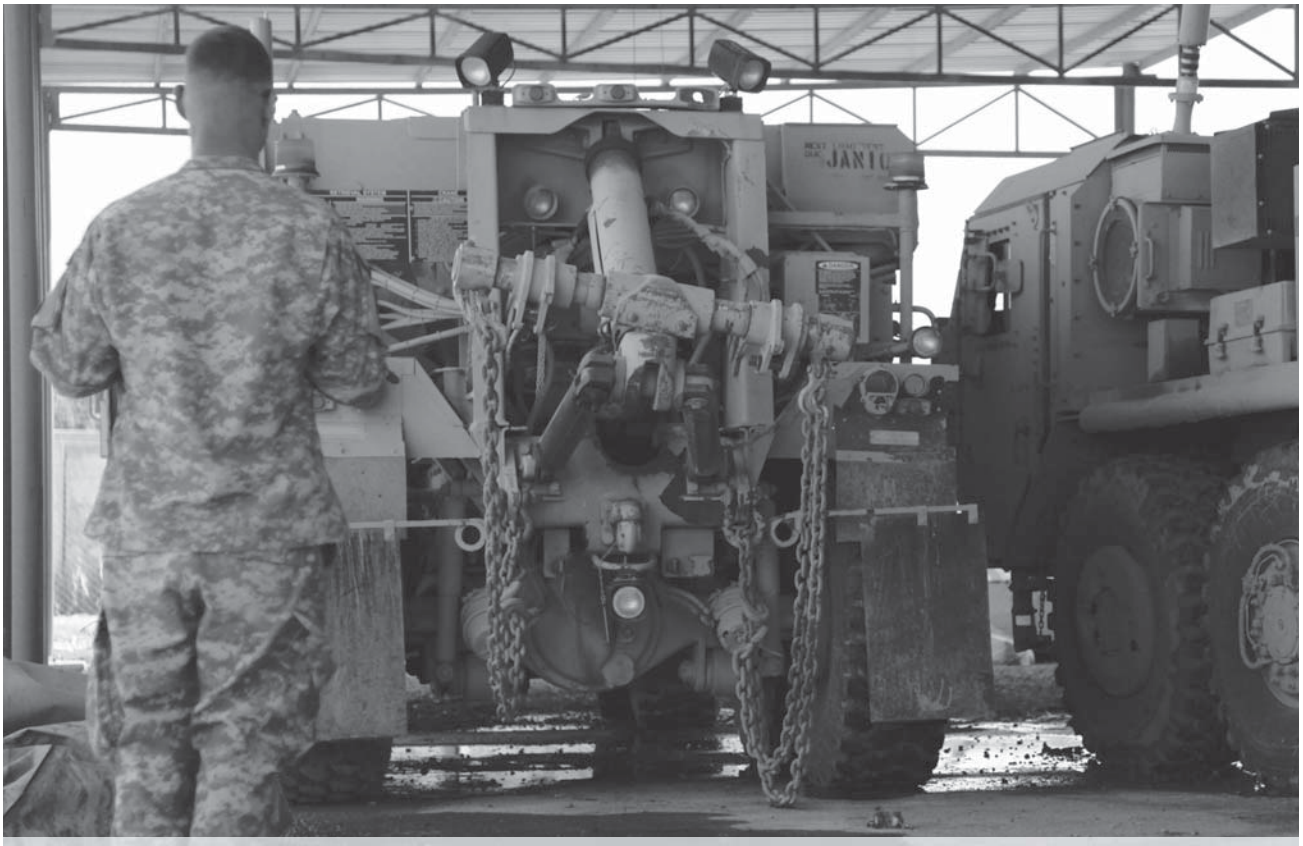
Everybody can relate to the inconvenience of an unexpected tire blowout on the freeway, and almost every driver has experienced the frustration of paying for serious repairs that could have been avoided if only they had known about wear and tear on a small part. Problems are even more severe when a wheel or track fails in the middle of the desert where a tow truck is not just a phone call away. Moreover, repairing a damaged tank engine tends to be significantly more expensive than fixing the family minivan. The ability to predict when a component may fail is crucial to maintaining vehicles and avoiding extravagant repair costs.

The U.S. Army, in collaboration with industry partner VEXTEC Corporation, is using advanced software to determine when vehicle components may fail and need repair to help keep entire fleets up and running in the field. In the process, they have also demonstrated the Army's Small Business Innovation Research (SBIR) Program's success and helped a young company gain national exposure.

Predicting the Problem

The U.S. Army Tank Automotive Research, Development and Engineering Center's (TARDEC's) Data Analysis and Optimization (DAO) team partnered with Tennessee-based VEXTEC through the Army's SBIR Program in 2006. The company's software uses complex computer simulations to determine when manufactured materials will begin to deteriorate, allowing users to understand a component's lifespan before it is even built. "We build out the simulations that the companies use to understand and diagnose why their components are failing," explained VEXTEC Vice President of Sales Carl Kolts. "We're able to understand how materials behave at the granular, microscopic level, and understand how they degrade to make accurate predictions."

The SBIR was created to assess what help VEXTEC could provide in predicting component reliability



A 10th Mountain Division Soldier guides a military wrecker into a maintenance bay at Joint Site Security Shaura Um Jidr, Baghdad, Iraq, April 6, 2010. With the use of new software being developed for the Army, systems engineers will use complex computer simulations to predict when manufactured parts and materials may begin to break down because of environmental conditions or operational stress. This new diagnostic software application should help to significantly reduce the number of wrecker field trips to recover broken down vehicles on the battlefield. (U.S. Army photo by SPC Jesse Gross.)

and performance and cost tradeoffs at the fleet level. "It was clear right away that it was going to be a good fit with TARDEC," stated TARDEC Deputy Chief Scientist Dr. David A. Lamb. "VEXTEC was a new company and wanted hard problems to solve, which we definitely could provide. They wanted to roll up their shirt sleeves, dig right in and get their hands dirty."

Using maintenance records or information on known mean time between component repairs, the software simulates the life cycles for single vehicles as well as hundreds of thousands of vehicles, providing fleet-level statistics on the relative number of repairs for each component and the corresponding repair costs. The software is able to "take advantage of the push toward high-performance computers to do more than could have been done 10 years ago," stated Lamb. "Before the advent of computers with multiple processors and the ability to make massive runs, you would never have been able to do the number of runs needed to calculate fleet-level reliability for fleets of 1,000 vehicles running 100,000 miles each. It just wouldn't have been feasible."

The simulation helps Army engineers understand whether increasing reliability will save money in the long run. "It's a way of looking at how component-level reliability stacks up to fleet-level reliability, cost and downtime," explained DAO Mechanical Engineer Dr. Matt Castanier. "We've used this approach to compare hybrid-electric [HE] and standard configuration vehicles and what kinds of component-level reliability increases would be needed on an HE vehicle to give it the same type of expected meantime between repairs as the standard configuration and what the cost may be."

"It's a way to better understand where you want to spend your money or focus your efforts in terms of component-level changes to achieve the system-level performance you need."

In addition to relying on maintenance records, the software utilizes in-depth knowledge of material properties to portray how components naturally degrade. An understanding of the vehicle usage and operating

"Ultimately, what we want to do is solve an optimization problem where we say that the minimum cost or maximum availability solution is to increase performance on these particular components. Existing software is geared toward pure cost analysis rather than cost and maintenance."

climate is also essential, as those factors can seriously impact reliability. "For example, if a vehicle was intended for use in Europe but was moved to Iraq and Kuwait, not surprisingly, the reliability drops dramatically with each move," Kolts explained.

Understanding a component's degradation allows Army engineers to know whether increasing its reliability will have a large or small impact on the fleet as a whole. "It's a way to better understand where you want to spend your money or focus your efforts in terms of component-level changes to achieve the system-level performance you need," Castanier stated. "As you increase the component reliability and cost, you get a nonlinear relationship between your fleet reliability and cost. At first you may get a significant reliability increase for a relatively small cost. However, once you've made that part good enough, it gets lost in the mix of all the other components, and you may have to spend a lot more money to see an increase in fleet-level availability from that component. The program can tell where that 'knee in the curve' is so that you can understand what kind of component-level increases would make sense, assuming you know the cost relationship between improving the component performance and the mean time between repairs."

Improving Logistics Support and Sustainability

In the future, the software may allow for improved logistics support and could extend a vehicle's life cycle to plan maintenance ahead of time and address component issues before they even occur, something that has the potential to affect fleet performance and save money on repairs. "This software looks beyond cost

U.S. Army Mechanic SSG Leonard Morgan, 25th Field Artillery Regiment, helps an Afghan National Army soldier repair a part for a High Mobility Multipurpose Wheeled Vehicle at Forward Operating Base Airborne, Afghanistan. The VEXTEC advanced software helps determine when vehicle components may fail or need repair, allowing Soldiers to perform preventive maintenance while on base, instead of in the field. (U.S. Army photo by SGT Teddy Wade.)

and studies the details about probability distributions of mean time between repairs. It's important that we understand how these things affect the availability of these vehicles," Castanier remarked. "Ultimately, what we want to do is solve an optimization problem where we say that the minimum cost or maximum availability solution is to increase performance on these particular components. Existing software is geared toward pure cost analysis rather than cost and maintenance."

The partnership is a testimony to the Army's continued collaboration with industry leaders. VEXTEC was named "America's Most Promising Company" in 2009 by *Forbes* Magazine. The TARDEC partnership has gone through two SBIR phases with VEXTEC receiving a Commercialization Pilot Program grant in 2008. "We've been working with them since Phase One, and now they're looking to put out a commercial product that addresses something that's probably a great need for a lot of companies and certainly the Army, as well," Lamb stated. "They're a success of the SBIR Program. A lot of Phase One programs never go to Phase Two, and not every SBIR produces something that winds up in the marketplace. In that sense, VEXTEC is in that low percentage that is going to have a commercially marketable product at the end of the SBIR process."

Increasing System- and Fleet-Level Performance

For the software to continue providing accurate fleet-level predictions, the Army will need to continue working with depots, bases and warfighters to maintain an up-to-date record of vehicle maintenance and repairs. Castanier stated that an improved, consistent record-keeping system is essential to obtaining accurate information. "Ideally, what you want is a maintenance record that tells you the time and date that a component came in and was repaired. What we're finding is that what's available is more rolled-up statistics, such as how many parts were replaced during the fiscal year. The power of the tool comes when you really understand the probability of needing repair versus time or mileage. The more we understand about that, the better we'll do."

"What we're most interested in are the things that really cause downtime, give you a big hit in availability and are big cost drivers. Those are the kind of things we want to address to achieve better reliability and availability for the warfighters."

The Army's goal is to compile more detailed databases about vehicle maintenance. "To date, the databases have been kept more for cost and logistics support rather than understanding system reliability at the component level and how we can make component-level changes to increase system- and fleet-level performance," Castanier explained. "Really, the more detailed information we can get from the field, the more useful this tool will be. The validation will be if we do see increases in reliability or decreases in life cycle costs." Understanding how much maintenance will impact cost is important. While some components may be expensive and require intensive work, others are relatively affordable and require little downtime. Light bulbs, for instance, may constantly need replacing, but they are relatively inexpensive and require no vehicle downtime, whereas problems with engine components could take vehicles off the field for extended periods. "You have to make sure you're capturing the cost in availability or system downtime drivers," Castanier emphasized. "That's another place where having detailed maintenance records help. What we're most interested in are the things that really cause downtime, give you a big hit in availability and are big cost drivers. Those are the kind of things we want to address to achieve better reliability and availability for the warfighters."

The TARDEC SBIR Program's collaboration with industry partners such as VEXTEC are critical to the Nation's future military success. This project is just one example of how TARDEC, the U.S. Army Research, Development and Engineering Command, U.S. Army TACOM Life Cycle Management Command and Program Exexutive Offices are working together with industry to help keep the Army's combat and tactical fleets up and running worldwide.

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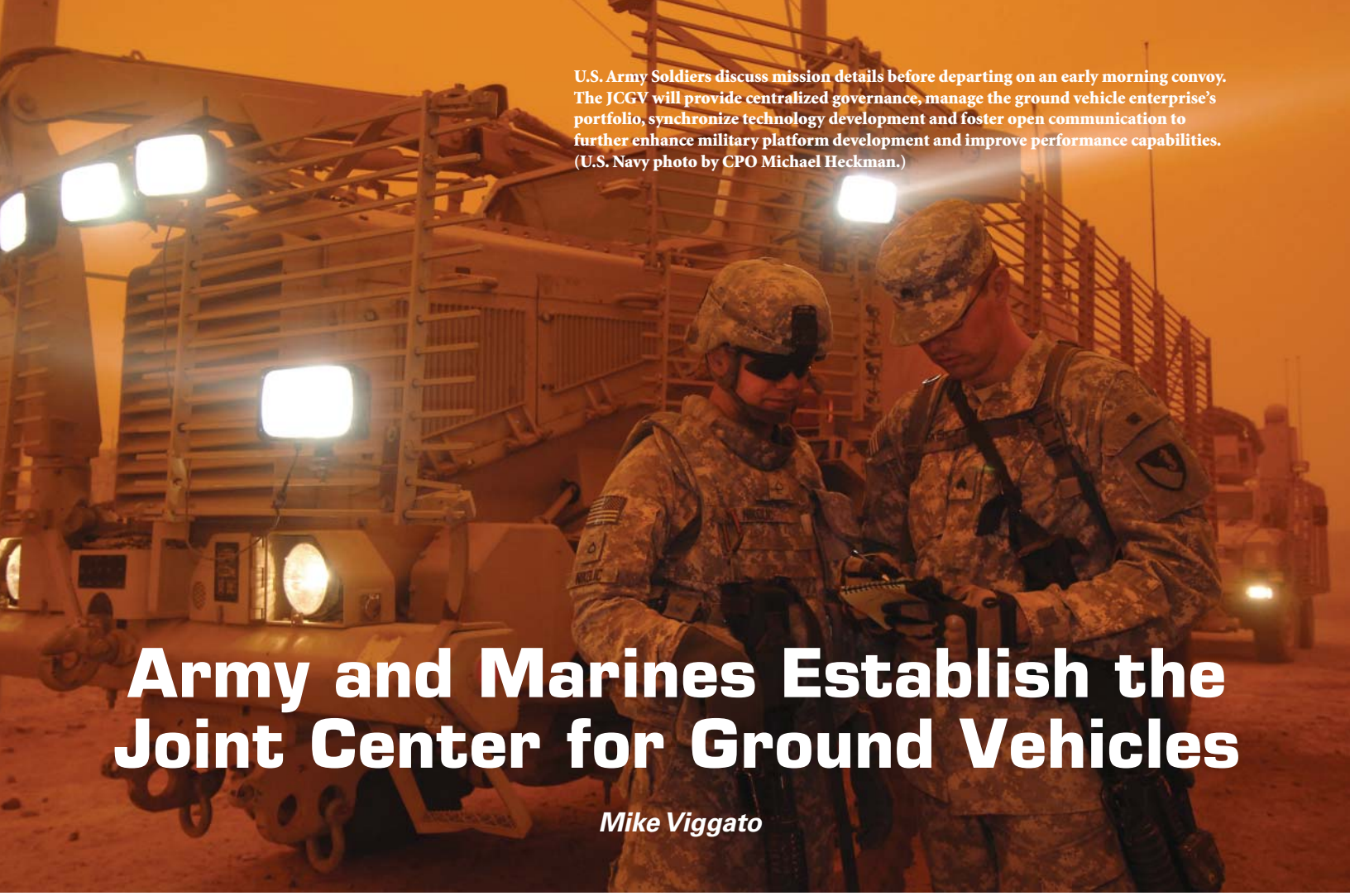


U.S. Army Soldiers discuss mission details before departing on an early morning convoy. The JCGV will provide centralized governance, manage the ground vehicle enterprise's portfolio, synchronize technology development and foster open communication to further enhance military platform development and improve performance capabilities. (U.S. Navy photo by CPO Michael Heckman.)

Army and Marines Establish the Joint Center for Ground Vehicles

Mike Viggato

The entire U.S. Army TACOM Life Cycle Management Command (LCMC) has been working diligently these past few years to ensure its people, processes and resources are aligned with one another and with the larger Army. The Army itself is doing the same by synching Soldier and equipment readiness in defined cycles with continuous modernization. At the same time, the Materiel Enterprise was established to support larger synchronization efforts and optimize business processes.

The success of these efforts requires something that is missing — a structure that will facilitate a specific interaction and communication among organizations in systems engineering and integration in the area where they all intersect. There is a need, therefore, to establish a formal construct that allows us to do that and ensures we are continually focused on our shared goal of providing the best equipment for warfighters.

We have recently taken a step to formalize such a construct. The Joint Center for Ground Vehicles (JCGV) is collaboratively formed by parts of TACOM LCMC, including Program Executive Office (PEO) Ground Combat Systems (GCS), PEO Combat Support and Combat Service Support (CS&CSS), PEO Integration, the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) and the U.S. Marine Corps (USMC) PEO Land Systems and Marine Corps Systems Command.

Institutionalizing the Enterprise

The JCGV's goal is to institutionalize systems integration excellence and collaborative enterprise-level planning and portfolio alignment and to achieve the best value in ground systems acquisition programs for warfighters. It is established, in part, under the authority of the 2005 Base Realignment and Closure (BRAC) report, which mandated the formation of a joint center between the Army and USMC, but mainly because it is the right thing to do to strengthen the ground systems community. Creating a single voice for ground vehicle research, development and integration leads

"The JCGV's role is to provide the centralized governance needed to manage the enterprise portfolio collaboratively, synchronize technology development, establish common goals and principles, drive efficiencies that will reduce costs, align resources and initiatives, and foster open communication."

to better information sharing, which, in turn, leads to better decision making at all levels. Dan Pierson, USMC Deputy PEO Land Systems, has been a driving force behind establishing the JCGV governance piece. "The JCGV's role is to provide the centralized governance needed to manage the enterprise portfolio collaboratively, synchronize technology development, establish common goals and principles, drive efficiencies that will reduce costs, align resources and initiatives, and foster open communication," Pierson stated. "The folks in Warren have created a lot of the pieces that are needed to support a wide range of ground systems acquisition programs, but what we are missing is that governance piece."

In many ways, the JCGV is the culmination of the LCMC's work during the past five years. When first formed, then-TACOM LCMC Commanding General MG William M. Lenaers asked the members how they wanted to behave collectively. The LCMC leaders desired to behave like a cohesive enterprise, but the existing structure lacked the fundamental elements needed to become that cohesive unit, meaning all the right pieces needed to exist and be put in place before moving forward. One of the major initiatives identified during that timeframe was the need to align the research, development and engineering (RD&E) portfolio across platforms and across the life cycle and create common systems engineering capabilities. TARDEC worked with its partners to develop the numerous systems analysis mechanisms needed, such as the Concepts, Analysis, Systems Simulation and Integration (CASSI) Group, the Systems Engineering Group and the Center for Ground Vehicle Development and Integration (CGVDI) within TARDEC. The CGVDI was developed through a collaborative process between TARDEC and Project Manager (PM) Mine Resistant Ambush Protected Vehicle. These and other initiatives have created pieces important to the support of ground acquisition programs.These are the pieces that attracted PEO Land Systems to the Joint Center construct, as mandated by BRAC 2005. That attraction did not come about due to luck. The capabilities that exist in what is now being termed the JCGV were designed to be attractive to PEOs by using the systems engineering process to design a system of functions created to support the PEOs in making better decisions.

