April - June 2009

accelerate

Lead · Innovate · Integrate · Deliver

POWERING THE ENTERPRISE

Another Evolutionary Step in Our Strategic Transformation

Welcome to the inaugural issue of *accelerate*, which is replacing *TARDEC Quarterly*. *accelerate* is TARDEC's new flagship publication and sets the course for other great products put together by our Strategic Communications team. Our vision for this magazine is that it will be a professional journal for the ground vehicle community, attracting readers and authors from U.S. Army Research, Development and Engineering Command partners, TACOM Life Cycle Management Command, as well as from the academic and private sectors.

You may wonder why this change was necessary. The short answer is that this is an evolutionary step in our strategic transformation. *accelerate* is indicative of the changes TARDEC is undergoing, and it is more reflective of our mission as the Department of Defense Ground Systems Integrator. *accelerate* also captures the speed at which the acquisition, logistics and technology communities are moving to keep pace with emerging battlefield requirements. More specifically, *accelerate* will profile what the entire Ground Systems Enterprise is doing to ensure our warfighters continue to be the best equipped, most lethal and most survivable and sustainable fighting force on earth. We'll also look at the collaborative side of our business, how critical strong partnerships are to the success of the Ground Systems Enterprise, and how TARDEC interfaces with our community partners.

As the Ground Systems Integrator, we are responsible for fostering open communication and collaboration across multiple technologies and platforms while facilitating science and technology requirements analysis; technology assessments and trade-studies; and technology maturation, development, insertion and sustainment for all ground systems. To accomplish this, we leverage our 1,200 associates' skills, abilities and robust systems engineering and integration experience to deliver innovative engineering and technology solutions for our Soldiers. Clearly, the systems integrator role is a weighty responsibility, and we are committed in our strategic transformation to continuously raising the bar in terms of developing enterprise-wide systems engineering standards, integrated business processes, strategic program development, transparent enterprise technology portfolio management and innovative new product development.

The process of developing and implementing the enterprise model of systems integration is complicated and requires the full participation of all the government and industry Ground Systems Enterprise partners. What's more, we tie in directly to similar efforts going on within the big Army. We are operating in a very dynamic environment, and reporting on our progress will be a significant facet of this magazine.

I believe you will find the content of these pages to be informative, thought-provoking and inspiring. I invite you, as a member of the ground systems community, to collaborate with us as we use this new communication vehicle to create dialogue and foster innovation and systems integration.

Dr. Grace M. Bochenek
TARDEC Director

US ARMY RDECOM
TARDEC

accelerate

April - June 2009

FEATURE ARTICLES

To contact the Editorial Office, call (586) 582-0288/(586) 838-2302

FAX: (586) 574-6941

e-mail: accelerate@conus.army.mil

US ARMY RDECOM
TARDEC

accelerate

April - June 2009

On the Cover

The cover is original artwork created by BRTRC graphic designers Rhonda Wilt, Jeff Wright and Nojae Kim. The cover depicts current manned and unmanned ground vehicle systems for which TARDEC is providing research, development and engineering (RD&E) support. The circuit boards are representative of the vehicle architecture and electronics, and systems integration TARDEC engineers and technicians are responsible for developing. The green spiral represents the technology spinout and RD&E innovations that TARDEC scientists and engineers mature and then integrate as solutions to enhance military ground vehicle protection, performance and payload.

TARDEC is responsible for more than 2,800 Army systems and many of the Army's and DOD's top joint warfighter development programs. From composite armor solutions and gunner restraint systems to countermine and improvised explosive device defeat mechanisms, TARDEC is fulfilling its role as the hub of the Ground Systems Enterprise. Using its Quick Reaction Cell and tremendously responsive engineering teams, TARDEC can *accelerate* technology integration solutions to rapidly meet Soldier battlefield requirements.

accelerate is published by TARDEC. Articles express written views of the authors and not necessarily official opinion of the Department of the Army. If articles are reprinted, please cite *accelerate,* the author and photographer.

POSTMASTER: Please send address changes to U.S. Army TARDEC, 6501 E. 11 Mile Road, Bldg. 200A, Mail Stop #206, Warren, MI, 48397-5000.

FEATURE ARTICLES

Powering the Enterprise — *A New Beginning*

Merriam-Webster's online dictionary defines ***ac·cel·er·ate*** as a transitive verb that means to "cause to move faster" or to "hasten the progress or development" of something. For our purposes, the verb ***accelerate*** means to "cause faster or greater activity, development, progress and advancement" toward one's corporate and professional goals. This publication is going to help transform the way our customers look at, think about and process information concerning the Ground Systems Enterprise. Since ***accelerate*** is all about the rate of motion, our editorial team is going to dynamically change the velocity at which information gets to our readers.

As the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) continues its strategic transformation, the editorial team has been challenged to create a publication that will be informative, relevant and compelling. Therefore, ***accelerate*** is all about keeping pace with the rate of change as our organization strategically transforms and more.

We are very excited to bring you a new publication that will profile the people, events, products and services that comprise the Ground Systems Enterprise. This issue of ***accelerate*** magazine will bring you inside the research and development (R&D) community to provide insight into several innovative programs, product developments and partnerships. A brief synopsis of each article follows.

Hybrid-Electric Vehicle Experimentation and Assessment (HEVEA) Program Supports the Army's Need for Increased Power Demands. TARDEC's Ground Vehicle Power and Mobility division, in partnership with the Defense Advanced Research Projects Agency, used innovative testing methods on hybrid-electric vehicles to develop a new standard test for fuel economy evaluation.

Fuel Efficient Ground Vehicle Demonstrator (FED) Program Evaluates Alternative Concepts for Improving Fuel Economy. TARDEC's FED program is developing innovative system-level concepts that integrate a wide variety of technologies. FED is also developing the future government engineering workforce and reducing fuel consumption and reliance on foreign oil.

Hydrogen Fueling Station: Powering a Successful Strategic Partnership. With the Department of Energy, Selfridge Air National Guard Base, Chevron and Hyundai Kia, TARDEC is exploring the use of hydrogen-powered cars. This partnership is breaking new ground and offering insights into developing new technology.

Vehicle Electronics and Architecture (VEA) Group Building Strength in Early Phases. Empowering today's Soldiers and giving them every advantage possible has always been TARDEC's goal. To better meet that goal, TARDEC formed the VEA technical area in December 2008. The VEA, part of TARDEC's Research Business Group, was established to specifically focus on information and power distribution and be the interface for ground vehicle systems applications.