"Systems engineering is the analytical underpinning for everything we're doing and serves as the driving force behind all of our alignment efforts to integrate people, processes, data and products."

"We watched and learned from other transformation efforts, and so many of them seemed to be struggling," said TARDEC Strategic Transformation Director and JCGV Development Lead Teresa Gonda, architect of the JCGV concept. "What we have come to understand is that successfully achieving and maintaining a fundamental level of organizational alignment without traditional command and control (like the LCMC) requires significantly more from the parties involved than is anticipated at the outset. The basics are a strong desire among the participants, an official declaration from the leaders, a well-thought-out roadmap and a facilitated implementation. And then a lot of patience and persistence," she mused. "But,

MRAPs line up at a staging area in preparation for a massive convoy to assist the Afghan national army in moving personnel and equipment. TACOM LCMC's work and TARDEC's CGVDI and CASSI organizations will continue to support the JCGV as vehicle modernization moves into the next phase of development. (U.S. Army photo by SGT Chris Florence.)

MRAPs light up the early morning darkness as 15th Sustainment Brigade members prepare for a mission Jan. 27, 2010, at Joint Base Balad. The MRAP has benefitted greatly from cross-service capability insertion programs and will continue to benefit from the JCGV in the future. (U.S. Army photo by SSG Rob Strain.)

ultimately, we believe the root cause for what we see as transformation frustration is that the problems and the solutions are both 'systems,' and they are rarely approached as such. The fact is, cutting-edge organizational design tells us that everything we know about the systems engineering process applies to designing, creating and maintaining the 'system' called an enterprise. That systems approach is what has been used in designing the JCGV."

One of the key Program Executive Officers who provided the early vision was Kevin Fahey, PEO CS&CSS, who was Program Executive Officer, PEO GCS, at the time the effort began. From his standpoint, the catalyst for achieving alignment between PEO partners and their RD&E center fell squarely on systems engineering. He stated his vision to maintain a small PEO core staff and have TARDEC host the systems engineering and subject-matter expertise he needed, especially for challenging issues when he wanted other options than those provided by the original equipment manufacturers. "I want to know that I can walk across the street and TARDEC can perform the right design of experiments and modeling and simulation I need and that they know my transmissions and engines better than I do," Fahey commented. This vision set the stage for creating many of the pieces that exist today.

Systems engineering becomes the foundational piece for any alignment because it is the means through which the data needed for better decision making are gathered. By leveraging the information obtained by groups like CASSI and the CGVDI and using an integrated annual business alignment process, the organizations within the JCGV can determine the extent of their alignment or, if certain functions are not in alignment, gain a better understanding of how to achieve that goal. TARDEC Director Dr. Grace Bochenek has championed this effort since she was Deputy Program Executive Officer, PEO CS&CSS. "When I was in the PEO, we were always starved for data. When I became TARDEC Director, the path forward was clear — re-establish and build strong systems engineering and integration functions. Systems engineering is the analytical underpinning for everything we're doing and serves as the driving force behind all of our alignment efforts to integrate people, processes, data and products."

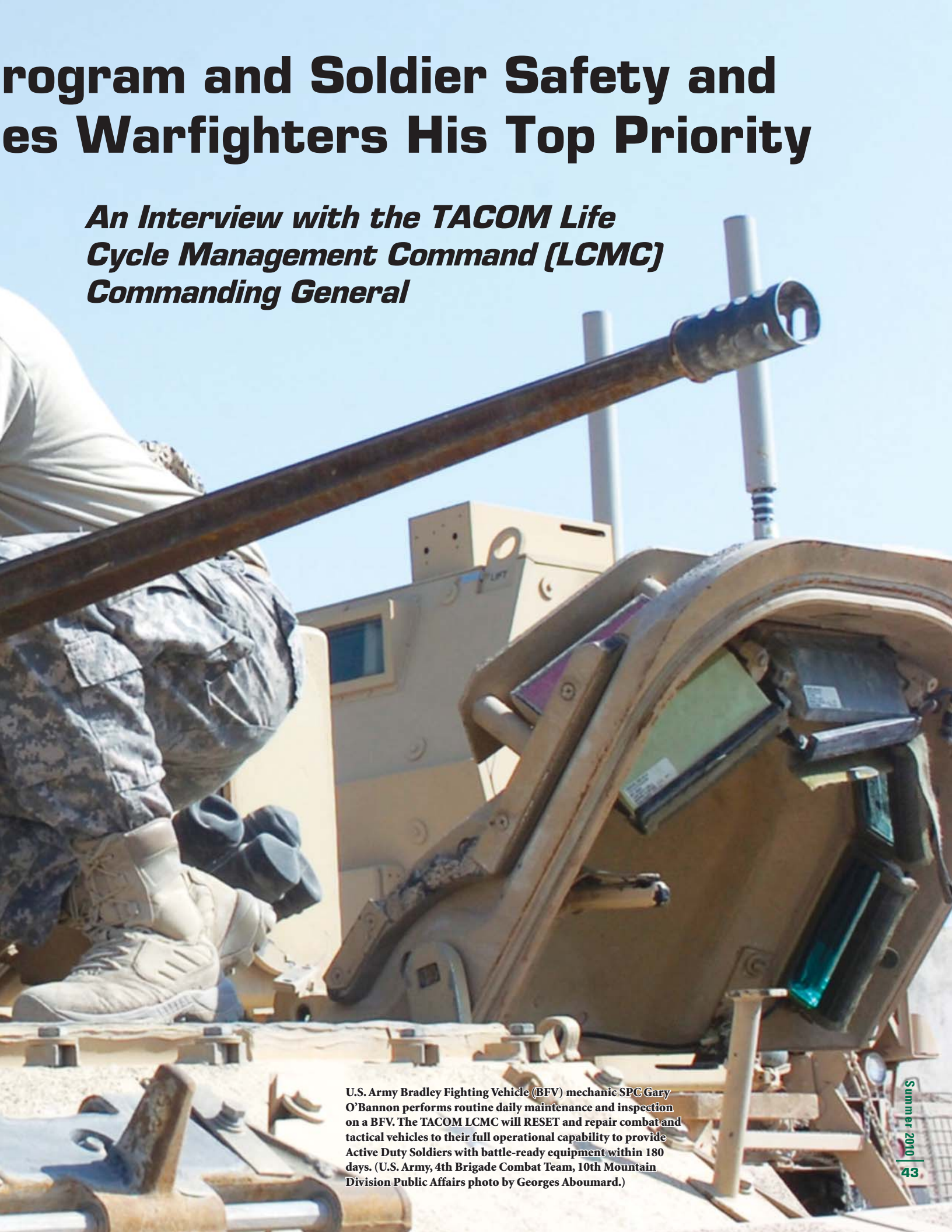
At its core, this is what the JCGV is about — integrating people, processes, data and products and taking a systems approach to establish the business methods — to speed the delivery of improved capabilities to Soldiers and Marines by enhancing the acquisition process. This is the piece that has been missing that will, ultimately, strengthen the interactions in the TACOM LCMC concept, be the means by which we achieve much of the Materiel Enterprise concept and create that single voice for ground systems that senior Department of Defense leadership needs to interface with on an ongoing basis. The entire LCMC and its JCGV partners must continue to work together, operating at a high level, so that we remain most effective and are better prepared to provide warfighters with the most advanced ground vehicle systems possible.

Mike Viggato is the TACOM LCMC Deputy to the Commanding General. During his 30 years of government service, he has held a number of positions within the acquisition community that have allowed him to acquire a wealth of financial, technical and leadership expertise. Viggato holds a B.S. in accounting from Canisius College and an M.B.A. from Wayne State University. He is also a Michigan-licensed Certified Public Accountant and a member of the American Institute of Certified Public Accountants and Michigan Association of Certified Public Accountants.

The Logistics Modernization P
Security — MG Kurt Stein Mak

rogram and Soldier Safety and es Warfighters His Top Priority

An Interview with the TACOM Life Cycle Management Command (LCMC) Commanding General



U.S. Army Bradley Fighting Vehicle (BFV) mechanic SPC Gary O'Bannon performs routine daily maintenance and inspection on a BFV. The TACOM LCMC will RESET and repair combat and tactical vehicles to their full operational capability to provide Active Duty Soldiers with battle-ready equipment within 180 days. (U.S. Army, 4th Brigade Combat Team, 10th Mountain Division Public Affairs photo by Georges Aboumard.)

***accelerate*: As the U.S. Army TACOM LCMC Commanding General, what are your five highest priorities for this command?**

MG Kurt Stein: I am extremely honored and privileged to become a member of the TACOM LCMC team. My initial focus includes meeting teammates and learning more about our TACOM LCMC organizations and installations. We're an important part of the Army's acquisition, logistics and technology business. Orientation briefings and site visits will help me better understand the full scope of our work as well as the nature and importance of our partnerships in the public and private sectors. There's a lot to learn, and the *TACOM LCMC Playbook* has been very helpful in this regard.

Our top priority is providing support to the warfighter — it's the reason this command exists. The warfighter is at the center of our TACOM LCMC mission and vision statements, and we're organizationally aligned to get warfighters what they need, when they need it and where they need it. Our work has purpose and value. I ask our TACOM LCMC teammates to look for the link between the work we perform here and the Soldier in the field. It's that kind of focus that adds real meaning to our daily labor.

Our efforts to strengthen the TACOM LCMC through improved communication, coordination and collaboration are important. The work we do requires the assistance of many organizations within and outside our LCMC. Regular contact and close cooperation with our business partners is necessary for success in our work. The Army and TACOM LCMC are in the midst of a major, ongoing transformation of our products, processes, people and culture. The Logistics Modernization Program, the revitalization of our industrial base facilities and the continuing progress of our base realignment and closure activities are a few of our key current initiatives.

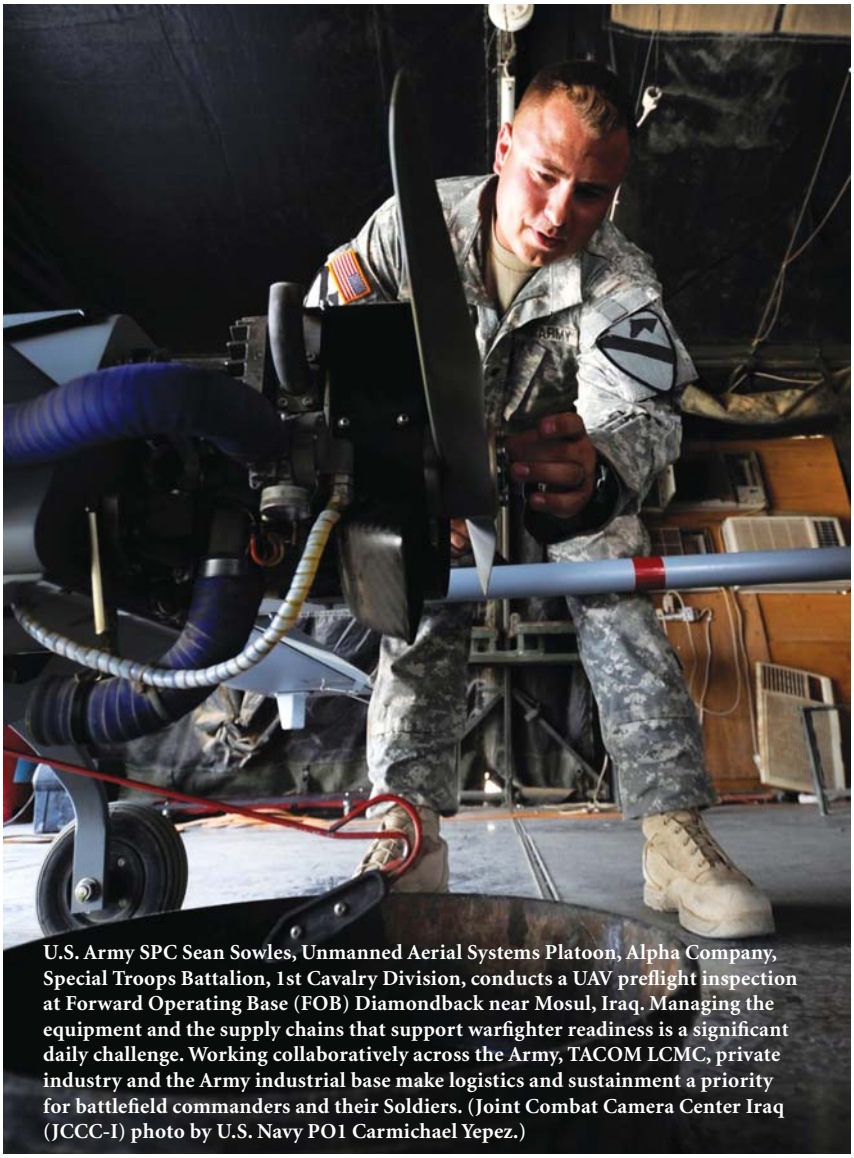
"Our top priority is providing support to the warfighter — it's the reason this command exists. The warfighter is at the center of our TACOM LCMC mission and vision statements, and we're organizationally aligned to get warfighters what they need, when they need it and where they need it."

In order to effectively tell the Army story and to highlight the value of the work we perform, we must strengthen our ties to the community through contacts with the media, academic institutions, civic organizations, veterans groups and local cities and businesses.

Finally, I intend to keep close watch on our near-term and midrange funding outlook. We need to prepare, make adjustments and be ready when the supplemental funding resources dry up.

***accelerate*: Under the Diminishing Manufacturing Sources and Material Shortages [DMSMS] Program, how is the TACOM LCMC identifying, coordinating and resolving industrial base and replacement part issues? How will**

Caterpillar Program Manager Dave Shipley (left) briefs MG Kurt J. Stein (center) and Red River Army Depot (RRAD) Commander COL Daniel G. Mitchell (right) about RRAD's partnership with Caterpillar to remanufacture 100 engines. The work done at RRAD is supported through the TACOM LCMC Depot Liaison Program, which expanded to RRAD in January 2010. (U.S. Army TACOM LCMC photo courtesy of RRAD.)



U.S. Army SPC Sean Sowles, Unmanned Aerial Systems Platoon, Alpha Company, Special Troops Battalion, 1st Cavalry Division, conducts a UAV preflight inspection at Forward Operating Base (FOB) Diamondback near Mosul, Iraq. Managing the equipment and the supply chains that support warfighter readiness is a significant daily challenge. Working collaboratively across the Army, TACOM LCMC, private industry and the Army industrial base make logistics and sustainment a priority for battlefield commanders and their Soldiers. (Joint Combat Camera Center Iraq (JCCC-I) photo by U.S. Navy PO1 Carmichael Yepez.)

the joint TACOM LCMC, the U.S. Army Tank Automotive Research, Development and Engineer Center [TARDEC] and Automation Alley contract help resolve some of these potential manufacturing and supplier issues?

MG Stein: The TACOM LCMC Industrial Base Operations [IBO] uses the Reactive DMSMS Program, working closely with TARDEC to mitigate potential DMSMS impacts on TACOM LCMC-managed weapon systems. The IBO screens potential cases, gathers data that affects the case and coordinates with TARDEC to ensure effective engineering support to resolve the concern. The IBO works with the customer and provides resolution data and status to the Army DMSMS Information System.

The joint TACOM LCMC, TARDEC and Automation Alley Contract ensures an efficient and timely response to parts issues by identifying qualified manufacturers and suppliers. This identification allows the TACOM LCMC to reduce the response time to the warfighter and improves equipment readiness.

***accelerate*: In the coming months, we know that RESET will become a major focus for the TACOM LCMC depots and arsenals as equipment begins returning from overseas. What is your strategy to make the Army's combat and tactical vehicles battle ready again?**

MG Stein: Our goal is to reset and return combat and tactical vehicles to full operational capability within 180 days for Active Duty units and 365 days for the Reserve Components. Our intent is to work closely with the program managers and product support integration directorates to leverage the capabilities of our industrial base and provide the best value to their programs and fleet strategies. The manufacturing, maintenance and logistics capabilities offered by our organic base is unmatched. Our sites have also made significant progress to improve their processes via Lean Six Sigma to become more competitive. We are confident that the sum of what we offer in conjunction with the partnerships we have established with the commercial sector will allow us to meet or exceed the Army's requirements.

"To effectively tell the Army story and to highlight the value of the work we perform, we must strengthen our ties to the community through contacts with the media, academic institutions, civic organizations, veterans groups and local cities and businesses."

***accelerate*: The TACOM LCMC shoulders a tremendous logistics and sustainment burden globally for the Army and the Department of Defense [DOD]. How do you manage logistics support for the**

largest vehicle fleet in the world? What works? What will you change moving forward?

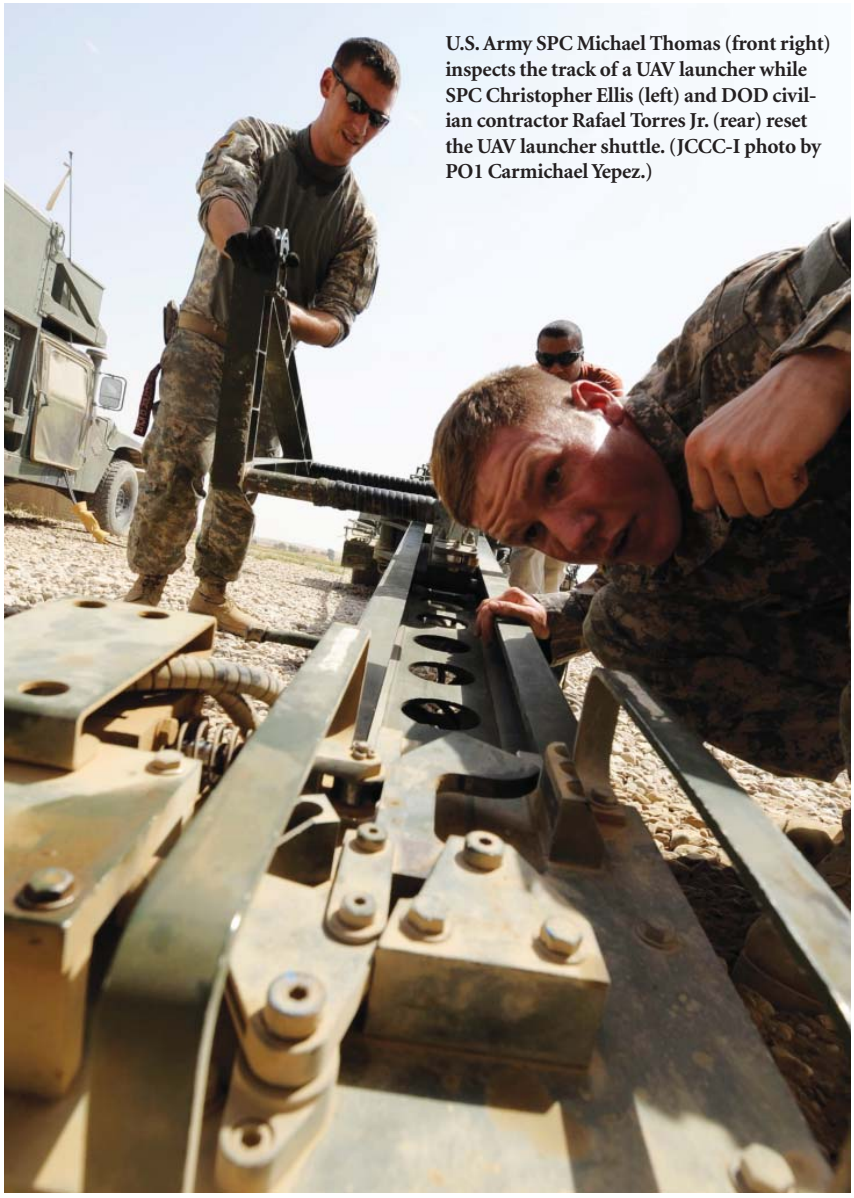
MG Stein: Managing the equipment and the supply chains that support the readiness of our warfighters is a significant challenge. Our success can be attributed to the efforts of many folks working collaboratively across the Army, TACOM LCMC, private industry, the Army industrial base and other DOD activities, such as the Defense Logistics Agency, to share information and data that enable us to anticipate and accurately forecast requirements and take the necessary actions to ensure that we have the right material, in the right place, at the right time.