TARDEC Engages Universities in Creation of Robotics Curricula. The Joint Center for Robotics' Ground Robotics Research Center partnership with Michigan universities proves mutually beneficial. The universities also offer courses in robotics engineering that will produce the next generation of robotics engineers.

Ground Vehicle Integration Center (GVIC) Develops Solutions that Address the Nation's Urgent Ground Vehicle Needs Now. In an interview with GVIC Director Dr. Bruce Brendle and Deputy Associate Director-Ground Systems Survivability Debbie DiCesare, ***accelerate*** explores GVIC's development and its relevance to the MRAP Expedient Armor Program.

TARDEC, Industry and Academia Urged to Gain 'Competitive Edge.' The Michigan Defense Industrial Symposium was hosted at Schoolcraft College in Livonia, MI, Nov. 17-18, 2008. One forum analyzed various ways that TARDEC, industry and academia could work together to advance U.S. technology in the world marketplace.

TARDEC's Christopher Scott Achieves Excellence at the 2009 Black Engineer of the Year Awards (BEYA) Conference. Christopher Scott, an engineer with TARDEC, was among the distinguished honorees at the annual BEYA Conference. The event recognizes individuals who have achieved exceptional career gains in government and industry, as well as lifetime achievement and pioneering feats.

Ground Systems Integration Domain's (GSID's) Mission Optimizes Collaboration Throughout Army. Like any successful organization, the U.S. Army depends on communication and information sharing to optimize research and maximize funding. Recently implemented SIDs are vital tools in understanding Armywide near-, mid- and long-term capability needs and further defining the relationships required between Research, Development and Engineering Centers to provide science and technology products.

72-Hour Collaboration Leads to Safer Vehicle Restraint Systems for Soldiers. TARDEC engineers and technicians successfully responded to a request to assess, design, fabricate, integrate, test, adapt and produce a universal restraint system to ensure gunners would not be thrown from MRAP vehicles in the event of an accident or vehicle rollover.

TARDEC Engineers Nab Best Paper Award at 26th Army Science Conference (ASC). Dr. Peter Schihl and Laura Hoogterp won the Best Paper Award for their Power and Energy presentation "On the Ignition and Combustion Variances of Jet Propellant-8 and Diesel Fuel in Military Diesel Engines." The conference theme was "Transformational Army Science and Technology: Harnessing Disruptive S&T for the Soldier."

I hope you find this issue of ***accelerate*** attention-grabbing and provocative. TARDEC's engineers and scientists are rapidly developing solutions to ensure that the Ground Systems Enterprise remains at the forefront of technology development and engineering and systems integration. Our R&D community is dedicated to enhancing the lethality, survivability and sustainability of our Soldiers wherever the battlefield or mission takes them. Our enterprise commitment:
Lead · Innovate · Integrate · Deliver.

Michael I. Roddin
Editor-in-Chief

Hybrid-Electric Vehicle Experimentation and Assessment (HEVEA) Program Supports the Army's Need for Increased Power Demands

Ghassan Khalil, MAJ Christine E. Allen and Michael Pozolo

An International Military and Government, LLC Future Tactical Truck System Utility Vehicle, designed to carry a payload of up to 3 tons, is attached to a dynamometer, which tests the engine's torque and rotational speed. (Photo courtesy of ATC.)

For more than 50 years, the Army has been considering the use of electric drive technology. As far back as World War II, there was an electric drive tank in the field, and subsequent reviews and technology studies occurred roughly every 15 years. In the 1960s attempts were made in partnership with the automotive original equipment manufacturers to produce electric drive trucks. From 1984 to 1987, there were study contracts with General Dynamics Land Systems and FMC (what is now BAE Systems). But every time the same conclusion was reached — namely, that the technology was neither mature nor efficient enough to compete with the comparable mechanical systems. Therefore, it was not worth the effort or investment to pursue at that time. It was not until 1993 that a serious HEV program started.

In the early 1990s, semiconductors began to appear and were adopted, which was encouraging. BAE Systems developed a demonstrator based on the M113 utilizing semiconductor technology, and this, too, was encouraging. At the same time, the Army was building a mechanical vehicle as part of the Army System Modernization program. The U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) built and tested this vehicle. Concurrently, Congress decided to explore electric cars for the civilian market. To that end, they gave the Defense Advanced Research Projects Agency (DARPA) $25 million and the task of demystifying electric drive train technology. A condition attached to this funding was that any commercial contractor wishing to benefit from the $25 million would have to partner with a government agency. As a result of this condition, TARDEC became involved as a partner to DARPA's Midwest Consortium. TARDEC assisted their partners by setting requirements and monitoring program efforts, including the production of a full electric M113, a hybrid-electric (HE) Bradley Fighting Vehicle and HE High Mobility Multipurpose Wheeled Vehicle.

In 1995, DARPA Program Manager (PM) John Gully decided that it was time to examine the systems integration issues related to the use of electric technology. During

the course of meetings with the Director of Advanced Technology under the Director, Defense Research and Engineering, Office of the Secretary of Defense, Dr. Donald Dix, many questions were raised that couldn't be answered without significant investment resources. So with an additional $100 million in funding, Gully established the Combat Hybrid Power System program, which ultimately transitioned from DARPA to the Army and, specifically, to the TARDEC Power and Energy Systems Integration Lab (P&E SIL).

TARDEC's role in developing the HEV has grown considerably over the past 20 years to the point where it is a critical component in implementing an HEV that meets Army needs. TARDEC's work in the field of HEVs has led to realistic goals of producing beneficial capabilities for future ground vehicle systems.

TARDEC has also been a leader in developing testing facilities and the expertise needed to further expand this emerging technology. As Army vehicle needs mature, TARDEC is constantly refining and testing methods to keep up with the ever-changing landscape of warfighter vehicles and the environments in which they will be deployed.

To continue the momentum, TARDEC is challenging what have become the standard methods of evaluating HEVs. Alterations to testing methods and streamlining testing tools are just two ways that TARDEC is trying to better understand the limitations and possible uses of HEVs in military situations. These changes in analyzing and testing are helping TARDEC take the next step in fulfilling the projected P&E demands of future Army vehicles.

Evaluating HEVs for Military Use

HEVs have been identified as a potential technology that can meet the Army's future needs and provide expanded mission capabilities to warfighters. The capability improvements include onboard and export power generation availability, silent operations, fuel economy improvements and synergy with high-pulsed loads such as electric weapons and electromagnetic armor.

Before fielding military HEVs, the technology has to be evaluated for its relevance to military operations and must withstand the harsh rigors of military environments. This includes varied terrains — from fully paved to hilly cross-country — and extreme environmental conditions — from arctic cold to desert heat. In addition to the mobility performance, military HEVs must meet safety, reliability, maintainability and availability requirements under all shock, vibration and environmental conditions. To address the above challenges, TARDEC has established the HEVEA Program.

The program has three key products:

- The HEV performance database that includes lessons learned.
- An established and accredited Test Operations Procedure (TOP) to assess fuel economy for hybrid and conventional vehicles.
- A validated Vehicle Propulsion System Evaluation Tool (VPSET) to predict HE and conventional vehicle automotive performance as well as projected fuel economy.

Additionally, the program can measure onboard and export power capability from a hybrid platform and the effects of extreme temperature conditions on HE performance.

Improving Testing Methods

For the HEV performance database, a total of nine HE and nine conventional mechanical vehicles were evaluated over five different test courses. These vehicles spanned all weight classes of tactical wheeled vehicles. Traditionally, the military conducts vehicle fuel economy tests at the Munson standard fuel economy course at the U.S. Army's Aberdeen Test Center (ATC), MD. The Munson test course is mainly flat, paved terrain with some moderate slopes. Although the Munson standard fuel economy course can be used to test the HEVs, it does not provide the opportunity to explore the full benefit of HE fuel economy. HEV fuel economy is heavily influenced by the frequency of braking to recover kinetic energy from the brakes.

The limitations of using only the Munson standard fuel economy course and the lack of a comprehensive method to estimate the fuel economy gain from the energy storage system (the battery pack) drove TARDEC and ATC to develop a new TOP. The new procedure takes into account the energy gain and loss from the battery and compensates for it in equivalent fuel consumption measurement. Another reason for the new TOP was to resolve the inconsistent fuel economy claims attributed to HE. Although the claims can be real, they vary from one driving condition to another. Therefore, a combination of five driving courses — ranging from public highways to rough, hilly cross-country terrains — were selected for the new test

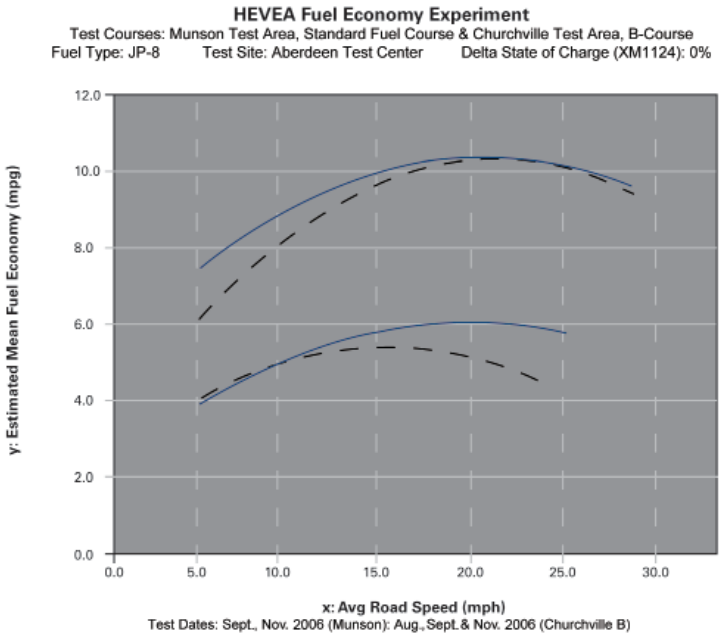


Figure 1.

method. These courses provide driving conditions that represent most of the expected mission scenarios that a military vehicle experiences throughout its life cycle. Although different vehicles have different mission profiles, using vehicle data from the five terrains traversed will provide valuable predictive information on performance variance as the mission profile is varied.

Evaluating Fuel Economy

An HE propulsion system contains two sources of power: an engine and a battery pack. Therefore, it is necessary for fuel economy evaluation to compensate for the energy usage from the battery. Statistical models based on regression analysis were used to derive a functional relationship between the mean fuel economy (miles per gallon (mpg)), the average road speed (miles per hour (mph)) and the battery's delta state of charge. Residual analysis was performed to validate this statistical model. This method proved to be adequate when the vehicle is going through varying driving conditions.

Under these conditions, the battery is continuously supplying energy to supplement the engine when needed, and then regaining the same energy when the engine power is sufficient enough for mobility and battery charging. It should be cautioned that when attempting to compare vehicle results, gross vehicle weights (GVWs) must be similar to make an accurate comparison on performance. Otherwise, results could be skewed in favor of lighter GVW.

Figure 1 shows a fuel economy gain of 11 percent over ATC's hilly, cross-country Churchville terrain and five percent over the flat, paved Munson terrain. The same model, with a 95-percent confidence band for the mean fuel economy, is shown in Figures 2 and 3. The statistical model TARDEC developed is used to validate a VPSET. VPSET was also developed by TARDEC to assess performance in support of programs.

TARDEC's VPSET Streamlines Acquisition Process

The VPSET has been developed by the TARDEC Ground Vehicle Power and Mobility (GVPM)

Figure 2.

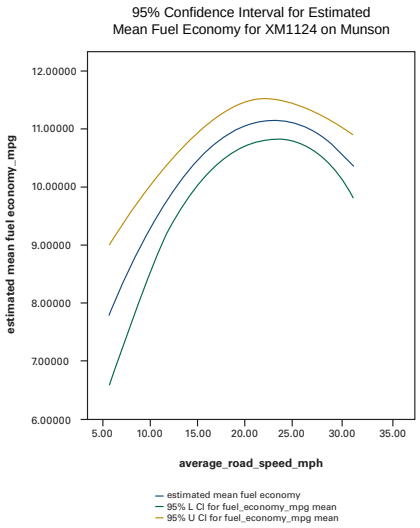
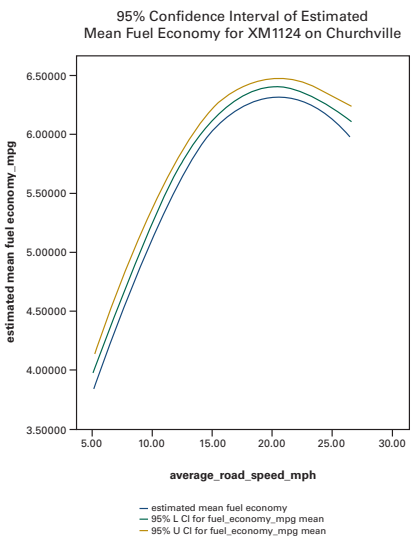


Figure 3.