After seven years of sustained conflict, we've learned quite a bit about the threats to both logistics support and sustainment of combat operations. We have learned that the premise of a linear battlefield having a clearly defined front and rear is erroneous. The battle space in Iraq and Afghanistan is made up of Forward Operating Bases [FOBs] connected by air and ground lines of communication. On the ground, these lines of communication are the main supply routes from which we launch everything from routine patrols and logistics support operations to major offensive operations. The FOBs are not in a linear arrangement, and the threat environment ranges from benign to hostile as the enemy continually responds and adapts to the dynamics of combat operations.

Sustained operations require that the convoys that carry the cargo and fuel required to logistically support such operations must traverse these lines of communication daily to keep the force fed, fueled, armed and functioning. Reconstituting units isn't done by magic — these are real trucks driven by real Soldiers and civilians. These trucks and personnel are subject to attack and destruction as much as any other battlefield combatant. Insurgent forces that want to avoid contact with combat units seek these logistics convoys because they are softer targets and, quite frankly, a 5,000-gallon fuel tanker makes for a spectacular target. Our enemies have also recognized that constraining or cutting supply lines can be a very effective method of undermining our ability to sustain combat operations. There is no reason to believe we won't face these same challenges as our attention shifts to Afghanistan.

"The joint TACOM LCMC, TARDEC and Automation Alley Contract ensures an efficient and timely response to parts issues by identifying qualified manufacturers and suppliers."

Keeping lines of communication protected requires a considerable amount of combat power. Although we cannot afford to let the protection of the logistics tail diminish our force projection capability, commanders must provide a balance and determine



U.S. Army SPC Michael Thomas (front right) inspects the track of a UAV launcher while SPC Christopher Ellis (left) and DOD civilian contractor Rafael Torres Jr. (rear) reset the UAV launcher shuttle. (JCCC-I photo by PO1 Carmichael Yepez.)

what resources need to be dedicated to keeping lines of communication secure and maintain the flow of logistics support and determine what resources are needed to sustain the combat power needed to accomplish other missions. Nothing suggests that the present nonlinear battle space is going to change in the foreseeable future, and because the insurgents' interruption of logistics convoys is viewed as having been successful, there is no doubt that interrupting logistics convoys has become doctrinally integrated into their future planning. The enemy doctrine we should anticipate for the foreseeable future includes improvised explosive device [IED] attacks and direct-fire ambushes.

We, too, have been adapting to the threat through modifications to our vehicles and tactics. We are mitigating the threat to logistics operations through "frag kit" modifications to tactical vehicles and developing new vehicle designs, such as the Mine Resistant Ambush Protected vehicle. We have also placed an emphasis on route-clearance systems, which has resulted in a number of prototype systems, such as the Buffalo. Tremendous resources and energy have also gone into counter-IED systems, jamming technology, unmanned aerial vehicle [UAV] technology, advancements in the use of robotics and myriad other battlefield advancements that preserve Soldiers' lives and maintain readiness.

Each new development will certainly be examined and challenged by our enemies and will likely result in an ever-evolving pattern of warfare. Moving forward, we will continue to adapt to deliver the world's best weapon systems and sustainment support to the warfighter. New developments in weapons technology will have to attempt to reduce the logistics footprint requirement, yet be responsive to conventional, urban and mountainous battlefield conditions. We must always ensure that U.S. forces possess unsurpassed mobility, lethality and survivability and are always up to the challenge, regardless of what the landscape of the battlefield looks like.

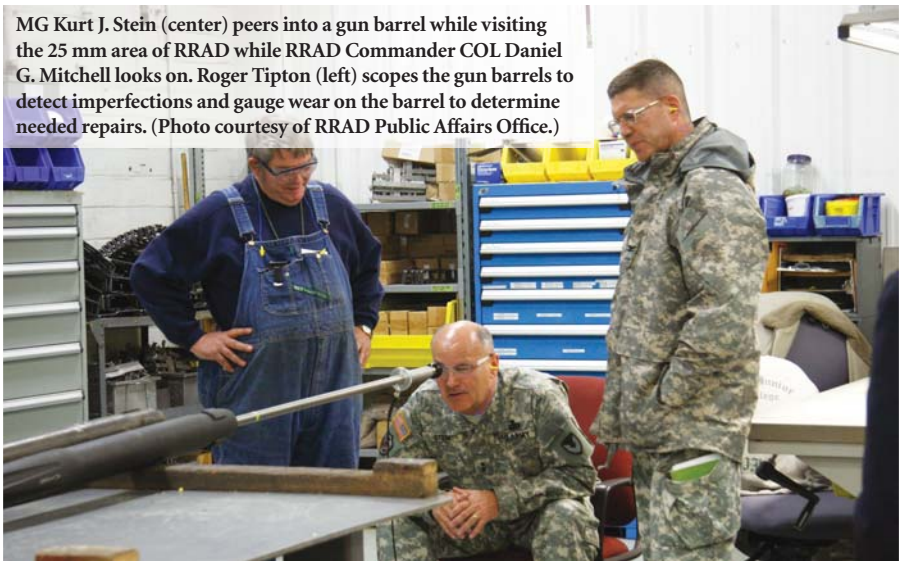
"Our success can be attributed to the efforts of many folks working collaboratively across the Army to share information and data that enable us to anticipate and accurately forecast requirements and take the necessary actions to ensure that we have the right material, in the right place, at the right time."

***accelerate*: How does TARDEC directly support the TACOM LCMC, and what are you asking TARDEC engineers, technicians and scientists to do to provide the highest level of support to the LCMC and Soldiers in the future?**

MG Stein: TARDEC is an important member of the TACOM LCMC, and I am extremely impressed with what I see. I place great value on the talents, skills and abilities that the men and women of TARDEC bring to bear on the technology part of our business. The TARDEC team is the premier research, development and engineering organization for manned and unmanned ground systems. TARDEC directly supports the work of our LCMC in four areas:

- Technology maturation and integration.
- Technology subject-matter expertise.
- Systems-level engineering analysis.
- Systems engineering and integration.

Each day, TARDEC folks provide technical solutions and engineering support for the TACOM LCMC systems throughout the entire life cycle. Here's what I ask of each TARDEC teammate: in the major aspects of your research, development and engineering work, and in the little details of each project, please make



MG Kurt J. Stein (center) peers into a gun barrel while visiting the 25 mm area of RRAD while RRAD Commander COL Daniel G. Mitchell looks on. Roger Tipton (left) scopes the gun barrels to detect imperfections and gauge wear on the barrel to determine needed repairs. (Photo courtesy of RRAD Public Affairs Office.)

Soldiers use a Buffalo MRAP vehicle to clear a lane during route clearing training at Victory Base Complex, Iraq. The Soldiers learn to operate the Buffalo's mechanical arm and other specialized equipment during the training in preparation for real-world route clearance and convoy operations. The LCMC has recently placed an emphasis on route-clearance systems as a direct response to threats Soldiers face every day in the field. (U.S. Army Multi-National Division Baghdad photo by SGT Tracy Knowles.)

the safety and security of our Soldiers first and foremost in all of your work.

***accelerate*: "Modernization" is an ongoing strategic focus area for Army senior leaders. What is your leadership vision for TACOM LCMC in supporting the Army's overall modernization goals and objectives?**

MG Stein: The primary goal of the Army Modernization Strategy is to develop and field an affordable and interoperable mix of the best equipment available to allow Soldiers and units to succeed in both today's and tomorrow's full-spectrum military operations. This strategy stems from two major challenges facing our Army — restoring balance to the force and setting conditions for the future Army.

The Army Modernization Strategy is a three-point effort:

- Develop and field new capabilities to meet identified capability gaps through traditional or rapid acquisition processes.
- Continuously modernize equipment to meet current and future capability needs through upgrade, replacement, recapitalization, refurbishment and technology insertions.
- Meet continuously evolving force requirements in the current operational environment by fielding and distributing capabilities in accordance with the Army Resource Priorities List and the Army Force Generation [ARFORGEN] Model.

TARDEC is deeply involved in all three efforts. My vision for our commitment to the Army's modernization goals places a special focus on TACOM LCMC's ability to support the ARFORGEN process as effectively and efficiently as possible.

***accelerate*: The TACOM LCMC is institutionalizing Industrial Base Workload Leveling. What is the LCMC's strategy for mastering workload allocation and supporting Army industrial base requirements for the ground vehicle fleet? What do you see as your organization's biggest challenges moving forward?**

"We must always ensure that U.S. forces possess unsurpassed mobility, lethality and survivability and are always up to the challenge, regardless of what the landscape of the battlefield looks like."

MG Stein: The Workload Leveling Initiative is a work in progress. The TACOM LCMC and TARDEC are collaborating to refine the process and guarantee a viable product that enhances our industrial base's abilities to actively workload its organic and

commercial base. We want to ensure our process places the right emphasis on Army requirements, ensures that the ground vehicle fleet is effectively sustained and that the workload is balanced across the industrial base. The biggest challenges we face are financial ones and the uncertainty of future requirements.

***accelerate*: How does the Depot Liaison Program create synergies across the LCMC and align engineering and direct support functions/responsibilities within the TACOM LCMC depot communities?**

MG Stein: The Depot Liaison Program builds collaborative partnerships with the goal of increased efficiency, product quality and overall effectiveness in support of the Army's manufacturing and remanufacturing needs. This program, piloted in January 2009, is currently on its third rotation with on-site LCMC points of contact. The program also expanded to include Red River Army Depot [RRAD] in January 2010.

There are plans to further expand this program to all the depots and arsenals under the TACOM LCMC. In essence, the Depot Liaison Program, in conjunction with the Industrial Base Integration Team, has provided the vehicle for TACOM LCMC to work as one team on industrial base issues, and the warfighter will benefit from this coordinated support.

"The Depot Liaison Program builds collaborative partnerships with the goal of increased efficiency, product quality and overall effectiveness in support of the Army manufacturing and remanufacturing needs."

***accelerate*: Are there any additional key points you want to leave with our readers?**

MG Stein: I am honored to be part of your team. I'd like to reiterate just how important it is for TARDEC and the entire TACOM LCMC community to provide our best support to the ARFORGEN process. The ARFORGEN process is used to manage Army forces and help ensure the Army's ability to support demands for its forces.

First-Line Machining Supervisor Toby Minnis (front left) briefs MG Kurt J. Stein (front right) during their walking tour of the new Soldier Weapons Readiness Center, Rock Island Arsenal (RIA), IL. TACOM LCMC's depots and arsenals support the equipment and supply chains that help ensure Soldier combat readiness. (U.S. Army RIA photo by Rebecca Parker.)

ARFORGEN establishes a basis to schedule Soldier deployments on an Army-wide scale. ARFORGEN sequences activities for all Active and Reserve Component Army units. This includes RESET, modular conversion, modernization, manning adjustments, Soldier and leader training and education programs, unit training, employment and stationing decisions.

MG Stein converses with several associates during the March 10, 2010, TACOM LCMC Meet and Greet. Stein praised the *TACOM LCMC Playbook's* value and discussed how it helps to explain the organization's crucial collaborative partnerships. (Photo courtesy of the *TACOM LCMC Community Report.*)

The ARFORGEN process works to improve the availability of trained and prepared forces for combatant commanders. ARFORGEN is especially important for Soldiers, families and the communities that support Army installations because it helps reduce the uncertainty associated with deployments. ARFORGEN addresses the Army's need for combat-ready forces and equipment, and it helps bring more stability for Soldiers and their families.

Editor's Note: The accelerate *Magazine editorial staff would like to extend its sincere thanks and appreciation to MG Stein, the TACOM LCMC Public Affairs Office and the TACOM LCMC G-staff for their timely and thorough assistance in making this interview with the TACOM LCMC CG possible. Thank you for the tremendous support!*

Integrating Brigade Combat Team (BCT) Capabilities Across the Spectrum of Conflict

Program Executive Office Integration's Evolving Role in Soldier Systems

Paul D. Mehney

An MRAP sports the improved suspension designed to better tackle some of the harsh terrain found in Afghanistan. The Army's new BCT Modernization Plan emphasizes the role of battle-tested Soldiers in the development of new equipment, provides for the incremental network delivery and incorporates MRAPs into its formations. (Photo courtesy of the U.S. Army.)

Program Executive Office Integration (PEO I) is a key BCT Modernization-supporting organization. PEO I provides systems engineering, integration and test/evaluation expertise to enable the fielding of fully integrated and tested capability packages composed of vehicles, network elements, equipment and supporting infrastructure to modernize BCTs in conjunction with the Army Force Generation (ARFORGEN) process.

As stated by Army Chief of Staff General George W. Casey, "The Army BCT modernization strategy will build a versatile mix of mobile, networked BCTs that will leverage mobility, protection, information and precision fires to conduct effective operations across the spectrum of conflict." The BCT Modernization Plan is informed by the comprehensive lessons learned from more than eight years of war, focuses on the evolving needs of our warfighters in a rapidly changing security environment and exploits the knowledge and technologies developed under the Army's former Future Combat Systems (FCS) program.

BCT Modernization Plan

Instead of making one modernization decision and then applying it across the Army over two or more decades as the Army has typically done in the past, the BCT Modernization Plan recognizes that modernization decisions must be made incrementally to anticipate the demands of a challenging, often unpredictable security environment to better protect and equip our warfighters. The Army's new plan emphasizes the role of battle-tested Soldiers in the development of new equipment, provides for incremental network delivery, incorporates Mine Resistant Ambush Protected (MRAP) vehicles into our formations, accelerates the fielding of capability packages (CPs) across all BCTs and initiates a new Ground Combat Vehicle (GCV) program as an element of a holistic plan for all combat vehicles.

The Army's BCT Modernization Plan is the blueprint for accomplishing that monumental task and will:

- Incrementally develop and field new capabilities based on advanced technologies, synchronized with our ARFORGEN process.
- Continuously be informed by current operations and guided by the insights and experiences of battle-tested Soldiers and the evolving needs of our warfighters.
- Field an expansible network with the capacity for incremental upgrades that will connect Soldiers and platforms into a coherent fighting force of unmatched power and capability.
- Leverage the investments our Nation has made in the MRAP family of vehicles to protect Soldiers' lives while accomplishing the most dangerous missions in hostile environments.
- Accelerate the development and fielding of incremental CPs to stay ahead of emerging threats or respond rapidly to surprise.
- Develop and begin fielding a new GCV within seven years that will enhance the options available to our Joint-force commanders for operations across the spectrum of conflict.

The Army's BCT Modernization Plan is closely linked with the ARFORGEN model by which the Army continuously supplies warfighters within both the Active and Reserve Components. ARFORGEN-based equipping is the main effort by which equipment is managed based on defined equipping goals linked to each phase (Reset, Train-Ready, Available) of the ARFORGEN cycle. Equipping resources are allotted to units to meet their missions during each stage of this cycle. This strategy allows the Army to build a versatile mix of tailorable and networked organizations, operating on a rotational cycle, to provide a sustained flow of trained and ready forces for full-spectrum operations and to hedge against unexpected contingencies at a sustainable tempo for the All-Volunteer Force.

The BCT Modernization Plan is informed by the comprehensive lessons learned from more than eight years of war, focuses on the evolving needs of our warfighters in a rapidly changing security environment and exploits the knowledge and technologies developed under the Army's former FCS program.

To best support the BCT Modernization Strategy, the Army is conducting Capability Portfolio Reviews (CPRs), holistically revalidating portfolios through an examination of combatant commander requests, wartime lessons learned, ability to support ARFORGEN, emerging technologies and affordability. These ongoing reviews have revealed both redundancies and gaps in capabilities. Review goals are to make recommendations for the validation, modification or termination of requirements that

drive investment, research and development, procurement and/or sustainment accounts across portfolios.

The BCT Modernization Plan recognizes that modernization decisions must be made incrementally to anticipate the demands of a challenging, often unpredictable security environment to better protect and equip our warfighters.

Eight initial reviews have been, or are in the process of being, conducted:

- Tactical wheeled vehicles
- Precision fires
- Air missile defense
- Radios/network
- Aviation (unmanned aerial systems (UAS) mix)
- Engineer mobility
- Combat vehicle modernization
- Intelligence, surveillance and reconnaissance

As a result of the CPRs, the Army will reunite portfolios previously divided into FCS and non-FCS systems. The Army is now transitioning management responsibilities for remaining FCS system development and acquisition from PEO I to respective system PEOs. This realignment to PEOs that already manage like systems provides the Army with a better way to holistically review and manage all like systems within a portfolio — i.e., all unmanned system capabilities managed by one PEO.

While the individual systems will be under portfolio management by various PEOs, PEO I will be given the expanded mission for ensuring integration across those PEOs and associated portfolios. System-of-systems engineering, integration and test will remain a PEO I responsibility. For example, rather than just integrating the Class I UAS into the network, PEO I will ensure that all UAS are integrated.

A subordinate organization to the Assistant Secretary of the Army (Acquisition, Logistics

The new MRAP All-Terrain Vehicle, built specifically for the mountainous Afghan terrain, sits parked next to the larger MRAP MaxxPro Dash. The BCT Modernization Plan will leverage the investment that the Army has made in the MRAP family of vehicles to protect Soldiers with further technological improvements in ground vehicles. (U.S. Army photo by SPC Elisebet Freeburg.)

and Technology), PEO I utilizes the Family-of-Systems approach to ensure integration and interoperability between Army Programs of Record, Current Force systems, urgent need systems and other Doctrine, Organization, Training, Materiel, Leader development, Personnel and Facilities (DOTMLPF) elements to achieve integrated incremental unit CPs. This integration approach is implemented through development, acquisition, testing, product improvement and fielding while ensuring total ownership cost reduction. PEO I consists of several project and product offices that support and manage current acquisition programs, to include tactical network integration and incremental modernization of brigades with selected capability packages. These offices will synchronize program and portfolio development and delivery to provide capabilities to Army brigade formations and support task forces to align these capabilities to each brigade type.

The Army's BCT Modernization Plan is closely linked with the ARFORGEN model by which the Army continuously supplies warfighters within both the Active and Reserve Components.

A key BCT Modernization strategy element, CPs provide the Army with a regular process to strengthen units with the latest materiel and non-materiel solutions to meet evolving operating environment challenges. This allows the Army to get the capabilities in highest demand to the Soldiers that need them, when they need them most. Accelerating proven solutions, these packages will upgrade our units every few years. These bundles of capabilities include doctrine, organization and training in conjunction with materiel to fill the highest priority shortfalls and mitigate risk for Soldiers. The incremental deliveries will build upon one another as the Army continually adapts and modernizes.

Low-Rate Production Early Infantry BCT Capabilities

Integrated by PEO I's Program Manager Infantry Brigade Combat Team, the Increment 1 equipment and network forms a part of the first CP. This CP will be fielded to a total of nine Infantry BCTs starting in 2011. Increment 1, consisting of the Small Unmanned Ground Vehicle, Unattended Ground Sensors, Class 1 UAS and Network Integration Kits that allow for the sharing of sensor data, is not the total package but comprises part of it. These items have successfully passed a 2009 Limited User Test, allowing them to enter Low-Rate Initial Production (LRIP) in 2010. The LRIP capabilities will be fielded to the 3rd Infantry BCT, 1st Armored Division, in 2011 and then undergo Initial Operational Test and Evaluation by that unit later that year.

Other capabilities in the package include: Human Terrain Teams (at battalion level), Advanced Precision Mortar Round and Ground Soldier System. CPs are aligned with the Army's ARFORGEN cycle, are adaptive and will be delivered to units preparing for deployment. These capability bundles can include organization and training in conjunction with materiel to fill the highest priority shortfalls and mitigate risk for Soldiers. The incremental deliveries can build upon one another as the Army continually adapts and modernizes. PEO I is also working systems engineering for networked CP 13-14. These efforts require close PEO I collaboration with the Army's research, development and engineering centers as

General Dynamics Robotic Systems' (GDRS) Tactical Autonomous Combat – Chassis vehicle, part of the ANS system. GDRS is responsible for the design, development, manufacture, integration and testing of the ANS for the Army's BCT Modernization Plan. The ANS system is capable of autonomously controlling any of several vehicles designated by the Army, including the Multi-functional Utility Logistics Equipment platform, the Armed Reconnaissance Vehicle and manned ground vehicles. (Photo courtesy of GDRS.)

TARDEC's Vetronics Technology Integration program tests robotic convoy concepts, such as this Crew Integration and Automation Testbed Autonomous Technology Demonstrator (ATD) and Robotic Follower ATD, components of the ANS. The ANS is a prime systems engineering collaboration example. TARDEC was instrumental in providing expert systems engineering, test and integration of ANS on vehicle platforms, which aided in successful CDR. (Photo courtesy of GDRS.)

Army Technology Objectives continue to influence technical solutions to CP requirements. A prime systems engineering collaboration example is the Autonomous Navigation System (ANS), which recently passed Critical Design Review (CDR). The U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) was instrumental in providing expert systems engineering, test and integration of ANS on vehicle platforms, which aided in successful CDR.

The GCV

PEO I has also been instrumental in the early GCV effort. The GCV, now managed by PM GCV as a part of PEO Ground Combat Systems, will take an incremental development approach that enables initial fielding by 2017, while establishing a basis from which to adapt. The GCV's modular design will allow for growth in size, weight, power and cooling, which enables rapid integration of improved capabilities in subsequent increments. Additionally, the vehicle's modular design, particularly for armor and armaments, will provide commanders with configuration and employment options, and complements the Army's versatile mix of forces.

The GCV initiative is part of a holistic Army plan to modernize its combat vehicle fleet. This includes incorporating MRAP vehicles into the fleet while also modernizing current vehicle fleets, including Stryker. The first GCV will be an Infantry Fighting Vehicle (IFV) offering a highly survivable platform for delivering a 9-man infantry squad to the battlefield. The GCV is the first vehicle that will be designed from the ground up to operate in an improvised explosive device (IED) environment. It will have greater lethality and ballistic protection than a Bradley Fighting Vehicle, greater IED and mine protection than an MRAP and the cross-country mobility of an M1A2 Abrams Main Battle Tank. The GCV will be highly survivable, mobile and versatile, but the Army has not set specific requirements such as weight, instead allowing industry to propose the best solution to meet the stated requirements.

In February 2010, the PEO released a Request for Proposal for the Technology Development (TD) phase of the IFV being developed under the GCV program. The GCV acquisition program will follow Department of Defense best acquisition practices and be a competitive program with up to three contract awards. GCV development will consist of three phases: TD, Engineering and Manufacturing Design, and LRIP. The Army anticipates awarding the first contracts for the TD phase in fourth quarter, fiscal year 2010.

The Army has designed its BCT Modernization strategy to be flexible, allowing for capability insertion based on operational requirements and maturing technology. As requirements are defined, PEO I will continue incorporating new technologies into the BCTs, recognizing that fielding a materiel solution is only part of adapting and modernizing the force. Incremental CPs fielded in synchronization with ARFORGEN provide sustainable forces fully integrated across DOTMLPF, and allow the Army to field capabilities required for the current fight more quickly.

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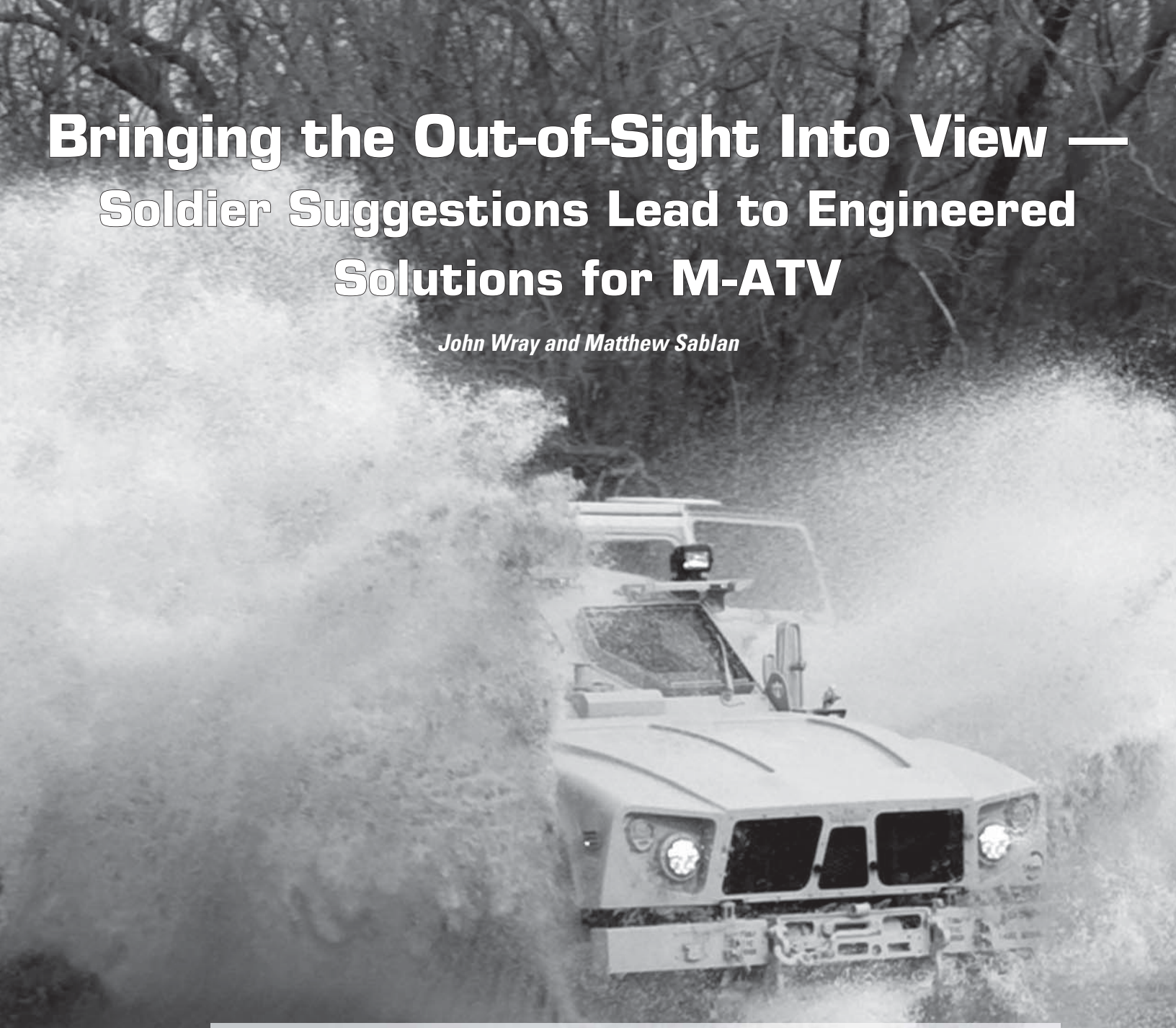
Bringing the Out-of-Sight Into View — Soldier Suggestions Lead to Engineered Solutions for M-ATV

John Wray and Matthew Sablan



Shortly after the first of more than 2,000 Mine Resistant Ambush Protected (MRAP) All-Terrain Vehicles (M-ATVs) rolled off the production line last summer, then U.S. Army Central Command Commander GEN David H. Petraeus inspected a vehicle at Headquarters Central Command with several members of the Special Operations Command (SOCOM). Under a stated mission of providing fully capable Special Operations Forces (SOF) to defend U.S. national security interests at home and abroad, more than 12,000 SOF and support personnel are deployed in more than 75 countries worldwide. To support operational missions across the full spectrum of conflict, highly versatile, mobile and tailorable vehicles were needed.

This M-ATV is demonstrated at Oshkosh, WI, Nov. 12, 2009. After the addition of the mirror-solutions at Oshkosh and Aberdeen Proving Ground (APG), Aberdeen, MD, systems engineers helped refine the vehicle's design to meet warfighters' visibility requirements. TARDEC then tested an M-ATV with the solution kit installed to gather user feedback. (DOD photo by Cherie Cullen.)

During the general's inspection, he received a question from a SOCOM Soldier regarding sight lines for M-ATV drivers and commanders. Specifically, "How could a SOCOM operator better see the tops of mountains as well as the ground underneath the M-ATV front tires?" That question prompted Petraeus to ask the Joint Program Office (JPO) MRAP to investigate visibility enhancements for a variety of Department of Defense (DOD) vehicles.

"The M-ATV, without enhancements, has more visibility than a High Mobility Multipurpose Wheeled Vehicle or a Cougar Category I or Category II," explained JPO MRAP Spokesperson Barbara Hamby. "TARDEC was asked to work with the product team and the greater JPO MRAP community and address the two desired vision enhancements to the M-ATV," Hamby continued. M-ATV's Product Manger (PM) and JPO MRAP's Integration team invited three TARDEC representatives to join a working group addressing vision enhancements. The TARDEC associates were from:

- Intelligent Ground Systems.
- Survivability.
- Center for Ground Vehicle Development and Integration (CGVDI) — the new organization comprised of the Ground Vehicle Integration Center and Prototype Integration Facility.

The working group's inaugural meeting convened in September 2009. The first order of business was to create a trade matrix weighing high- and low-tech solutions' pros and cons. Once completed, technologies for development were selected from the matrix, and a 36-hour clock began counting down to a limited-used assessment deadline. "For this project, time was precious," noted TARDEC Electrical Engineer Jillian McDonald. TARDEC's engineers developed two high-reward paths to better view road edges and M-ATV front tires — low-tech mirrors and high-tech electronic cameras.

Enhanced Visibility

TARDEC Engineers Michael Manceor, Alan Chichosz and James Mason shouldered the challenges associated with optimizing low-tech mirrors to overcome existing and potential visibility problems. Actually finding the mirrors was their first obstacle. The team dug through piles of spare parts, bins and tool cribs to locate a series of surplus mirror kits from other vehicles. At the same time, Mason brought in a commercial manufacturer to present sample mirrors and mounting brackets. Engineers consolidated the assembly of mirrors and available information and began the arduous process for actual vehicle placement and bracket design. TARDEC's in-house prototyping facility took the drawings and immediately fashioned testable prototypes.

"By September 2010, all M-ATVs are scheduled to have mirrors installed." These solutions increase awareness for M-ATV drivers and commanders, and the mirror kits are another example of the Ground Systems Enterprise's ability to field lifesaving enhancements for our warfighters quickly.

To mount the mirrors, engineers used existing mounting holes, when available, and clamps and magnets when they were not. "We wanted to give evaluators options that they could touch and see to help them make solid, informed decisions," explained Chichosz.

The result was low-cost, easily-installed mirrors located on the vehicle sides and front corners. Mirrors were also added to existing front- and side-mounted mirrors. With these additions, drivers could better see into blind spots and in front of tires, increasing their situational awareness and reaction time.

Cameras Eliminate Blind Spots

While the mirror work progressed, other TARDEC engineers were experimenting with potential electronic and high-tech solutions. On a display vehicle, two camera systems were added. View 12 was a single camera that allowed Soldiers to view in front of the vehicle. Check 6 included two cameras on the rear fender — one mounted to running lights and one mounted to the rear lights. Together, View 12 and Check 6 allowed Soldiers to view the vehicle's front and rear 12 o'clock and 6 o'clock positions relative to the terrain.

While View 12 and Check 6 came from already available parts, nearby partners brought additional cameras for evaluation. According to TARDEC Electrical Engineer William Easterday, the camera solution was spurred by a number of questions. "We immediately began asking, 'Would the display and cameras work with the M-ATV? Were Soldiers familiar with them? How rugged are they?'"

During the October 2009 user jury, the CGVDI team speaks with a Soldier. User feedback proved invaluable in finalizing placement and integration techniques on the M-ATV. Feedback from warfighters allows technology to be refined to best serve them. (U.S. Army TARDEC photo.)

Cameras were then mounted to a demonstrator vehicle's rear fender, front axle, wheel well, vehicle front and vehicle sides.

Deadline, Demo and Decision

Within 36 hours, a demonstrator vehicle with both the high- and low-tech solutions sat ready for evaluation. To demonstrate the improved sightlines, a grid of white tape was laid out in one-foot increments around the vehicle, and testers gave feedback. "We gave them something to see and feel to help make a decision," Easterday remarked. "User feedback clearly iterated a need for a second-generation display."

Quickly, monitors were modified as part of the second display. The M-ATV's driver display was made to swing down for use and returned to the ceiling. The commander's display was set on a RAM Mounting Systems, Inc., mount with a two-ball joint to reposition and hold the display. That innovative mount allows the vehicle commander to tilt the display toward the driver and share information when needed. TARDEC and PM MRAP reviewed user feedback and decided to go with the mirrors and not use the cameras. Even though the cameras were not selected, valuable insight was gained. "The process gave us a better understanding of what camera solutions are available," Easterday noted. "It also helped us learn exactly what the Soldier is looking for."

Testing Leads to Solutions

Following further refinements that changed the mirrors' bracket from a two-part design to a one-part, Mason took a completed kit to Oshkosh Defense in Wisconsin for testing. With technicians there, the mirror kit was installed and SOCOM warfighters drove M-ATVs around a test track. "The Special Ops guys gave terrific feedback, especially about potential interference with other kits," Mason recalled. That testing was conducted in late October.

With Wisconsin notes in hand, Mason took a kit to Aberdeen Proving Ground (APG) and Aberdeen Test Center (ATC) in Maryland. After completing testing there, Mason went to install the mirrors on an M-ATV that was displayed at the Pentagon in November. Following this static display, the vehicle returned to ATC for further testing.

"Oshkosh is producing mirror kits to be installed in theater and installing the mirrors on current production vehicles," Hamby asserted. "By September 2010, all M-ATVs are scheduled to have mirrors installed." These solutions increase awareness for M-ATV drivers and commanders, and the mirror kits are another example of the Ground Systems Enterprise's ability to field life-saving enhancements for our warfighters quickly.

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MRAP Capability Insertion Response to Warfighters'

Chris Williams

Shortly after ground combat operations began in Afghanistan and Iraq, the U.S. military identified a critical need to provide warfighters with vehicles that kept them safe from improvised explosive device (IED) attacks, land mines and small-arms fire without compromising vehicle protection, power or payload. Urgent needs precluded designing and fielding a common vehicle from the ground up. Instead, to rapidly provide warfighters with a safe and effective solution, the Department of Defense (DOD) competitively contracted with industry partners to produce the Mine Resistant Ambush Protected (MRAP) vehicle, which has played a significant combat and tactical role in theater. Multiple MRAP variants, provided by six original equipment manufacturers (OEMs), are currently fielded to provide warfighters with a vehicle to safely and effectively complete diverse missions.

As MRAPs are deployed in combat areas, new capability upgrades continue to be developed to help warfighters remain safe and complete their field missions. The MRAP Capability Insertion Program (MCIP) was created by Joint Program Office (JPO) MRAP to assist in rapidly developing, integrating and fielding solutions to make the vehicles more survivable and effective. "Because this was an urgent program, we actually started inserting things back into the vehicles almost immediately," explained JPO MRAP Deputy Program Manager David Hansen. "We focused first on anything that helped us manufacture or install our government-furnished equipment and then on survivability and safety issues, such as a gunner restraint system [GRS]. If you look across the program, we've been adding capabilities to the vehicle almost since day one, but MCIP itself began in mid-2008."

The program is a multiservice initiative stretching across DOD. As Soldiers and Marines request additional vehicle capabilities, JPO MRAP examines these requests and coordinates with its partners and OEMs to incorporate them into the systems wherever possible. Lifesaving and mission-enhancing capabilities, such as improved armor protection and better integrated vehicle electronics, receive top priority, although MCIP has also assisted in developing solutions for easier vehicle entry and improved suspension for off-road travel.

A GRS, which keeps warfighters secure in the event of a rollover, has also proven to be one of the

Program Provides Rapid Urgent Needs

A Soldier maneuvers his MaxxPro MRAP through a sand pit during driver training in Kuwait. The MRAP has played a crucial role in protecting Soldiers from IEDs and land mines. MCIP works with teams throughout DOD to enhance the vehicles' capabilities and make them more survivable and mission-effective for warfighters. (U.S. Army photo by 2LT Christian Venhuizen.)

program's greatest successes. "Hundreds of new capabilities have been added," Hansen remarked. "Some of them are just little tweaks and upgrades that help with human factors, safety and survivability — we may modify seat belts, add a GRS or a better pass-through for wiring." The numerous upgrades are partly due to the number of vehicle variants. "We work with six different manufacturers and have three different MRAP categories, plus the MRAP All-Terrain Vehicle, so there are about 7-10 MRAP variants. I probably have 75 different configurations that I'm managing of this one type of truck," Hansen noted.

Adding these capabilities requires careful planning and collaboration among partners throughout DOD and industry, including the U.S. Army Aberdeen Test Center; Marine Corps System Command; Space and Naval Warfare Systems Command; U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC); and several other organizations within the Ground Systems Enterprise. "So many people have been involved in this program over the last few years — it's very vast and very broad. There have been many people with good ideas that need to be incorporated rapidly," Hansen explained. "Proper systems engineering is crucial — it's the methodology on how we approach the requirements, look at the answer and collect feedback to see that we've met the requirements. It's the basis for how we do capability insertion."

JPO MRAP works closely with DOD teams like TARDEC's Center

Army Loadmaster SSG Kellie Collier, 816th Expeditionary Airlift Squadron, secures an MRAP vehicle into the back of a C-17 Globemaster III aircraft on March 10, 2010. The MRAP has played a significant lifesaving role in theater, and TARDEC's CGVDI takes requirements that come from the field and leverages the organization's expertise in areas such as M&S and software development to integrate mission-enhancing capabilities onto platforms in a timely manner. (U.S. Army photo by CPL Brandon Babbitt.)

for Ground Vehicle Development and Integration (CGVDI) to take requirements from theater and leverage the organization's expertise in modeling and simulation (M&S) and software development to integrate these mission-enhancing capabilities onto existing vehicle platforms in a timely manner. "The requirement to add common capabilities to a diverse set of vehicles is likely the reason JPO MRAP chose TARDEC to perform the systems integration portion of its capability insertion program," remarked CGVDI Associate Director Dr. Bruce Brendle. "CGVDI's primary role is to integrate the appropriate organizations into a single, coordinated project to manage cost, schedule, performance and risk. We provide a forum for engineering development and decision making, as well as a single entry point and communication mechanism for customer organization projects."