Modeling and Simulation (M&S) team in partnership with Southwest Research Institute. VPSET has great potential to streamline the acquisition proposal evaluation process for ground vehicles by both the U.S. Army and the U.S. Marine Corps. As M&S-based acquisition becomes more prevalent, there is a greater need for common, well-understood software tools to support technical analysis during the acquisition process. VPSET provides a flexible, easy-to-use tool to evaluate a wide range of conventional and HE propulsion system types in a consistent and timely manner.

In past acquisitions, contractors submitted propulsion system/vehicle performance models to the Source Selection Evaluation Board (SSEB) using many different commercial and in-house software tools. Execution of these performance models by the SSEB was cumbersome because of software license issues as well as user training required for unfamiliar programs. Also, there was no assurance that the various models handled all technical aspects with the same level of fidelity, making comparison of outputs more difficult. VPSET was developed to address these issues by creating a standardized evaluation tool for propulsion analysis to the acquisition proposal evaluation process.

While not intended to replace commercially available codes, the data inputs and computational approach are similar and will be familiar to the contractor's M&S staff. Both government and contractor personnel will have a clear understanding of model inputs, component properties, assumptions and performance predictions. The code supports development of first-order propulsion system models for a wide variety of power trains, including conventional diesel-mechanical and series or parallel HE. Higher fidelity models can also be developed with additional component input data.

Code modularity will facilitate future updates to VPSET to incorporate new propulsion technologies. VPSET will enable the government to verify contractor model input and results and to evaluate performance prediction and risk against technical requirements while also achieving considerable time savings. Use of a single evaluation tool will provide greater clarity for both evaluators and contractors when comparing M&S results from different concepts. VPSET model output is being extensively validated with conventional and HEV test data obtained during the HEVEA Program. The Office of Naval Research, Naval Surface Warfare Center, is also pursuing further development of VPSET for assessing fuel efficiency-enabling technologies. This tool has already been used and displayed its relevance throughout TARDEC to assess performance in support of PM programs.

In conclusion, the previously used standard fuel economy TOP has been revised to include the HEVs over the courses described herein. The draft TOP was sent out to government agencies, industry partners, academia and engineering societies, such as the Society of Automotive Engineers and Environmental Protection Agency, for review and comments. Once all comments to the draft TOP are collected, the new TOP will be finalized and adopted as a standard test for fuel economy evaluation. The VPSET will continue to be validated as additional data become available from the HEVEA Program and other field vehicle testing. HEVEA vehicle testing is continuing through the end of 2009, and all the test data generated to date has been stored in a government database for future reference.

Editor's note: This article was first published in the January-March 2009 issue of Army AL&T *Magazine. To obtain additional information about the HEVEA Program go to:* http://asc.army.mil/docs/pubs/alt/2009/1_JanFebMar/articles/50_Hybrid-Electric_Vehicle_Experimentation_and_Assessment_(HEVEA)_Program_Supports_the_Armys_Need_for_Increased_Power_Demands_200901.pdf

Ghassan Khalil is the Team Leader for HE Mobility, part of TARDEC GVPM. Khalil holds both a B.S. and an M.S in mechanical engineering from Wayne State University.

MAJ Christine E. Allen is the Assistant PM Mobility Common Systems, Future Combat Systems Manned Systems Integration. She previously was the PM for the HEVEA, GVPM, TARDEC. Allen holds a B.S. in aerospace engineering from Embry Riddle Aeronautical University. She is a U.S. Army Acquisition Corps (AAC) member.

Michael Pozolo is the Team Leader for Powertrain M&S, part of TARDEC Concepts, Analysis, System Simulation and Integration. He holds a B.S. in mechanical engineering from Wayne State University and an M.B.A. from Western Michigan University. He is an AAC member and is certified Level III in systems planning, research, development and engineering.

Fuel Efficient Ground Vehicle Demonstrator (FED) Program Evaluates Alternative Concepts for Improving Fuel Economy

Mark Mazzara

The Department of Defense's (DOD's) future tactical vehicles (TVs) will require new concepts and technologies to reduce the total amount of fuel consumed in both peace and wartime operations and dependency on oil. To address this challenge, the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) is developing innovative system-level concepts that integrate a wide variety of technologies under the FED program to demonstrate the possible terms of fuel efficiency.

Program Overview

The Office of the Secretary of Defense (OSD) initiated the FED program to address energy conservation needs highlighted by the Defense Science Board: Energy Security Task Force. The program's overarching goals are to improve military vehicle technology, reduce fuel consumption on the battlefield and reduce dependence on oil.

The FED's objectives are:

- Identify and assess technologies that support increasing fuel efficiency and decreasing fuel consumption for light tactical vehicles.
- Develop and assess fuel efficient tactical vehicle concepts that increase fuel efficiency while maintaining tactical vehicle capability against the baseline performance of a High Mobility Multipurpose Wheeled Vehicle (HMMWV).
- Demonstrate hardware that promises fuel efficient tactical vehicle concept(s) against the baseline performance of a HMMWV.
- Train the next generation of government engineers in fuel efficiency processes and tools.

TARDEC Director Dr. Grace M. Bochenek addressed Michigan industry leaders at Automation Alley for the kick-off of FED Industry Day on Sept. 30, 2008. "TARDEC is ... uniquely situated in the heart of the automotive capital of the world. We want to leverage your expertise to help the Nation and the warfighter." (U.S. Army TARDEC photo by Elizabeth Carnegie.)

The FED program is undertaking two parallel approaches to the development of concepts. The first is a contractor-led effort with embedded TARDEC engineers, where a contract is awarded to private industry to produce concepts, designs and data. The second is a TARDEC-led collaborative working group approach, in which subject-matter experts (SMEs) from government, industry and academia come together to prioritize candidate technologies and develop innovative concepts and ideas.