"Proper systems engineering is crucial — it's the methodology on how we approach the requirements, look at the answer and collect feedback to see that we've met the requirements. It's the basis for how we do capability insertion."

The article that follows on page 61 highlights TARDEC's support to integrate electronic capabilities, develop software and provide crucial M&S expertise to the MCIP and JPO MRAP. While TARDEC is a collaborative partner in this initiative, several services, research centers, OEMs and other partners are actively involved. Hansen emphasized that they are all working toward the same mission — providing survivable, effective vehicles for warfighters in the field. "MRAP is still in the urgent fielding stage right now, so, really, we're focusing on making the vehicles survivable and relevant in Afghanistan," he remarked. "It's one of the few programs that has such a high level of interest that we get feedback almost daily, not just from warfighters but from visitors who have seen the vehicles. But the best feedback we get is when we find out that the things we've done have saved lives."

An MRAP driver negotiates an obstacle course in Iraq. MCIP is working with partners throughout DOD to add lifesaving survivability, electronics, power and suspension to vehicles to address emerging field and warfighter requirements. (U.S. Army photo by SPC Darryl Montgomery.)

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MRAP Capability Insertion Program (MCIP) Uses Modeling and Simulation to Characterize Vehicle Systems

Chris Williams

Time and Soldier safety have always been of the essence with the Mine Resistant Ambush Protected (MRAP) vehicle.

Multiple MRAP variants were quickly ordered and fielded from six different original equipment manufacturers (OEMs) to protect warfighters from threats posed by improvised explosive devices and landmines in Iraq and Afghanistan. As warfighters requested additions to make the vehicles safer and more mission-effective, Joint Program Office (JPO) MRAP and its military partners began researching, developing, integrating and fielding solutions through the MCIP. Crucial to engineering these capabilities in a timely manner is advanced modeling and simulation (M&S), which identifies potential integration challenges and solutions for each variant before physical changes are made to any vehicles, system or subsystem components.

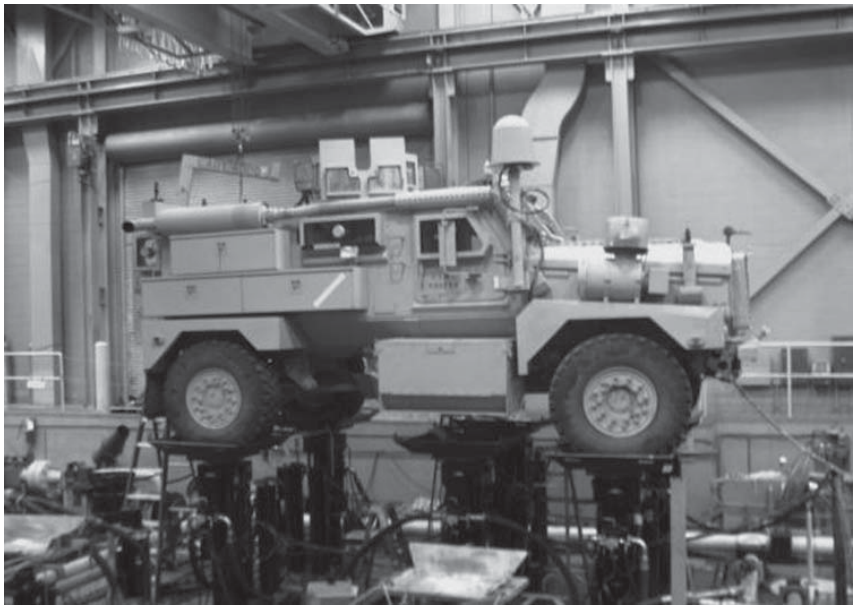
Soldiers conduct a combat mission in Afghanistan in their MRAP vehicles. To properly equip MRAPs with mission-enhancing capabilities, M&S work conducted by TARDEC's CASSI team alerts engineers to potential challenges, constraints and tradeoffs that capability integration may pose. (U.S. Army photo by SGT Efren Lopez.)

A key partner in the MCIP is the U.S. Army Tank Automotive Research, Development and Engineering Center's (TARDEC's) Concepts, Analysis, Systems Simulation and Integration (CASSI) team, which utilizes advanced computer models to illustrate the impact of integrating new technologies onto existing vehicle platforms. "If you have to go back and fix something after it has been added to the vehicle, it often takes you back to square one, and it's going to cost you time and money," explained CASSI Energetic Effects and Crew Safety Team Mechanical Engineer Nancy Prall. "If you know the challenge up front, you can address it right away. M&S raises flags and lets engineers know where they need to take a second look and reevaluate the system design or the positioning of new components."

"We have a standard practice of characterizing a system prior to integration, predicting and minimizing integration impacts using M&S during our design process and then verifying integration impacts through physical characterization after integration."

Developing and Integrating New Capabilities

JPO MRAP requested TARDEC's support in integrating a diverse set of capabilities into the MRAP fleet through the MCIP in summer 2008. CASSI was initially brought on board to assist with M&S work on new capabilities for the MaxxPro MRAP variant. JPO MRAP worked closely with TARDEC's Center for Ground Vehicle Development and Integration (CGVDI) to design, fabricate and integrate potential technology solutions. Before any capabilities were added to an MRAP, CGVDI brought the requirements to CASSI for M&S and analysis to determine the impact these additions would have on overall system performance. "Understanding and assessing the impact of additional equipment to system performance is one of TARDEC's primary responsibilities in supporting vehicle integration efforts," remarked CGVDI Associate Director Dr. Bruce Brendle. "We have a standard practice of characterizing a system prior to integration, predicting and minimizing integration impacts using M&S during our design process and then verifying integration impacts through physical characterization after integration."



An MRAP's suspension is tested on TARDEC's Reconfigurable N-Post Simulator. The CASSI team conducts physical testing of platforms to ascertain relevant vehicle characteristics for accurate modeling and analysis. (U.S. Army TARDEC photo by Carolyn Baum.)

CASSI's Advanced Concepts team incorporates information from a vast database of system and component models to assemble detailed computer-aided designs (CADs) of both the baseline model and with the requested capability integrated onto the system. CASSI works closely with OEMs, JPO MRAP partners and other Army Research, Development and Engineering Centers (RDECs) to understand vehicle and component properties and conduct testing to fill in any knowledge gaps. If sufficient data for the models does not exist, Advanced Concepts will conduct the data-gathering process. The team works with system managers to obtain drawings or data for the actual baseline vehicle, which are then tested on TARDEC's Vehicle Inertia Properties Evaluation Rig (VIPER) to determine the center of gravity and moments of inertia. Team members also conduct suspension characterization testing, which is needed for automotive performance and braking dynamic models. Data on internal components, engines, exhaust and anything that generates heat is collected for thermal analysis, often using TARDEC's Full Load Cooling Test Chamber to validate the data.

The models provide timely knowledge of vehicle

Collaboration is essential to developing accurate models and conducting proper analysis.

characteristics and can be quickly configured to incorporate multiple solutions and scenarios. Advanced Concepts Deputy Associate Director Jeffrey Carie remarked that the team's work provides a quick and accurate understanding of technology insertion. "Typically, the models allow us to turn around a technology assessment in fewer than three weeks," Carie stated. "Without the models, there would be no real way of characterizing the vehicles other than estimating the technologies' mass, physically fabricating and adding a component onto a hardware piece and then reevaluating it on the VIPER, which would take much longer than doing it via CAD."

With six OEMs involved in MRAP production, models must be created for each variant, as the vehicles have different layouts, physical properties and characteristics that can affect component placement and integration. "It creates challenges but also opportunities," Carie stated. "A goal of the Capability Insertion Program is to have common solutions for the various OEMs. In doing this front-end modeling, we're using the same technologies in our database to provide common components for the various OEMs. Each vehicle is different and has its own unique integration challenges, but there is an opportunity to insert common technologies and reduce the logistics footprint."

Collaborative Data Sharing Crucial to Program Success

Collaboration is essential to developing accurate models and conducting proper analysis. "We work very closely with other partners," Carie emphasized. "You can't get an accurate product done in three weeks if you're not working with the people who need to be involved — that includes CGVDI, the program manager offices and JPO MRAP. We work closely with the Space and Naval Warfare Systems Command, a Navy agency that integrates the government-furnished MRAP equipment, and with RDECs like the

U.S. Marine Corps (USMC) personnel maneuver their MRAP vehicle through desolate terrain in Iraq. CASSI's contribution to the MCIP has helped engineers understand power demands and thermal challenges posed by technology integration, which better prepares the vehicles for the environmental rigors of Iraq and Afghanistan. (USMC photo by LCPL Gabriela Garcia.)

U.S. Army Communications-Electronics Research, Development and Engineering Center for antennae modeling."

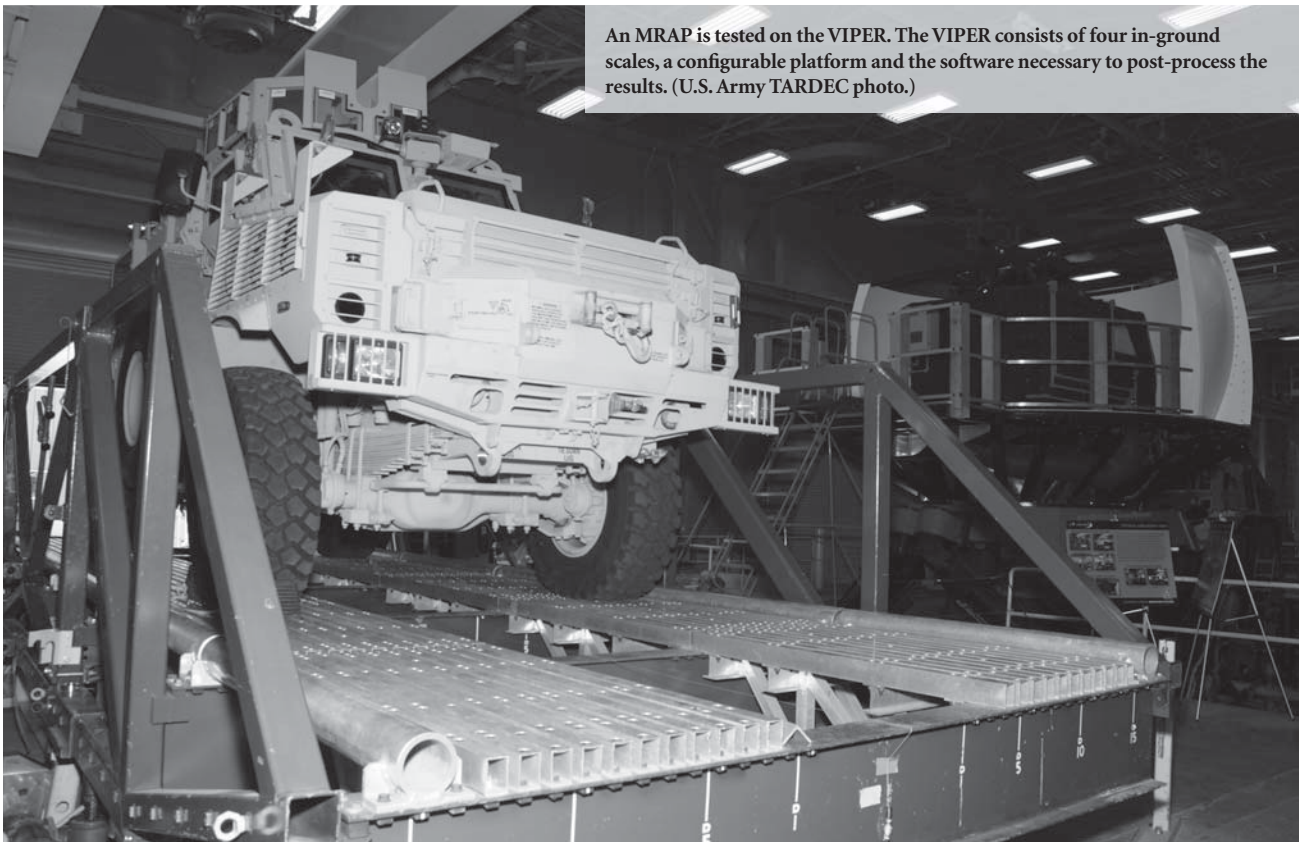
"M&S have provided a lot of data for us, but we've always gone back and tested that. On the survivability side and on the automotive capabilities side, our test data are going to be incorporated into many of the models to make them better."

Prall stated that this collaboration has led to a greater understanding of challenges posed to capability insertion and solutions that can make those capabilities more effective. "M&S comes into play upfront and gives CGVDI a heads-up, which they, in turn, can provide to the customers," Prall explained. "It has given them some important information, whether it's to position something on the left or right side of the vehicle, or to change the duct work in a vehicle to avoid thermal issues."

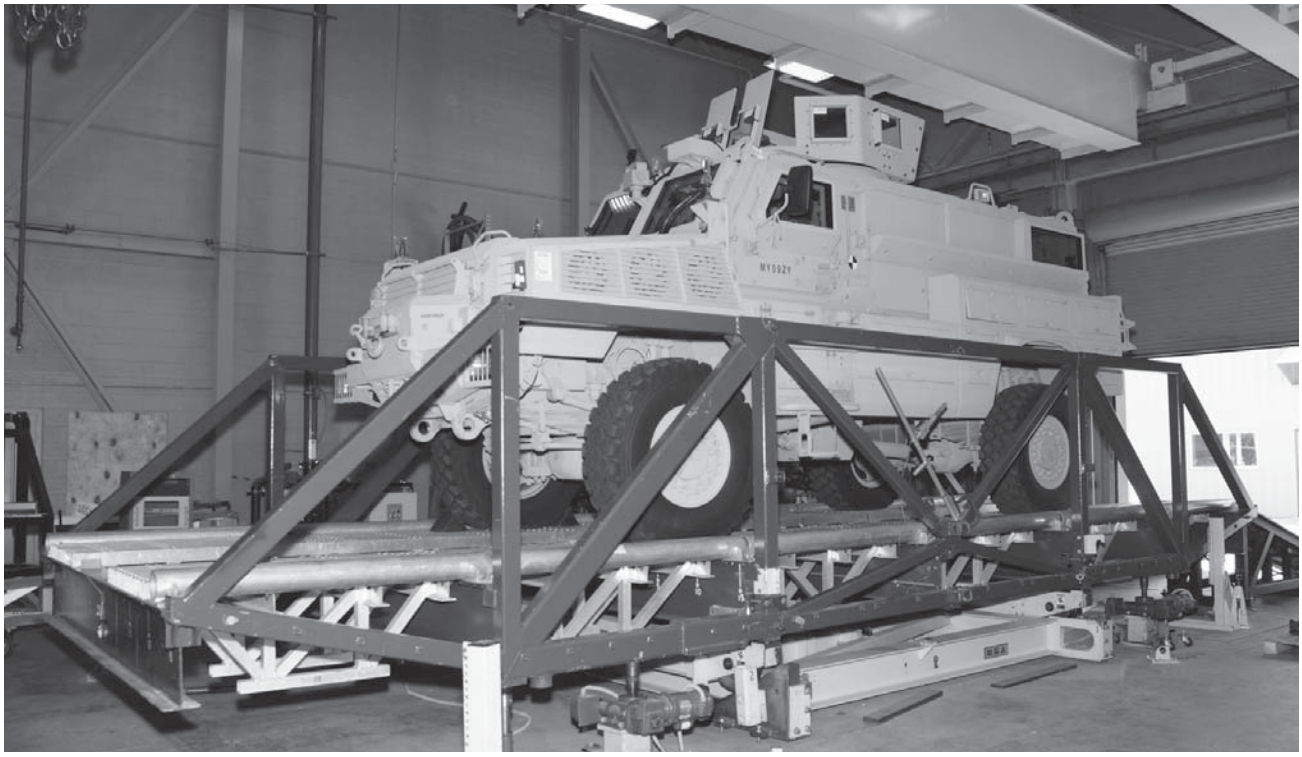
One example that Prall points to is CASSI's involvement in thermal analysis for the Caiman C2 On-The-Move MRAP variant. CASSI modeled cooling and power units that the customer was planning to integrate onto the vehicle. The M&S analysis helped the customer avoid complications that could have affected vehicle performance and also provided several possible solutions. "We looked at where they were mounting the cooling units and a small power unit. They were both located on the same side of the vehicle, and it seemed like it was adding a slight lean to it. We ran some analyses and gave them three or four different options for how they could mount these and what the effect would be for each," Prall stated. "Based on those analyses, they determined the best positions for these two units."

M&S Data Leads to Unique Survivability and Automotive Capabilities

After two years of involvement with MCIP, Carie stated that CASSI has enhanced its technology database and capabilities to conduct fast, accurate M&S analysis to assist its partners in providing warfighters with lifesaving, mission-enhancing solutions and strengthening TARDEC's relationships with MRAP OEMs and military partners. "We have delivered on every capability insertion task we've been given in the last two years. If there's an MRAP fielded in any quantity, chances are we have done a technology insertion assessment on it and provided the customer with an integration review within three weeks, characterizing the space, weight, power and cooling impacts of the technologies they are considering integrating into the fielded vehicles to address very urgent requirements," Carie



An MRAP is tested on the VIPER. The VIPER consists of four in-ground scales, a configurable platform and the software necessary to post-process the results. (U.S. Army TARDEC photo.)



An MRAP is characterized on the VIPER, which is used to accurately measure the system and subsystem inertial characteristics of trucks, trailers and turrets. Most vehicles can be evaluated without modification or disassembly. (U.S. Army TARDEC photo.)

stated. "It has given us a deeper appreciation of the technology insertion project and of what CGVDI needs as we hand off our conceptual design, so we can become more efficient. It has also cemented our relationship with our U.S. Army TACOM Life Cycle Management Command partners, JPO MRAP and USMC. They're much more aware of what TARDEC does."

"From a programming perspective, the modeling data has given us the initial baseline of what we believe to be good improvements, but we are also very stringent about our test regimen. Anytime we've made major changes to the vehicle, we've taken it up to Aberdeen Proving Ground, MD, and tested it to the levels of performance that we need," remarked JPO MRAP Deputy Program Manager David Hansen. "It's a balancing act. M&S have provided a lot of data for us, but we've always gone back and tested that. On the survivability side and on the automotive capabilities side, our test data are going to be incorporated into many of the models to make them better. So if the MRAP program has done anything, I think that we're actually going to have the ability to improve the modeling in both survivability and automotive because of the amount of testing we did."

Prall explained that as CASSI's involvement with the program continues, lessons learned are helping to expedite the process and provide better, more enhanced detail for the computer models, which assists her team in providing high-quality analyses. "Our main objective right now is if we a know a system is going to be slated for capability insertion, gathering as much data as we can up front before we even have the requirement to start providing results because the most important thing with M&S is collecting all your data," she stated. "If you have all the data up front and you can start building models, you can have a quick turnaround, which is what everybody desires."

As joint partners throughout the Army, USMC and industry strive to enhance MRAP protection and capabilities for our warfighters, M&S will continue to be an important tool for understanding the challenges posed by technology insertion. "We have a lot of expertise here in CASSI," Prall concluded. "CGVDI and the customers are fully understanding of what we need and are very supportive. We have a very good working relationship."