This includes considering emerging technologies to attain maximum fuel economy and minimum fuel consumption while maintaining other tactical wheeled vehicle capabilities. Through this process, the FED program intends to provide the requisite experience to train the next generation of government engineers in fuel efficient design. The FED program will also quantify cost impacts and leverage modeling and simulation (M&S) capabilities to predict performance and optimize clean-sheet, system-level designs.

Part of the challenge is these advances must be attained without sacrificing the vehicle platform's performance, capability and payload. To measure the program's success, TARDEC will use the M1114 Up-Armored HMMWV at 15,400 pounds gross vehicle weight as a baseline for comparison. The FED will integrate technical solutions to inform the requirements and designs of next generation military trucks. Successful application and integration of fuel efficient technology will be transitioned to other wheeled vehicle programs across DOD.

TARDEC's Advanced Vehicles and System Demonstrators and FED Team Lead Carl Johnson answered audience questions during a question and answer panel at FED Industry Day. (U.S. Army TARDEC photo by Elizabeth Carnegie.)

Defining the FED's Approach to Problem Solving

The FED program involves significant outreach to private industry, academia and other government agencies to leverage the expertise in fuel efficient design in those leading organizations' toolsets, and improve TARDEC's internal expertise. To initiate this outreach, an Industry Day was conducted on Sept. 30, 2008, to inform industry about the program and define how organizations could participate. A series of FED Working Group sessions were planned at which approximately 50 individuals from government agencies, industry and academia broke into TARDEC-led subgroups to develop concepts.

In October 2008, the FED Working Group #1 was conducted and successfully met its objective of prioritizing more than 100 candidate technologies for overall utility in balancing fuel efficiency improvements with other metrics such as cost, technological maturity, technical performance and integration complexity. In December 2008, the FED Working Group #2 session was conducted, meeting its objective of developing six system-level concepts for the optimal combination of technologies for integration into the FED demonstrator(s). The concepts that resulted from the FED Working Group #2 form the basis for the current M&S phase. During the M&S phase, the concepts are undergoing analysis to quantify each concept's potential benefits in terms of fuel economy and consumption and provide the rationale required to make difficult trades.

In April 2009, the FED Working Group #3 session will review the M&S phase's results and develop a final set of recommendations to decision makers as to the effort's path forward. In May 2009, an Executive Steering Group Concept Review will occur. A group of executive stakeholders from a variety of agencies — chaired by TARDEC's Executive Director of Product Development Thomas Mathes — will review the recommendations and decide whether or not any concepts resulting from the effort will proceed into the design, demonstrator build and test phases. If the decision is made to proceed, the concept(s) resulting from the effort will be developed into detailed designs, and one or more demonstrators will be produced and subjected to testing.

Throughout the concept and M&S phases, a number of initiatives have been conducted to increase the program's probability of success and infuse innovation into the effort. With the FED being sponsored by OSD, it becomes very important to define the program's stakeholders and customers so that the technology transition strategy for the program can be optimized to provide maximum value to all relevant organizations.

The FED Team established a close working relationship with TARDEC's Lean Six Sigma (LSS) Cell and the TACOM Life Cycle Management Command (LCMC) master black belt to apply the most value-added tools to the program. The FED Team and LSS Cell have worked together to perform both supplier, input, process, output and customer, and voice of the customer analyses for the program. These analyses will affect the technical set of requirements that form the basis for the program's end product.

OSD initiated the FED program to address energy conservation needs highlighted by the Defense Science Board: Energy Security Task Force. The program's overarching goals are to improve military vehicle technology, reduce fuel consumption on the battlefield and reduce dependence on oil.

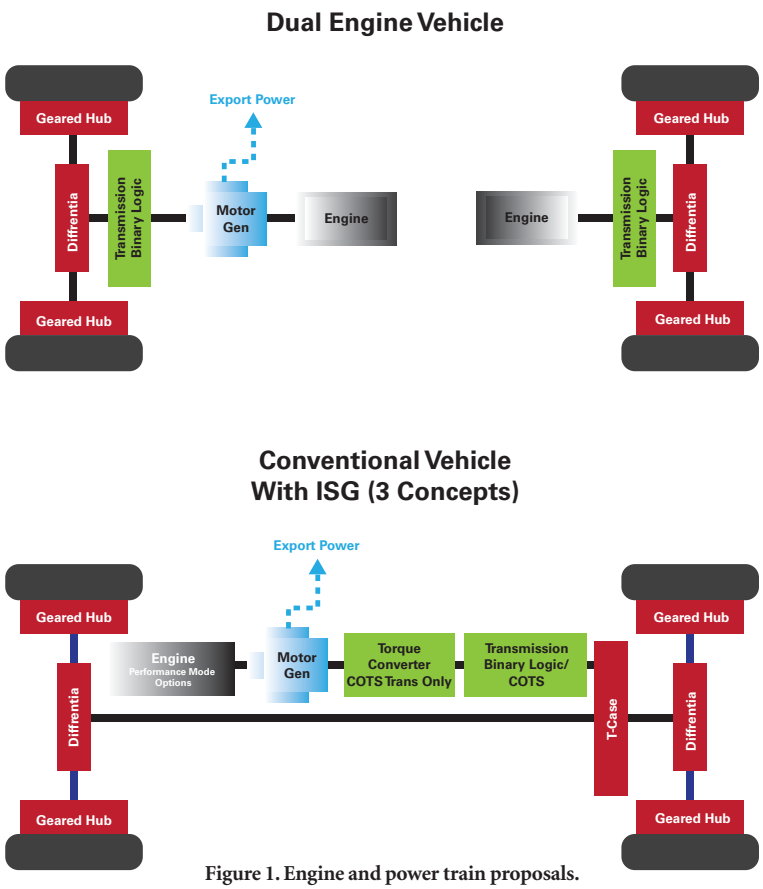


Figure 1. Engine and power train proposals.

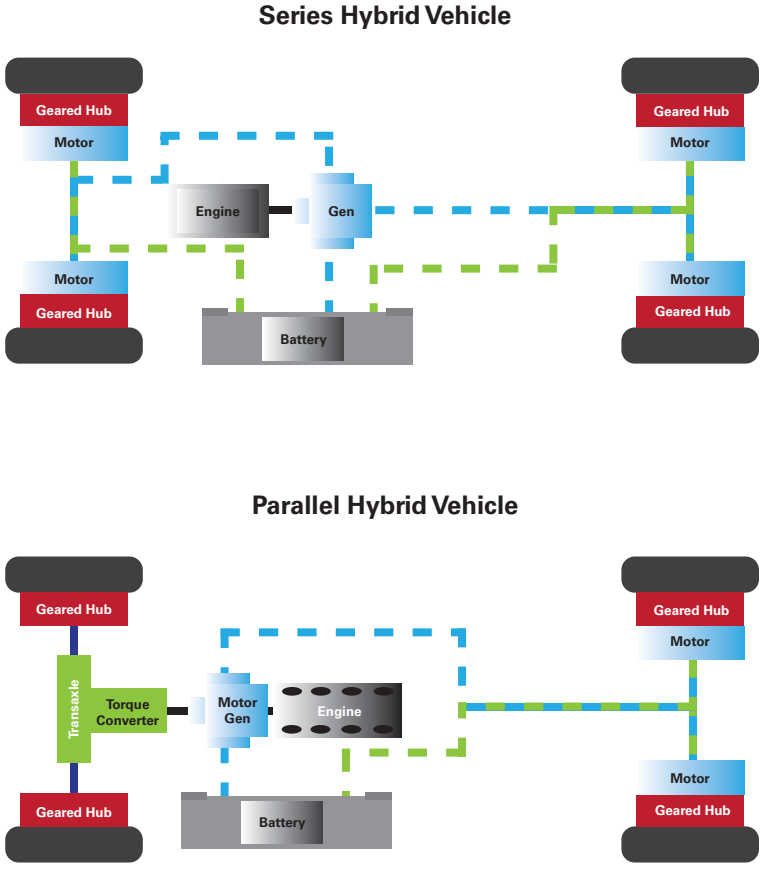


Figure 2. Hybrid vehicle engine and power train proposals.

FED program participants also were provided with Structured Innovation training to expose them to the fundamental tools of the Theory of Inventive Problem Solving. This training exposed FED participants to historical tools that have led to breakthrough innovations in product development. Through partnership with the LSS Cell, the FED program has begun applying Design for Six Sigma tools to the program by integrating Axiomatic Design principles through the concept phase, with the purpose being to develop a structured method for working through the series of trade studies and M&S. Additionally, the FED team formed a close relationship with TARDEC's Systems Engineering Group to develop a structured process for requirements management and architecture development.

Concepts Under Consideration

The six preliminary concept architectures developed under the program range from conventional to high-risk. Among the propulsion systems being considered is a dual internal combustion (IC) engine concept in which there are small IC engines in both the front and rear of the vehicle. This architecture enables only one small engine to be used at most times with the second engine utilized on demand through the help of an integrated starter generator (ISG) as illustrated in Figure 1. This concept eliminates the driveline components going through the mid-section of the vehicle, allowing the crew cab to be optimized for a survivability solution that reduces overall surface area and mass requiring armor.

Additional propulsion systems under consideration include a series-hybrid architecture with wheel motors (eliminating the need for a transmission

and driveline), a parallel-hybrid architecture and a more conventional lightweight modern diesel engine with an ISG to enable engine-off at idle. (See Figure 2.)

Transmission technologies being considered include a 32-speed binary logic transmission. Suspension concepts being considered include an adjustable height suspension, enabling a larger distance from the ground to the vehicle's bottom and thus lighter weight armor for blast protection.

Additional peripheral technologies being considered in the preliminary concepts include:

- Low-friction coatings.
- Advanced synthetic lubricants.
- Lithium-ion batteries.
- Multiple user-selectable engine modes (e.g., "convoy mode" and "combat mode").
- Advanced body materials.
- Ceramic brake rotors.
- Aluminum wiring.
- Metal matrix composite calipers.
- Remotely operated weapon stations.
- Magneto-rheological shocks.
- Regenerative braking.
- Central tire inflation systems.
- Light-emitting diode lighting.
- Driver feedback (fuel economy displays).
- Aerodynamic designs.
- Monocoque V-shaped hulls.
- Isotropic superfinishing.
- Thermal and kinetic energy recovery systems.

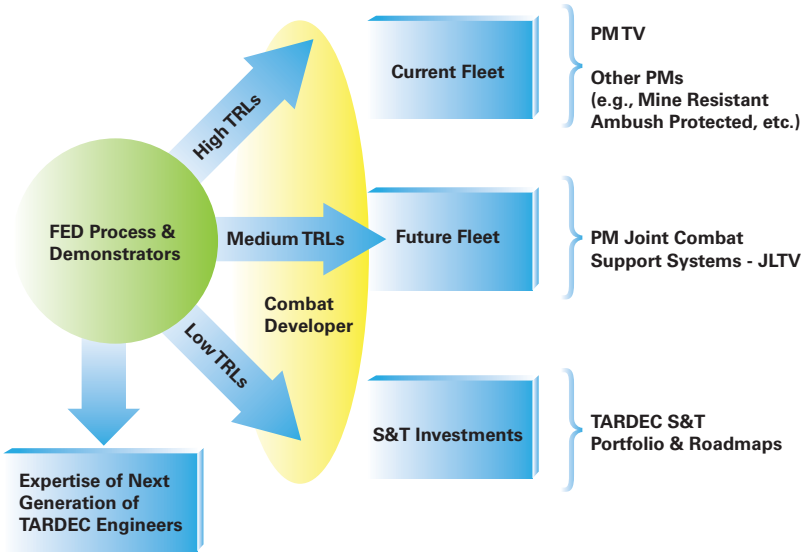
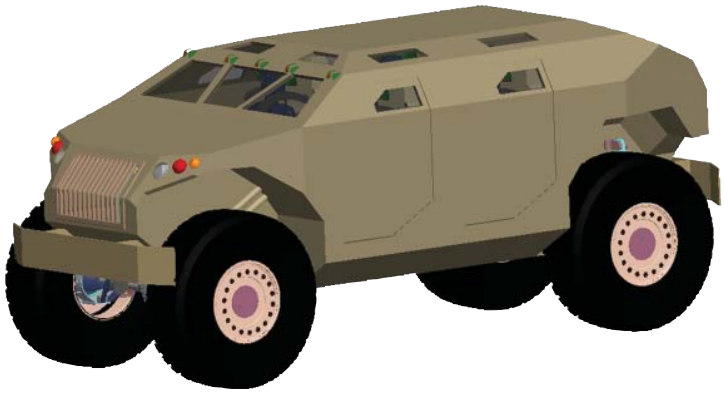


Figure 3. Technology transition strategy.