Chris Williams is a Writer/Editor with BRTRC and provides contract support to TARDEC's Strategic Communications team. He has a B.A. in communication from Wayne State University and has previously written for *The Source* newspaper in Shelby Township, MI, and *The Macomb Daily* and C & G Newspapers in Macomb County, MI.

Systems Engineers Optimize

Garett S. Patria

Determining the best way to distribute workload across various resources can be a challenge. The more complicated the workload, the more transient factors to simultaneously consider. In addition, workload decisions that affect numerous people or facilities tend to involve multiple perspectives — principally, subjectivity.

Soldiers from Headquarters Company, Scout Platoon, 1st Battalion, 30th Infantry, 2nd Brigade Combat Team (2BCT), 3rd Infantry Division (3ID), man an Iraqi Traffic Control Point in Kirkuk, Iraq, Feb. 2, 2010. The Army's organic IB ensures that Soldiers have the necessary equipment and vehicle platforms to perform their missions. The newly developed TACOM LCMC optimization tool will assist engineers and decision makers plan workload strategies to meet critical objectives and goals. (U.S. Army photo by SPC Matthew Lestikow.)

Workload Leveling Challenges

Subjectivity is an engineer's worst nightmare. Take distributing the workload of a major ground vehicle system, for example. What if the number of units within a fielding schedule is decreased by 75 percent in fiscal year 2013? Some factories may have the resilience to absorb this change, but work may have to be reshuffled, or "leveled," across several sites to reestablish an optimum state. If so, which workload leveling (WLL) solution is best for the Army? What's best for the industrial base (IB), in general? How much IB data is enough to analyze a WLL case like this? Generic guidance dictating that we must choose between cost, schedule and performance never qualifies the context — which point of view should be considered as primary? Should the goal be a short-term rate of return or a long-term benefit?

Addressing WLL Challenges

Depending on which perspective a decision maker esteems at the time, the WLL solution will vary. This variation can result in a suboptimal assessment, giving mixed strategy signals to our original equipment manufacturers (OEMs) and organic IB comprised of the Army's arsenals and depots. That's why the WLL Team — comprised of members from across the U.S. Army TACOM Life Cycle Management Command (LCMC) — is developing an optimization tool to apply to the "black art" of WLL justification.

The WLL initiative, sponsored by Program Executive Office Ground Combat Systems, is currently focusing on an optimization model that will run on a Windows application. The intent is to develop workload planning strategies, with optimization, to meet objectives and goals within dynamic constraints. These strategies will be utilized within a simulation model to evaluate alternative strategies and associated risks not captured in the optimization. Iterations between the optimization and simulation analyses will offer the opportunity to explore various IB decisions and their associated impacts. The combination of the optimization and simulation tools provides a robust, science-based approach with quantifiable insights into IB dynamics. A successful proof-of-concept illustrated the ability to model the IB using optimization and simulation to represent the interrelationships of objectives within an enterprise view. However, defining the view was the team's next challenge.

Data requirements definition involves revealing what the customer wants or what data the WLL decision makers need to declare a confident workload allocation.

To define the appropriate scope for such a model, the WLL Team chose to leverage the Lean Six Sigma (LSS) process. To date, the model's heart has been centered

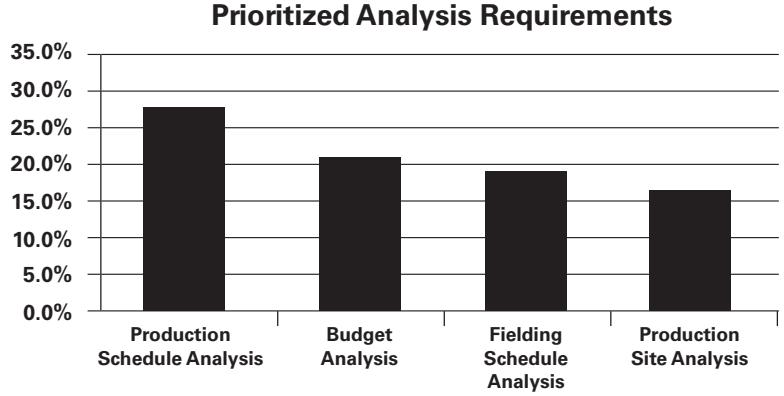
From left: TARDEC Industrial Base Integration Team members Stan Michener, Kenneth Zurek, Mike LaRaia (standing), Garett Patria, Lori Bartsch, Adrennia Hughley and Bernice Conn review documents for the WLL tool. WLL Team members commonly leverage the expertise of subject-matter experts across the TACOM LCMC. (U.S. Army TARDEC photo.)

around two distinct conduits: data requirements definition and data collection planning, led by LSS Black Belts Bernice Conn and myself, respectively. Data requirements definition involves revealing what the customer wants or what data the WLL decision makers need to declare a confident workload allocation. Just as "showing your work" cannot be overemphasized in a mathematics course, the same is true for WLL analysis.

The WLL Team is exposing the reasons and data behind intermediate WLL decisions that can help determine an overall WLL solution's robustness. For example, there was subjective debate on what analysis areas the WLL model should represent. Using data, the decision was made to focus on four areas of analysis. All to be equally (within 10 percent) influential when leveling workloads, as depicted in the figure. Survey feedback revealed:

- Production schedule
- Budget
- Fielding schedule
- Production site

In contrast, data collection planning involves identifying all IB data repositories within the Detroit Arsenal to reduce the number of data points collected from OEMs and depots by 10 percent. Once these data sources are identified, a standard operating procedure will be developed to streamline the data collection/feed into the WLL optimization model for processing. Data such as component cost, factory location and production lead time can be easily gathered internally at no cost via databases such as the U.S. Army Materiel Command's Logistics Support Agency and Haystack Gold. However, a production line's minimum sustainment rate (MSR) is something that is more often determined by a particular site. Accurate MSRs across the IB may be a potential data feed that has a cost associated with it. After all, MSR violations are one advance indicator of producers needing more work to justify their production configuration.



The above chart demonstrates the various requirements the IB must meet. By using the WLL tool, the IB can plan WLL strategies to meet dynamic requirements. (U.S. Army image by Bernice Conn.)

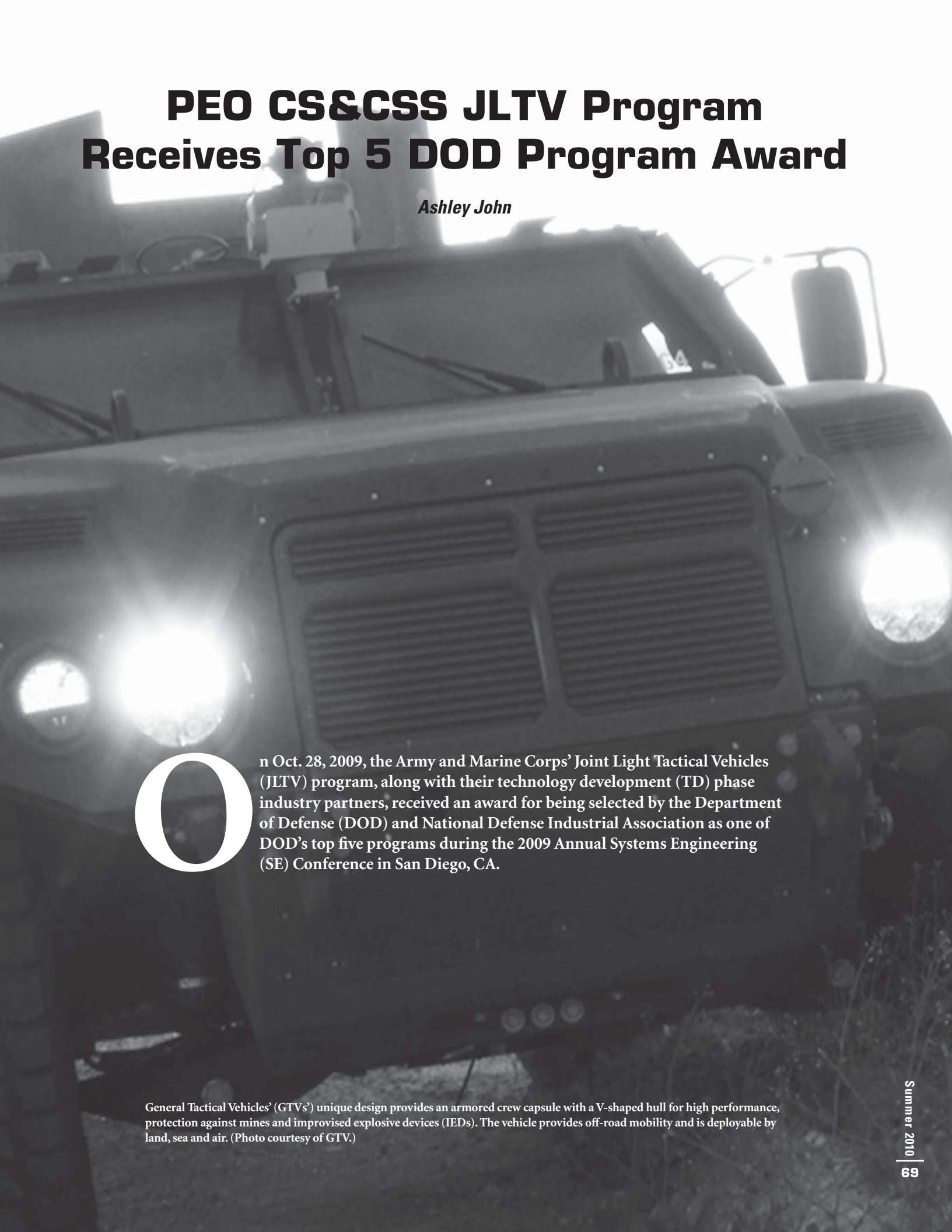
Data collection planning involves identifying all IB data repositories within the Detroit Arsenal to reduce the number of data points collected from OEMs and depots by 10 percent.

Like any machine, the critical factories that make up the core defense IB cannot afford to be stagnant for long periods; otherwise they begin to atrophy — thus the phrase, "needing to keep the industrial base warm." Obviously, the United States' reliance on a warm IB is an important piece of the Arsenal of Democracy's military heritage. Consequently, the WLL Team is cognizant of the IB's fragile ability to remain on call whenever the demand to produce arises.

Garett S. Patria is a General Engineer on TARDEC's IB Engineering Team in the Integrated Industrial and Sustainment Engineering Department. Patria holds a B.S. in mechanical engineering and an M.E. in manufacturing systems from Lawrence Technological University. He is Level 1 certified in systems engineering. Prior to joining TARDEC last year, Patria led various design and engineering teams at BAE Systems and Chrysler.

PEO CS&CSS JLTV Program Receives Top 5 DOD Program Award

Ashley John



On Oct. 28, 2009, the Army and Marine Corps' Joint Light Tactical Vehicles (JLTV) program, along with their technology development (TD) phase industry partners, received an award for being selected by the Department of Defense (DOD) and National Defense Industrial Association as one of DOD's top five programs during the 2009 Annual Systems Engineering (SE) Conference in San Diego, CA.

General Tactical Vehicles' (GTVs') unique design provides an armored crew capsule with a V-shaped hull for high performance, protection against mines and improvised explosive devices (IEDs). The vehicle provides off-road mobility and is deployable by land, sea and air. (Photo courtesy of GTV.)

The JLTV program, alongside TD phase government, international and industry partners, received formal recognition for its significant accomplishments in research and development (R&D), SE technical planning, management and program execution, demonstrating how early TD phase planning and execution efforts exemplify acquisition excellence. "The U.S. Army Program Executive Office Combat Support and Combat Service Support [PEO CS&CSS], working with the U.S. Marine Corps [USMC], began developing the JLTV program years before the Milestone A decision, in a well-thought-out R&D strategy in an effort to gain an understanding of the status of leading-edge technologies," said U.S. Army COL John S. Myers, Project Manager, Joint Combat Support Systems (PM JCSS).

Sound SE Process Delivers Tangible Results

The JLTV program began laying the groundwork for its sound SE program during the robust R&D phase and continues to do so during its competitive prototyping TD phase activities. Early development efforts helped the program frame which technologies were within performance reach, while trying to avoid high future JLTV life cycle and sustainment costs. Working with users and combat developers, the JLTV program was able to develop a usable draft Capability Development Document (CDD) set of requirements that served as the basis for the TD phase purchase description specification. "JLTV's concerted efforts with the Office of the Secretary of Defense for Acquisition, Technology and Logistics, Marine Corps Combat Development Command, U.S. Army Training and Doctrine Command, industry, and international partners enabled the JLTV program team to wisely establish knowledge point review processes to incorporate knowledge gained from engineering technical reviews, test results, user juries and lessons learned from operations in Iraq and Afghanistan to produce a low-risk CDD by Milestone B," added U.S. Army LTC Wolfgang Petermann, Army Product Manager, JLTV.

Trade Studies and Critical Design Review Lead to Informed Decisions

The JLTV program team is currently conducting a series of whole-system trade studies throughout the TD phase to make sound and informed trade decisions that can be document-

BAE Systems' JLTV design incorporates lessons learned from DOD's Mine Resistant Ambush Protected vehicle program and features the latest in lightweight, advanced armor and a V-shaped hull design to provide maximum crew protection against mines and IEDs. (Photo courtesy of BAE Systems.)

The JLTV program is comprised of a Family of Vehicles and companion trailers. JLTV will provide warfighters with a balanced solution — protection, performance and payload — packaged in a transportable and expeditionary solution when full production and fielding begin in 2015. The Lockheed Martin Corporation investment test vehicles underwent extensive testing and have accumulated more than 70,000 combined test miles, more than half of which have been conducted off-road to simulate mission conditions, prior to delivering government vehicles in April 2010. (Photo courtesy of Lockheed Martin Corporation.)

ed with valid rationale for later use. JLTV has also developed a solid TD phase SE program consisting of event-driven technical reviews and test planning. "Conducting early and tailored TD phase preliminary and critical design reviews with each of the industry teams has helped the services determine what trades each vendor is making in an attempt to meet the requirements of the draft CDD," added USMC LTC Ben Garza, Marine Corps Program Manager, JLTV. This approach will feed the service's knowledge point reviews to conduct whole system trade studies to refine the engineering and manufacturing development (EMD) phase requirements.

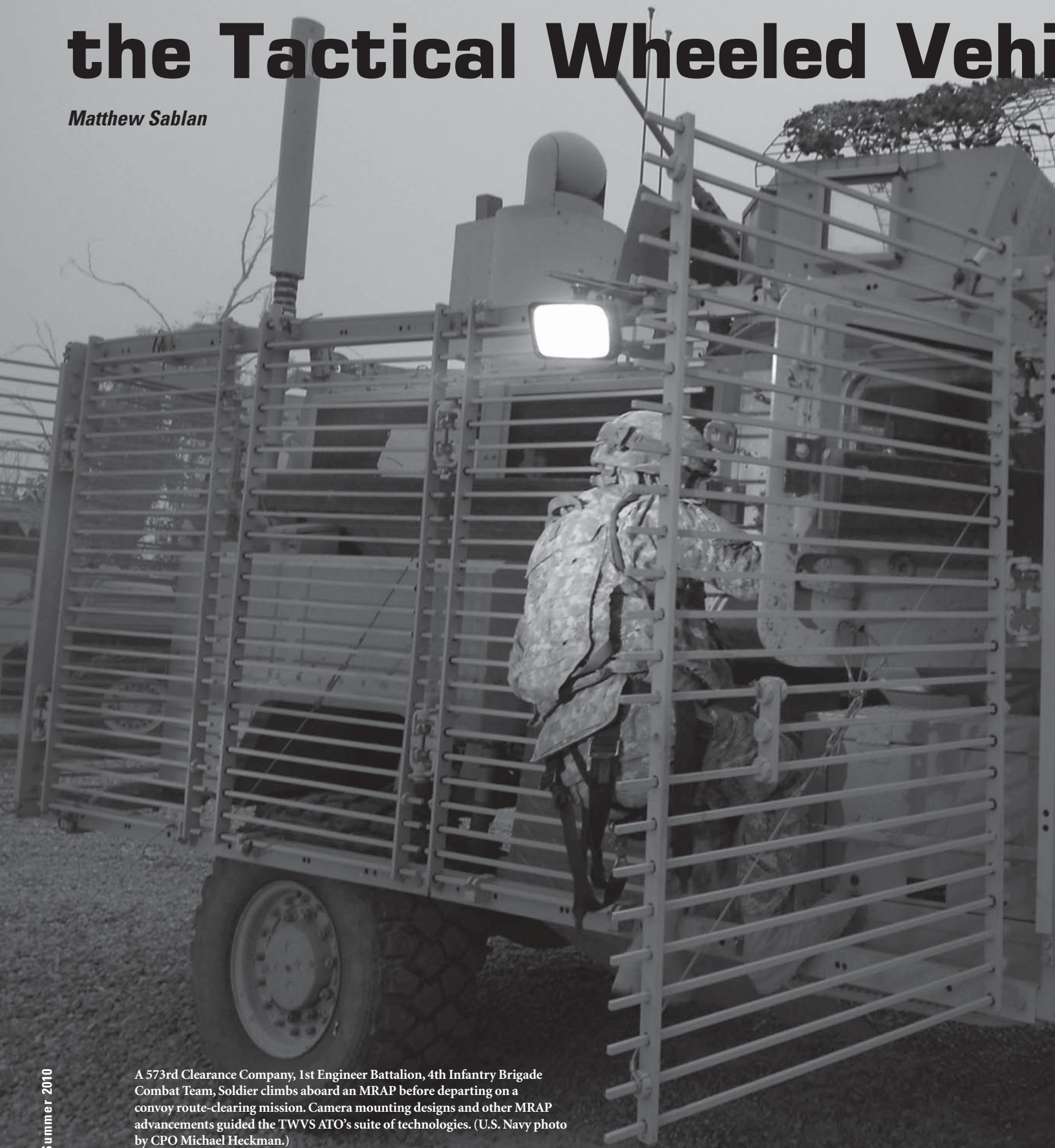
Following the TD phase, the services intend to conduct another full and open competition for the EMD phase with a Milestone B decision planned for fiscal year (FY) 2011. A Milestone C decision is planned for FY 2013 and full production and fielding is anticipated to begin in 2015.

The JLTV program is aligned with a joint program office under the management of the U.S. Army PM JCSS, which falls under the leadership of PEO CS&CSS. The joint protection requirements found within JLTV are designed to better meet warfighters' current and future survivability needs, all packaged in a mobile, transportable, supportable and expeditionary solution. The JLTV will restore balance and unprecedented capability to the tactical wheeled vehicle fleet.

Ashley John, Strategic Communications, PEO CS&CSS, has a B.A. in marketing from Michigan State University.