Technology Transition Planning

The program's limited funding and finite schedule mean the technologies to be physically demonstrated on the FED must be of a sufficient maturity level. Unless a recommended technology can be matured to a Technology Readiness Level (TRL) of five by FY10, it will not be able to be physically produced and integrated into the system. It is expected the act of integrating the technologies together into a system that will be demonstrated will mature the technologies to TRL six by the time that a physical demonstrator is produced. As a general rule, technologies that are currently less than TRL four will not be considered for integration into the physical demonstrator. Any technologies currently at TRL four must be capable of being matured to TRL five by FY10 and TRL six by FY11 to be considered for the physical demonstrator.

However, technologies not mature enough to be physically integrated into a demonstrator are still of interest to the FED program. Figure 3 shows the overall technology transition approach for the FED. High-payoff technologies that are currently mature at TRL seven and above (and TRL six in some cases) will be advertised to Materiel Developer Project



One of several preliminary FED system-level concept designs developed by TARDEC's Advanced Concepts Group. (U.S. Army TARDEC image.)

The FED program involves significant outreach to private industry, academia and other government agencies to leverage the expertise in fuel efficient design in those leading organizations' toolsets, and improve TARDEC's internal expertise.

Managers (PMs) of fielded systems as technologies that can potentially enable their systems to improve in terms of fuel economy or consumption, which could create an opportunity for those PMs to obtain Value Engineering savings.

Technologies that are integrated into the demonstrator and can be matured to TRL six by FY11 will be advertised to the PMs for future systems, such as the Joint Light Tactical Vehicle (JLTV) Pre-Major Defense Acquisition Program. Programs that have not yet entered the Engineering and Manufacturing Development (EMD) phase of the DOD Acquisition Framework (for example, programs that haven't yet reached Milestone B) are potential candidates for this type of transition. In order to increase the probability of successful transition for these technologies, the FED team members plan to work with the relevant program's PM staff and the sponsoring Combat Developer office to influence the requirements in the program's Capabilities Development Document. This will give the PM an avenue for tying the technology to an approved requirement when the actual system is developed throughout the EMD phase of the program's acquisition cycle.

Technologies that are of high potential for improving fuel economy or consumption but are not likely to be matured to a TRL of six by FY11 will be advertised as potential high-payoff investments for the DOD's science and technology (S&T) investment strategy. These less mature but high-payoff technologies should be further developed in Army Technology Objective programs and other DOD efforts. Recommendations for these technologies will be made clear within TARDEC and will influence its Alternative Energy Strategy.

Expertise Building

An additional FED objective is to build the expertise of TARDEC's internal workforce. Since the concepting and M&S phase is being executed in-house, this provides a tremendous opportunity for TARDEC teams to undertake new tasks. The fact the FED team is part of the Systems Demonstrators Team within the newly established Concepts, Analysis, System Simulation and Integration (CASSI) group enables the other teams within CASSI to collaborate extensively with the FED group, forming an integrated team. The internally executed nature of this program allows for M&S representatives to participate in the FED ideation process. The FED team intends to interact with the other groups in CASSI as an integrated team as opposed to a traditional customer/supplier relationship.

Also, as the FED has access to industry and academia SMEs during the concepting and M&S phase there is an opportunity to leverage these individuals' expertise and the organizations that they represent. The FED team's intent is to bring the industry experts in to work collaboratively with the FED core planning group, and more importantly, with the M&S teams supporting the FED. This will enable TARDEC to identify and improve upon any shortfalls — from a human capital standpoint and from an organizational toolset standpoint — in its ability to optimally perform tasks related to fuel efficiency, concepting and design in general.

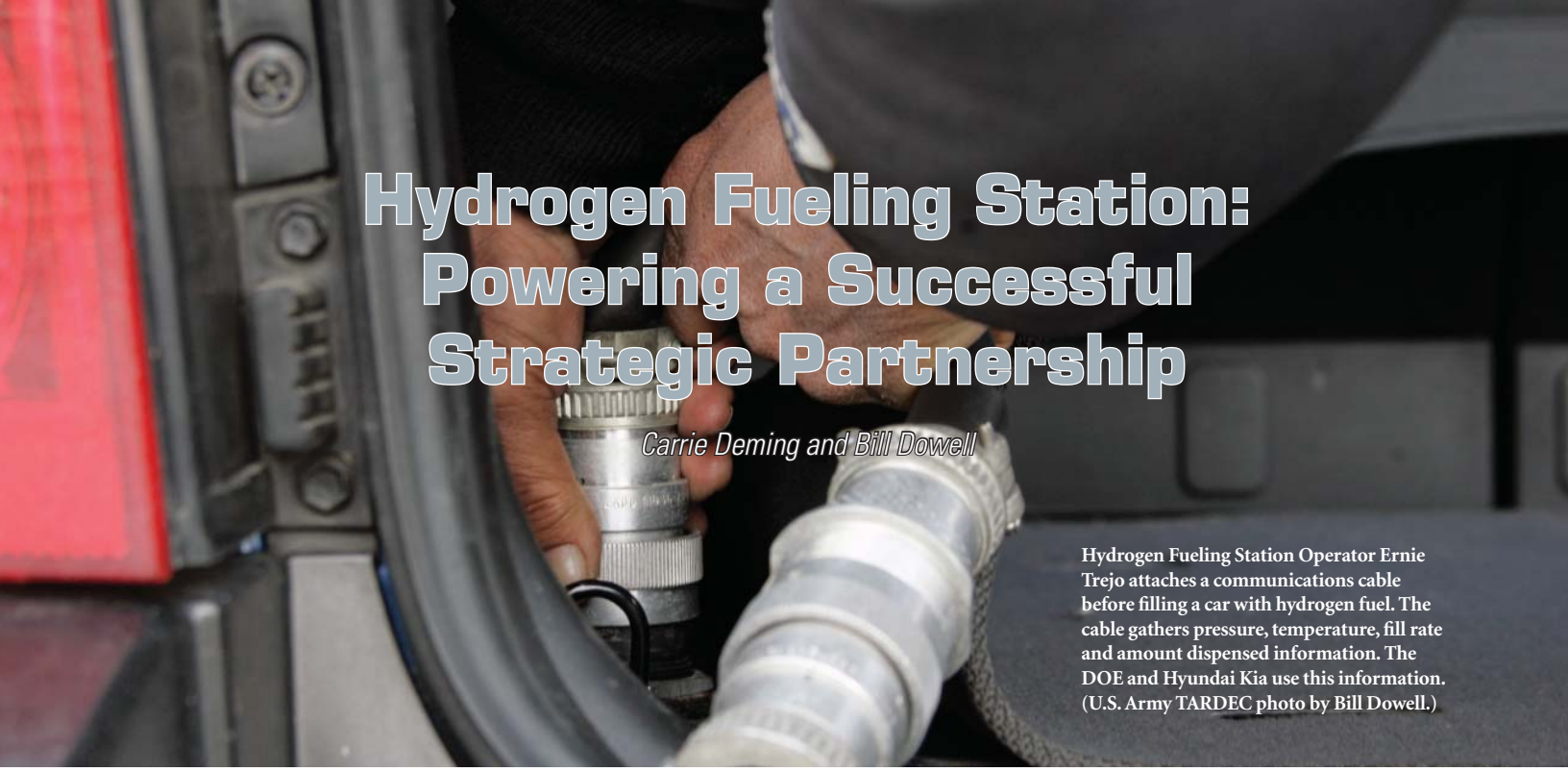
The FED program provides a unique opportunity to demonstrate innovative system-level concepts and their ability to improve fuel economy, as well as to enhance TARDEC's expertise for the long term as a provider of optimized, fuel-efficient design expertise.