Encounter Avoidance — P
the Tactical Wheeled Vehi

Matthew Sablan



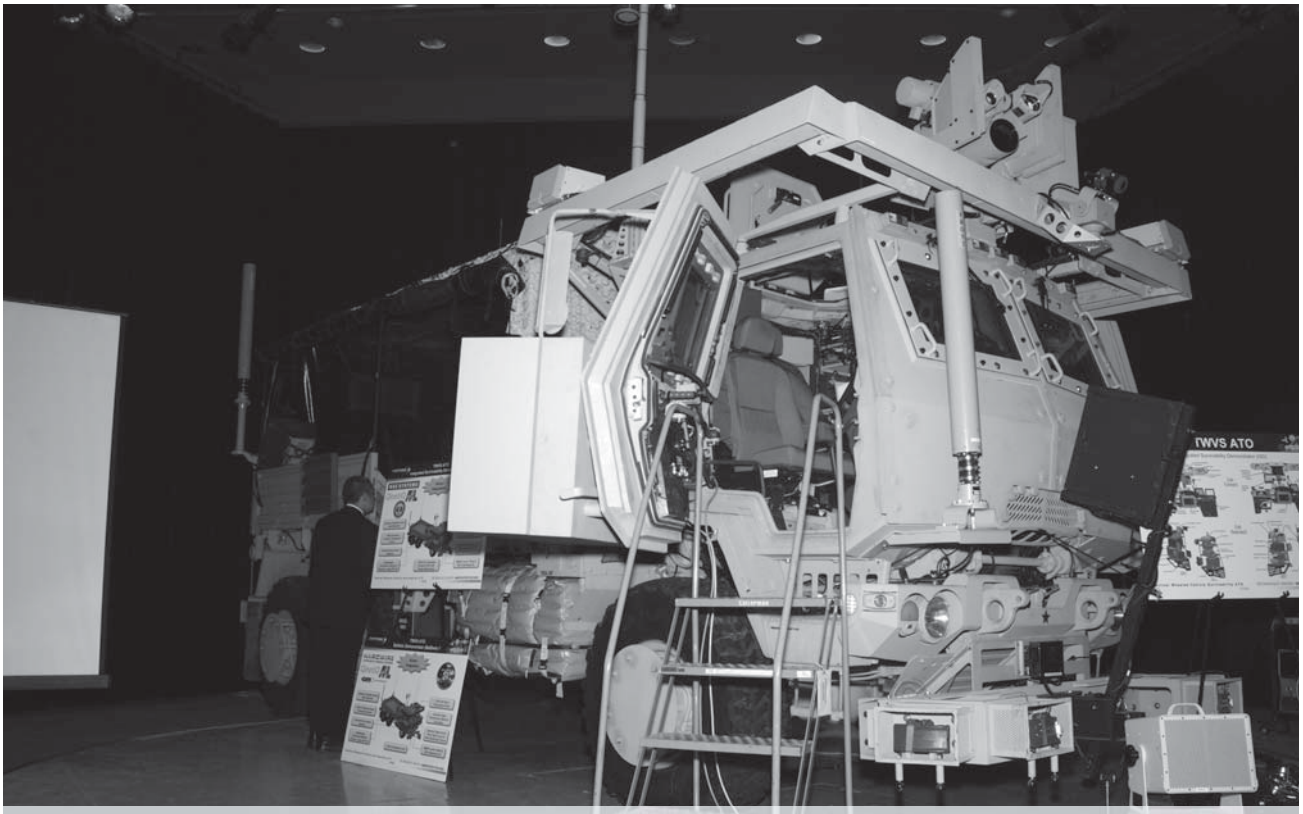
A 573rd Clearance Company, 1st Engineer Battalion, 4th Infantry Brigade Combat Team, Soldier climbs aboard an MRAP before departing on a convoy route-clearing mission. Camera mounting designs and other MRAP advancements guided the TWVS ATO's suite of technologies. (U.S. Navy photo by CPO Michael Heckman.)

rotecting and Sustaining icle (TWV) Fleet

For the past 50 years, Army tactical trucks have been under-protected compared to their combat vehicle brethren. In conventional warfare, this shortcoming was rarely an issue. On today's ever-changing battlefield, however, military trucks face threats similar to those sustained by combat vehicles, but without the same armor-enhanced protection. Underbody blasts, improvised explosive devices (IEDs), explosively formed penetrators (EFPs), rocket-propelled grenades (RPGs) — even direct and indirect artillery fire — all pose threats to military trucks and their crews. In the past, Army-developed survivability technologies were often integrated onto systems in an ad-hoc manner, creating burdensome power demands, decreased mobility and maneuverability capabilities and increased thermal management challenges, among others.

Former U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) Tactical Wheeled Vehicle Survivability (TWVS) Army Technology Objective (ATO) Systems Manager MAJ Larry N. Ross explained the situation from a user's perspective: "In order to turn [the survivability technologies] on, I had to be flexible and do my best yoga move, open the blast door, reach back there, turn on the air conditioning unit and then turn on the jammer. Once I got down the road, I didn't know anything about those systems' statuses anymore."

In 2006, Program Executive Office Combat Support and Combat Service Support (PEO CS&CSS) noticed that TWVs were underequipped for current contingency operations. Along with TARDEC, PEO CS&CSS identified an opportunity to combine efforts on what would become the TWVS ATO. Partnering with government organizations that included the U.S. Army Research Laboratory (ARL) and Engineer Research Development Center (ERDC), and collaborating with academia and industry, PEO CS&CSS and TARDEC joined forces to develop a truck survivability approach that could adapt to changing missions, threats and technologies. The ATO's objective was to demonstrate holistic survivability through the integration of cutting-edge technology solutions for warfighters' current and future needs. The demonstrator truck would be a versatile vehicle



One of three ISD demonstrators is displayed at TARDEC's Warren, MI, campus. The vehicle, the result of four years of partnership and cooperation between government and industry, has 50 survivability technologies integrated onto it to demonstrate its robust encounter avoidance capabilities. (U.S. Army TARDEC photo.)

with plug-and-play capabilities. The overarching mission requirement was broad — provide protection to the entire TWV fleet.

Developing an Integrated Systems Engineering Approach

TARDEC studied each potential technology's impact with respect to payload, performance and protection, while keeping cost in mind. In addition, the TWVS ATO team as a whole worked with the U.S. Army Training and Doctrine Command (TRADOC) and other government agencies to conduct requirements analysis, technology assessment and concept development. "We needed to show we had the technology and engineering capabilities to integrate the technologies onto tactical vehicle platforms," stated Bobbe Desmond, Assistant Program Executive Officer CS&CSS, Systems Engineering and Technical Integration.

Extensive systems engineering (SE) analyses yielded valuable technical information. The TWVS ATO solicited user reviews about the vehicle and trucks, which were correlated with requirements and mapped to technical objectives. TARDEC also conducted tradeoff analyses and detailed technology assessments. All of this data was compiled in a correlation matrix, where various requirements and methods were weighted against one another.

To help analyze the tactical truck requirements, the entire fleet was divided into four discrete roles or missions:

- Force application
- Focused logistics (distribution)
- Focused logistics (line haul)
- Combat support

In the end, the ATO team, guided by Program Executive Officer PEO Integration MG John R. Bartley and then-Project Manager Tactical Vehicles U.S. Army COL Scott Kidd, settled on using a Family of Medium Tactical Vehicles truck platform for the demonstrator. This Integrated Survivability Demonstrator (ISD) does not show the final production integration of a single vehicle. Rather, it focuses on showing the art of the possible in configuring a large number of protection technologies to meet all identified potential threats.

Engineers Take a Comprehensive Look at Survivability

Following the analysis process, the TWVS ATO team developed an ISD plan to addresses technical integration challenges. This included creating a Survivability Systems Deskbook (SSD) to address user requirements through 2017 and help PEOs/program managers (PMs) navigate technology advancements. The SSD allows

users to look across the entire truck fleet, while also providing key decision makers with a documented methodology to examine recommendations for survivability modernization planning.

The PEOs and PMs can reference the SSD to review technologies that the TWVS ATO team conducted concept work on, developed and tested. More than a reference book, "It's a modernization planning tool to make our customers more informed buyers," TARDEC TWVS ATO Engineer Jeffrey Chinoski explained.

Because the SSD is actually an electronic TWV modernization planning tool, it will be available online via TARDEC's Advanced Collaboration Environments. It will cover the TWVS ATO requirements, concept integration analysis and lessons learned. In addition, the SSD will review threat and requirements analyses, technology assessments, systems and technology integration information, modeling and simulation (M&S), and methods to optimize the survivability suite. This hard data will be coupled with survivability upgrade recommendations and cost, reliability, durability, size, weight, power and cooling analyses.

The ATO's objective was to demonstrate holistic survivability through the integration of cutting-edge technology solutions for warfighters' current and future needs.

By providing Ground Systems Enterprise partners with this information, TARDEC is giving PEOs and PMs the information to make informed integration decisions. "This reference book will be a good resource," stated Bob LaPolice, PEO CS&CSS Chief Systems Engineer. "The challenge has always been that once an ATO is complete, the information is squirreled away. The SSD is something beyond other ATOs and shows the investment is more useful — it spreads the knowledge gained."

The Army views occupant-centric survivability as a layered approach, similar to the layers of an onion. The TWVS ATO program took that methodology and expanded it. The figure on the next page illustrates the various layers with each layer representing a protective system — active or passive — that a threat must defeat to harm the occupant. For example, if a Soldier can avoid detection or acquisition as a target — with smoke or electronic jamming — he or she is safe. If targeted but unable to be hit due to electronic countermeasures, the Soldier is safe. When hit, if the armor is not penetrated, serious harm may be avoided. Even once

TARDEC Engineer Scott Payton (left) observes as Project Manager Tactical Vehicles COL David G. Bassett (middle) examines the ISD's interior configuration and discusses the vehicle's capabilities with former TARDEC TWVS Systems Manager MAJ Larry N. Ross. Extensive SE relied on feedback from users and other organizations to draft the vehicle's future requirements. (U.S. Army TARDEC photo.)

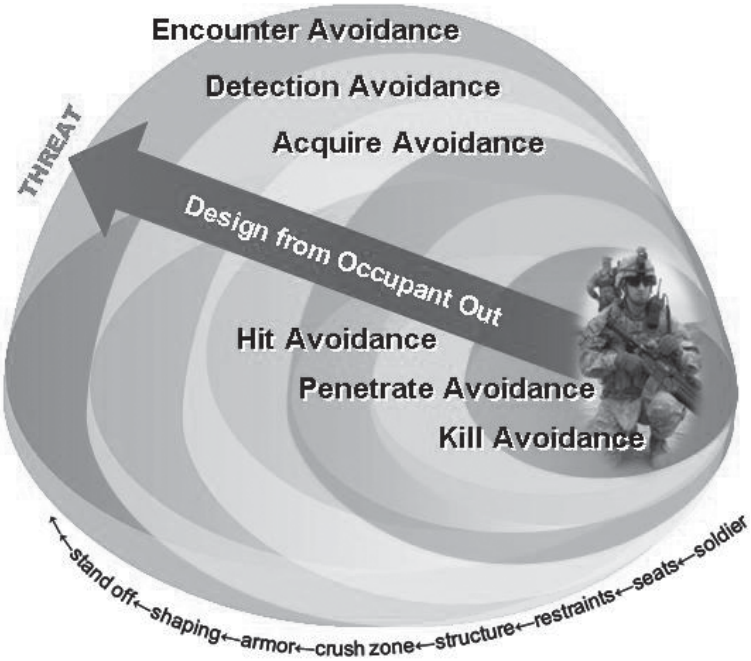


Figure — Survivability Layers. TARDEC's survivability approach is Soldier-centric and focused on preventing injury to Soldiers and minimizing damage to Army vehicles and equipment. The projection arrow shows that the program designed its technologies first, focusing on kill avoidance and covering each survivability layer in turn, out to the newest layer, which the TWVS ATO categorizes as encounter avoidance. (U.S. Army TARDEC image.)

penetrated, there are methods to prevent a hit from proving lethal. Many current programs, such as armor kits, focus solely on one layer. While these programs increase Soldier survivability, the TWVS ATO program took a more comprehensive approach. "TARDEC takes a Soldier-centric view of survivability, slicing across all the layers," Chinoski explained. During the analysis process, that Soldier-centric view revealed three common elements the demonstrator needed to achieve its survivability requirements:

- Integrated armor solutions
- Non-armor technologies
- M&S tools

The TWVS ATO team began by looking at the inner Soldier layers and expanded the outer onion layers to include what it calls "encounter avoidance." *Encounter avoidance* emphasizes the value of command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) and 360-degree situational awareness — capabilities the TWVS ATO brings to the fight. Theoretically, if Soldiers avoid encounters, they cannot be harmed. The platform uses intelligence, communication and technology tools to protect Soldiers.

Technology Improvements Reinforce Crew Protection

To build the three demonstrators the program delivered to the Army, TARDEC used a baseline military truck as a starting point. The team integrated the standard communications package with which most vehicles are equipped. "Our challenge in this ATO was to layer survivability subsystems on top of this existing comms package without degrading truck performance," stated TARDEC Engineer and former TWVS ATO Manager Munira Tourner. Technology was integrated by addressing the physical, data and power interface challenges. At the kill-prevention layer (the innermost layer), the team added restraints, safety harnesses, fire-suppression systems and blast mitigation technologies. The B- and C-kit armor solutions were layered, and active protection systems were added to decrease the likelihood of a projectile penetrating the truck. "The TWVS ATO addressed signature management and electronic countermeasures, situational awareness through multiple camera systems and, finally, nonlethal technologies," Tourner continued.

"The TWVS ATO addressed signature management and electronic countermeasures, situational awareness through multiple camera systems and, finally, nonlethal technologies."

— Munira Turner, former TARDEC TWVS ATO Manager

To allow all new and existing technologies to communicate with one another, the communications system leveraged the PEO Command Control Communications-Tactical-developed vehicular integration for C4ISR/electronic warfare interoperability (VICTORY) architecture. The VICTORY architecture is an open, flexible, network-centric, systems-oriented methodology that reduces redundant systems by providing all equipment with a common data backbone. It streamlines and prioritizes the data coming to the Soldier, communicating useful information directly to the vehicle commander through common displays rather than having him or her track all 50 systems on the demonstrator manually. While

no vehicle will be equipped with all 50 potential technologies, each capability has been demonstrated. "If anything goes wrong with the truck, a message is sent to me instantly," Ross explained. "From a Soldier's perspective, the 'so-what' of all of this is that I can manage more systems, and each system increases my survivability on that vehicle."

The VICTORY architecture provided access to the digitized power control of all 50 technologies, allowing the driver and commander to share access to the information through common displays. When integrating cameras on top of the armor, the ATO took advantage of Mine Resistant Ambush Protected (MRAP) vehicle designs. Armor solutions included higher-performance and lighter-weight B-kits for opaque and transparent armor, sensor-enhanced armor for armor health monitoring, advanced medium and large EFP C-kits and a high-performance vehicle underbody kit. The ISD also integrated its RPG-defeat and counter-sniper "slew to cue" with the Common Remotely Operated Weapon Station II weapon system through a common radar system. "Some of the work migrated directly to field improvements," Desmond noted, citing the MRAP digital backbone. "By working hand-in-hand with other PMs, we can leverage more ongoing, real-world efforts and see more direct benefits by bringing different pieces to the hands of the warfighters."

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— Bobbe Desmond, Assistant Program Executive Officer CS&CSS, Systems Engineering and Technical Integration

Putting it all Together — Integrating the Demonstrator

The next step, integration, used an Enterprise Integrated Program to unite various divisions of the U.S. Army Research, Development and Engineering Command (RDECOM), industry and academia. Government organizations included PEO CS&CSS, TRADOC and the Defense Advanced Research Projects Agency (DARPA). First, a set of requirements were drafted following user reviews and capabilities analyses. TARDEC conducted extensive M&S of technologies and combinations of technologies through various war-gaming tools and technology optimization efforts. The TWVS ATO team matured and developed the operational effectiveness of M&S tools to include trucks, which were not included prior to fiscal year (FY) 2006. The ATO also helped develop a blast and fragmentation underbody kit design tool to assist in ISD design efforts. "The tools also modeled the systems' impacts due to the addition of technologies," TARDEC TWVS ATO Engineer Jerry Dixon noted. TARDEC also modernized tools associated with vulnerability, thermal, heating, ventilation and air-conditioning modeling.

By FY 2007, complex scenarios with trucks, such as convoy resupply, were possible. In the future, the TWVS ATO team will work with the TRADOC Requirements Analysis Center at White Sands Missile Range, NM, on new truck mission models for Combat XXI, a government owned and developed modeling tool used by the Army and Marine Corps. These models have the potential to expand the Army's M&S capabilities. "The capabilities developed while producing these demonstrators will prove invaluable in the future," stated Jennifer Hitchcock, TARDEC Director of Research and Technology Integration. "Together, the many organizations within the Army and the U.S. Army TACOM Life Cycle Management Command have furthered technology and realized new capabilities that will prove invaluable in enhancing future vehicles."

The ISD cockpit is crammed with technology. Each piece of equipment was carefully positioned after a detailed human factors analysis. The ISD crew compartment will continue to be modified with future Soldier-in-the-loop training to make the system as user-friendly as possible. (U.S. Army TARDEC photo.)

MRAP designs inspired numerous TWVS ATO survivability technologies. Since trucks serve multiple purposes on the modern battlefield, TWVS ATO program engineers are conducting extensive SE analyses to correlate requirements and map technical objectives for future vehicle platforms. (U.S. Army photo.)

Advanced M&S Provided by the Integrated Survivability Systems Integration Laboratory (ISSIL)

The ISSIL used advanced modeling to create computer-aided design (CAD) drawings to run various simulations. "The ISSIL was the bridge to take this integrated survivability vision from paper to steel," Tourner declared. "It was a close partnership with Intelligent Ground Systems, TARDEC's newly established Vehicle Electronics and Architecture group, the Software Engineering Center and numerous other organizations."

The ISSIL allowed the TWVS ATO team to work with TARDEC's Concepts, Analysis, Systems Simulation and Integration (CASSI) Advanced Concepts and Demonstrators groups to refine each concept by looking at integration, power, data and physical challenges to incorporate a wide range of technologies. The initial design resulted from the defined concepts. "Then, we worked with the Center for Ground Vehicle Development and Integration [CGVDI] and CASSI groups and actually went on to do the detailed design, fabrication and integration," Tourner stated. The demonstrator's concept design and development through final integration and delivery were managed by TARDEC CASSI Demonstrators Group Engineer Scott Payton. TARDEC CASSI Engineer Judy McIntyre was the Advanced Concepts Lead.

"TARDEC takes a Soldier-centric view of survivability, slicing across all the layers."

— Jeffrey Chinoski, TARDEC TWVS ATO Engineer

Once the ISSIL completed its work, TARDEC's TWVS ATO and CASSI turned to the CGVDI to fabricate and integrate the demonstrator. In close coordination with CASSI, the demonstrator underwent extensive physical simulation at TARDEC's various vehicle simulation labs, including Test Cell 9 for environmental testing and the Ground Vehicle Simulation Lab's Vehicle Inertial Properties Evaluation Rig and Shaker. After each physical simulation, the team fine-tuned the ISD. It underwent a live demonstration in late March 2010.

Demonstration and Further Testing Await the ISD

The ISD's demonstration was a success. Ross, Tourner, Payton and other TWVS ATO team members used the event to explain the technology and share lessons learned. The ISD validated M&S tools through physical simulation. Further validation is possible after receipt of the automotive, live-fire and ISSIL Soldier-in-the-loop testing results. DARPA PM Dr. Karen Wood remarked on the value M&S brought to the TWVS ATO as well as possible future products: "I think that [M&S] is extremely valuable. But, a model is only as good as what you put in it." Validating the models through iterative designs, Wood noted, would "be huge" and "a great way to save money."

In addition to creating a survivable military truck, the TWVS ATO team discussed various technologies that were advanced and used during the project. The partnership also found new ways to centralize vehicle power for the truck's subsystems and expanded the second-generation VICTORY architecture to encompass 50 survivability technologies, a new height to the architecture's capability. The work will result in Technology Readiness Level 6 armors, meaning that these armors will have been validated in a representative and integrated environment.

After the demonstration, TARDEC shipped three FMTVs — the ISD and two ballistic truck assets — to Aberdeen Proving Ground (APG), MD, for live-fire, field performance and durability tests. "We're going to run the trucks over 3,000 miles of the roughest courses at Aberdeen. That is something that, to date, we haven't really done," Tourner

stated. "Afterwards, we can actually hand out some really good data to the PMs."

TARDEC will continue to conduct Soldier-in-the-loop evaluations and gather data on human factor assessments using the ISSIL in parallel with physical testing at APG. Soldier-in-the-loop testing will evaluate how Soldiers interact with the vehicle and measure the benefit of using common displays across systems. "These tests will explore the cognitive burden on the Soldier," Chinoski asserted.

Success Through Enterprise Collaboration

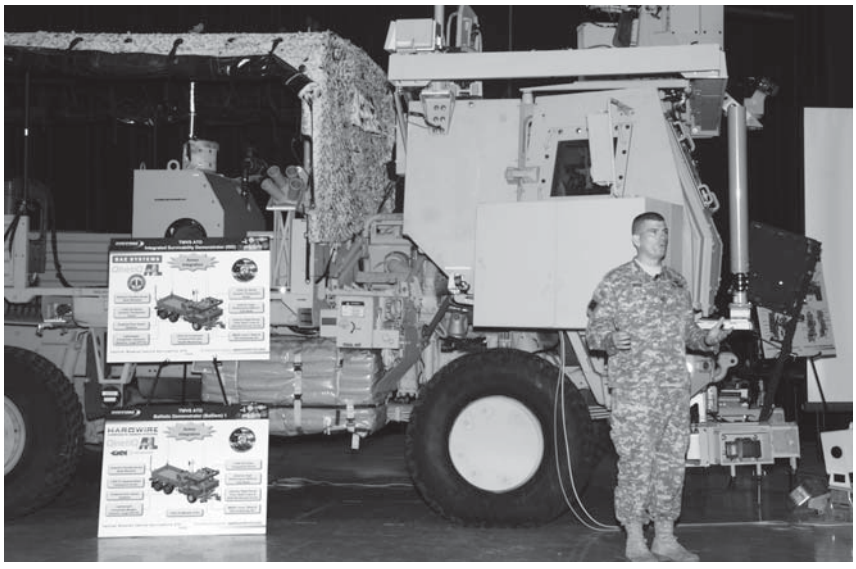
These accomplishments were not achievable by any single entity — government or industry. "The way we accomplished this was, first, through extensive partnering, not just through RDECOM but across other government agencies like DARPA, the user community and industry," Tourner recalled. "What was really instrumental was having subject-matter expert involvement from across RDECOM and DARPA. You really needed their hand-in-glove involvement." Other commands assisted RDECOM, including the U.S. Army Corps of Engineers' ERDC, which provided expertise with blast, buried land mine and IED modeling. Their support was invaluable in finalizing many of the ISDs' technologies. "We're not vehicle and armor people — we're explosives and soils people. That we can provide our area of expertise to the TARDEC and ARL vehicle people benefitted the entire program," commented ERDC Engineer Dr. Kent T. Danielson.

Cross-organizational partnering allows the Army to avoid duplicating efforts and maximizes time and research funds. "The TWVS ATO team did a great job working across organizations. DARPA has stayed very much aware of what they're doing, and we are a lot more cognizant of what each organization is doing so we're not doing the same thing," Wood stated. DARPA supported the program with radar, display and network systems, and the Boomerang, a gunshot location detection system. "The TWVS ATO has laid the groundwork for future efforts," Desmond added. "By breaking institutional stovepipes, the entire community can apply the various technologies demonstrated to a variety of platforms." Additionally, by working with other organizations, PEO CS&CSS and other PEOs and PMs can use lessons learned on platforms as they rotate in for RESET and recap.

TARDEC Director Dr. Grace Bochenek emphasized the TWVS ATO's collaborative success, stating, "It is an awesome capability, and it didn't just happen overnight. It happened because a lot of good people put a lot of hard work into making this happen. Some of the technologies came from Small Business Innovation Research grants, some of them came from Cooperative Research and Development Agreements with industry, and some of them were internally developed capabilities."

Close partnerships with government, academia and industry made it possible to integrate the 50 systems on the ISD. These partnerships helped establish the research and provide the information necessary for PEOs and PMs to equip America's warfighters with the most technologically advanced solutions to best complete their missions safely and efficiently.

Editor's Note: TARDEC Engineer and former TWVS ATO Manager Munira Tourner, former TARDEC TWVS ATO Systems Manager MAJ Larry N. Ross, TARDEC TWVS ATO Engineer Jeffrey Chinoski and TARDEC TWVS ATO Engineer Jerry Dixon contributed to this article.



Former TARDEC TWVS Systems Manager MAJ Larry N. Ross presents the ISD. Ross provided a user's perspective of the demonstrator, which helped analyze how the vehicle could be employed in theater to ensure the most beneficial options were selected by decision makers. (U.S. Army TARDEC photo.)

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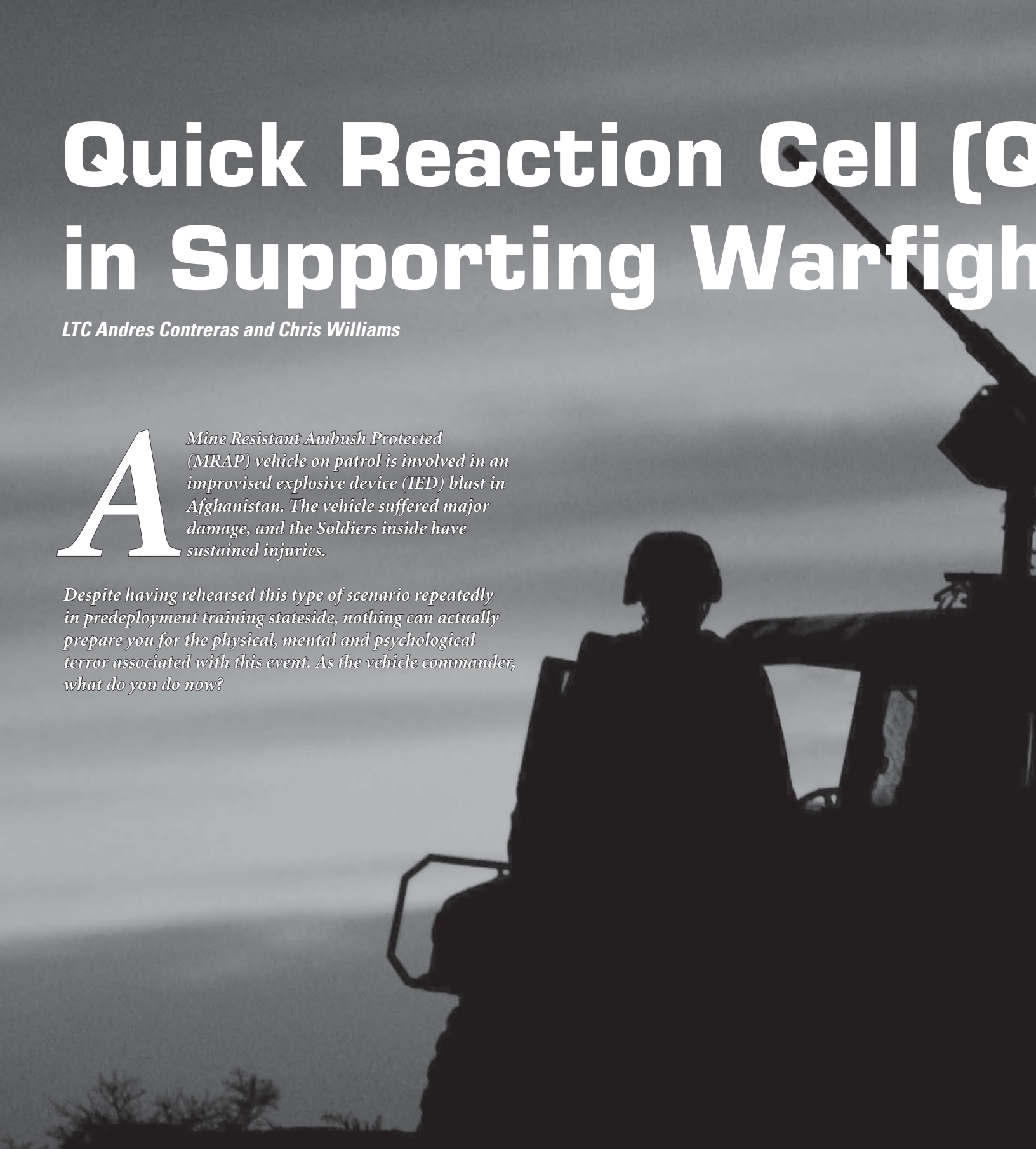
Quick Reaction Cell (Q in Supporting Warfigh

LTC Andres Contreras and Chris Williams

A Mine Resistant Ambush Protected (MRAP) vehicle on patrol is involved in an improvised explosive device (IED) blast in Afghanistan. The vehicle suffered major damage, and the Soldiers inside have sustained injuries.

Despite having rehearsed this type of scenario repeatedly in predeployment training stateside, nothing can actually prepare you for the physical, mental and psychological terror associated with this event. As the vehicle commander, what do you do now?



U.S. Army 1st Infantry Division Soldiers provide roadside security from their up-armored High Mobility Multipurpose Wheeled Vehicle (HMMWV) for Logistics Support Area Anaconda near Balad Air Base, Iraq. The QRC supports HMMWVs by producing technology in response to Requests for Information from theater. One recent example is the Thrown Object Protection System, which protects vehicles from thrown explosives. (U.S. Air Force photo by SSGT Aaron D. Allmon II.)

QRC) Plays Key Role
nters

With scenarios like this increasing in Iraq and Afghanistan, Soldiers are in need of quick, effective solutions to keep them safe and survivable on the battlefield. Dozens of requests are sent to the U.S. Army TACOM Life Cycle Management Command (LCMC) and U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) from theater each month, seeking help in developing lifesaving solutions for the Army's ground combat and tactical vehicles fleet. Units in the areas of operation readily seek TACOM LCMC and TARDEC's expertise in conducting the necessary research and development (R&D) to quickly modernize and integrate mature technology solutions onto tactical and combat vehicle formations.

To assist the TACOM LCMC, TARDEC and the Ground Systems Enterprise's collaborative partners and customers to develop and field lifesaving, mission-enhancing products for warfighters in the shortest time possible, TARDEC created the Quick Reaction Cell (QRC) in 2007. "TARDEC Director Dr. Grace Bochenek recognized that there was no central organization

in TARDEC to handle all of the incoming issues from the field," commented QRC Associate Director Matt Reisner. "We formed a small team to develop a process to handle these issues, and, from there, we developed the concept of a QRC. Shortly afterward, we started laying out the plan to figure out how to run the team, how to quickly handle incoming issues and then create a process to handle long-term needs."

The QRC is designed around a multistep process that allows team members to provide timely responses shortly after a Request for Information (RFI) is generated from the U.S. Army Research, Development and Engineering Command's (RDECOM's) Science and Technology Acquisition Corps Advisor (STACA) and Field Assistance in Science and Technology (FAST) theater teams. Within days of receiving an RFI, the QRC coordinates with partners throughout the Army ground vehicle community to validate the inquiry, develop a plan of action, coordinate with the corresponding Program Management Office (PMO) and deliver a solution to the FAST team to close the capability gap and ensure that a well-researched, timely and viable engineering solution is integrated, incorporating all expertise areas in providing advanced capabilities to the warfighter.

Collaborative Planning

The QRC receives 20-30 RFIs from theater each month, which is only the beginning of the process. "The work that everyone has done from the onset up until now has established the QRC as a 'go to' organization in both TARDEC and RDECOM. We want TARDEC to be the first choice for the program managers [PMs] to seek solutions and help solve some of their engineering challenges," explained TARDEC QRC Military Deputy MAJ Dan Rowell. "The QRC gets RFIs and works to find solutions and provide timely feedback to the ultimate customer — the warfighter. We pride ourselves on providing timely responses."

"We use collaboration and coordination as a basis for success. We could not do these things on our own."

Once an issue is received, the QRC validates whether TARDEC is the appropriate organization to address the issue. "If it is not within our area of expertise, we make sure it is brought before the correct experts. Some requirements are better handled, for example, at a place like the U.S. Army Communications-Electronics

Communications Specialist Denika Warren, 13th Sustainment Command (Expeditionary), tests a Single Channel Ground and Airborne Radio System before deploying on a mission. While TARDEC responds to 50–60 percent of the RFIs generated, some, such as communications and electronics requests, are forwarded to more appropriate R&D centers like CERDEC. (U.S. Army 15th Sustainment Brigade photo by SPC Navara Torres.)

A 173rd Airborne Brigade Combat Team Soldier demonstrates the GRS in the gun turret of an MRAP vehicle during MRAP operator training conducted at the 7th Army Joint Multinational Training Command's (7th Army JMTC's) Hohenfels Training Area, Germany. (Photo by Christian Marquardt, 7th Army JMTC Public Affairs Office.)

Research, Development and Engineering Center [CERDEC], which deals with communication and electronic equipment. We try to narrow that ownership down," remarked Reisner. "Roughly 50 to 60 percent of the issues that come in are handled by TARDEC because, with our ground vehicle integration expertise, we have a very wide scope of knowledge."

After the inquiry has been validated and coordinated with the proper partners, an action plan is developed and executed, and the QRC begins user assessments and limited production and monitors the fielded system to make sure the solution works as designed. "In developing an action plan, we lay out a timeline and figure out who we need to work with and when," Reisner explained. "We then execute the action plan and complete the design, prototype fabrication, technical testing and evaluation. We also conduct user assessments that allow us to send equipment to theater after safety testing and evaluations are complete."

Lifesaving Solutions

Since its formation, the QRC has played a key role in organizing the development of hundreds of warfighter solutions, including an MRAP Gunner's Restraint System (GRS), which prevents Soldiers from being thrown out of a vehicle during rollovers, and the MRAP Overhead Wire Mitigation (OWM) Kit, which keeps vehicle antennas from snagging on overhead power wires.

The QRC's crucial role in assisting with these critically needed products' development has not gone unnoticed by partners throughout the military. "Our success in the MRAP program is made possible by the incredible support we get from partner organizations such as TARDEC's QRC" said Paul Mann, Joint Program Manager for MRAP Vehicles. "GRS is just one example. We received the requirement and were able to deliver more than 9,500 GRS in 110 days."

The QRC was also involved in developing the Thrown Object Protection System (TOPS). TOPS, which originated from a Joint Urgent Operational Needs Statement, is a series of nets and telegraphing poles that provides protection from grenades and other types of explosive devices that might be thrown at a vehicle. The prototype was sent to theater in April 2009 with initial kits available for the Caiman, MaxxPro and RG-33 MRAP variants and the M1151 HMMWV. The system has been instrumental in protecting warfighters from a series of threats in the field and is an excellent example of how the QRC partners with multiple PMs and the Army Research Laboratory (ARL) to develop technology solutions that improve vehicle capabilities, mobility and survivability across the full spectrum of conflict.

Collaborative Planning and Soldier Support

The QRC, which directly supports the Ground Systems Integration Domain, answers a large volume of RFIs each year and serves as the RDECOM lead in executing tasks to spearhead project and product development. The team continues to build strong partnerships with PMOs and various RDECOM Research, Development and Engineering Centers (RDECs) to develop well-integrated warfighter solutions. "We use collaboration and coordination as a basis for success. We could not do these things on our own," commented Reisner. "We didn't come up with the initial TOPS concept on our own. ARL did, but we worked closely with other organizations to bring the best solution to the Soldiers."

The QRC's collaborative work directly impacts Soldiers on the battlefield — the quicker the team develops and facilitates solutions, the better Soldiers are protected. Reisner remarked that the contact he has with Soldiers is the most important and rewarding part of his job. "TARDEC's mission and vision

A 1195th Transportation Company, Nebraska National Guard Soldier serving with the 41st Infantry Brigade Combat Team tests equipment inside an MRAP prior to a convoy security mission at Camp Liberty, Iraq. TARDEC's QRC reached out to other collaborative partners to innovate solutions and field new technology for MRAPs, including the OWM Kit mounted here. (U.S. Army photo by SPC Cory Grogan.)

is to support the warfighter, but most people don't get a chance to interact with them directly. One of the reasons I feel we in the QRC are as truly motivated as we are is because we get that direct feedback," explained Reisner. "We conduct regular teleconferences with theater liaison officers where they tell us their issues and the things we have done that are successful for them."

RDECOM's primary mission is warfighter support, and its science and technology (S&T) advisors are attached to and coordinate with the supported unit's G-3 to support the commander and his staff by solving emerging problems with targeted engineering solutions and technologies. S&T advisors act as technology intelligence officers and scouts to shape materiel problems and concerns into areas of research and report observations through unit-generated RFIs. The QRC's vision is to continue fostering the working relationships it has established with the TACOM LCMC community, program executive offices, PMOs and RDECOM RDECs to support warfighters. As RDECOM and TARDEC transform, the QRC will transform as well to better support deployed S&T and STACA Teams and relay emerging requirements from the field to ground vehicle system PMs.

The enemy constantly develops new threats to defeat the Army's current technologies, and the QRC is chartered to relay emerging requirements from the field and coordinate with respective organizations to eliminate those threats with quick solutions and technology that provides Soldiers with the best possible battlefield protection. As overseas contingency operations evolve, the QRC will continue to collaborate across the Army to ensure that today's warfighters are better equipped, better protected and more survivable and adaptable than ever before.

LTC Andres Contreras is the TARDEC QRC Director. He holds an M.A. in educational leadership from St. Mary's University and is a graduate of the Armor Officer Basic and Advanced Courses, Combined Arms and Services Staff School and Army Command and General Staff College. His awards and decorations include the Parachutist Badge, Bronze Star, Meritorious Service Medal (with five Oak Leaf Clusters (OLCs)), Army Commendation Medal (with four OLCs), Army Achievement Medal (with four OLCs) and Army Staff Badge.

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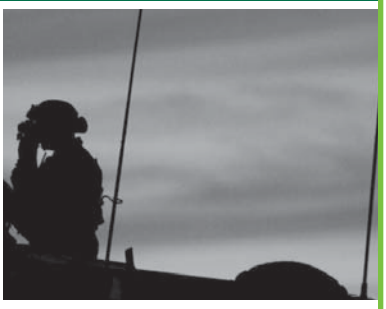
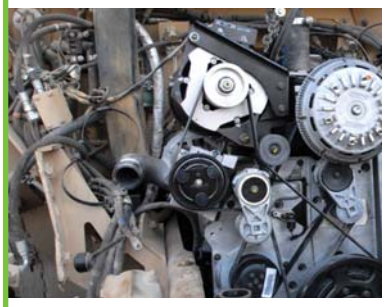


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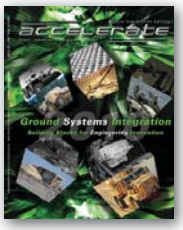

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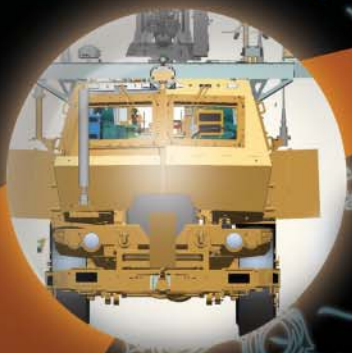

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