FED
FUEL EFFICIENT GROUND VEHICLE DEMONSTRATOR

Mark Mazzara is the Systems Engineer for TARDEC's FED program. He has worked in the U.S. Army TACOM LCMC for the past six years. Prior to assignment on the FED, he was the Program Executive Officer Staff Systems Engineer for Program Executive Office Combat Support and Combat Services Support. Prior to that, he worked on TARDEC's Manufacturing Technologies team. He has a B.S. in mechanical engineering and an M.S. in systems engineering, both from Oakland University. He is Level III certified in systems planning, research, development and engineering – systems engineering and Level II certified in program management.

Hydrogen Fueling Station: Powering a Successful Strategic Partnership

Carrie Deming and Bill Dowell



Hydrogen Fueling Station Operator Ernie Trejo attaches a communications cable before filling a car with hydrogen fuel. The cable gathers pressure, temperature, fill rate and amount dispensed information. The DOE and Hyundai Kia use this information. (U.S. Army TARDEC photo by Bill Dowell.)

Testing the feasibility of using hydrogen as a possible alternative fuel, the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) leveraged a significant Department of Energy (DOE) investment by partnering with two companies at Selfridge Air National Guard Base (SANGB), MI.

"We are proud to be a part of the hydrogen refueling cooperative program that is providing important data to the U.S. Army and DOE so that we can determine the best alternatives to fossil fuels," remarked TARDEC Executive Director of Development Thomas Mathes at the Hydrogen Fueling Station grand opening in 2007.

According to DOE, the overall challenge to hydrogen production is cost reduction. Cost-competitive transportation is a key driver for energy independence. Therefore, hydrogen must be comparable to conventional fuels and technologies on a per-mile basis to compete in the free market.

TARDEC, as the Department of Defense's Ground Vehicle Enterprise, is tasked to help execute the Army's Energy Strategy. This strategy was recently highlighted when Secretary of the Army Pete Geren made energy conservation and reduction an Army priority. After the Defense Science Board and Energy Accountability Office issued energy reports in early 2008, Geren wanted to determine the significance of these reports for the Army. He created the Army Energy Task Force to generate a report on how the Army plans to handle its energy strategy. "I expect the Task Force Report to be the guiding document to reduce Army energy consumption, increase efficiency across platforms and facilities, promote the use of new sources of alternative energy, establish benchmarks for our environmental footprint and provide guidance for the creation of a culture of energy awareness across the Army," exclaimed Geren.

The 3-year Hydrogen Fueling Station and fuel cell vehicles (FCVs) program began as Cooperative Research and Development Agreements (CRADAs) between TARDEC's National Automotive Center (NAC) and Chevron in 2005 and Hyundai Kia Motors in 2006. TARDEC also entered into an interagency agreement with SANGB to serve as the site for hydrogen FCV testing and fueling station cold-weather testing.

TARDEC, Chevron and Hyundai engineers and technicians are collecting real-world operational data at the SANGB testing facility for DOE's Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Program. So far, the group found that hydrogen generation, storage and transport are technically viable. Chevron has developed the technical capability to meet seven to 10 percent of a conventional gasoline station's daily fuel dispensing requirement using on-site hydrogen production.

However, there are still some challenges that remain, such as reducing the cost of dispensed hydrogen to be competitive with conventional fuels that are, on average, $3 per gallon. If a natural gas line is not available, hydrogen can also be generated by biomass conversion

Fill 'er up — Chevron Station Operator Ernie Trejo fills a car at the TARDEC Hydrogen Fueling Station at SANGB. As a safety procedure, he uses a combustible gas detector to check for leaks during refueling operations. SANGB also serves as the cold weather hydrogen test site. (U.S. Army TARDEC photo by Bill Dowell.)

to a synthesis gas hydrogen and carbon monoxide mixture, though it is generally through reformation with fossil fuels.

Depending on the availability of water, natural gas or waste, the decision will be made if on-site production is viable or not. If not, shipment of tube trailers from commercial sources to a stationary dispensing system is the most economical method. The number and frequency of the tube trailers would be determined by the rate of usage and pressure requirements. Due to the characteristics of hydrogen, gaseous transmittal through piping or tubing over long distances would require a lot of maintenance and monitoring and could result in massive hydrogen losses in very short timeframes. Energy requirements for liquefied hydrogen are high, and the longer the piping, the more massive the chilling system would need to be.

Hydrogen Station Program Manager Steven Eick commented, "The methods of generating, storing and transporting are better understood due to research and development of the technologies. The economics of hydrogen vary greatly from one method of generation to the next, depending on catalyst costs, purity requirements, utilities required and rate of generation. If it is not economically and technically viable now, it will likely be viable within a few years."

Currently, the Hydrogen Fueling Station at SANGB houses a piece of equipment known as a "reformer" that converts natural gas into hydrogen. The hydrogen is compressed to greater than 5,000 pounds per square inch and stored in gaseous tubes. The hydrogen is then dispensed through a mechanism that looks very similar to a regular gas pump. The dispenser has a nozzle and a communications cable that interacts with the FCV to get important refueling information, such as pressure and temperature. With that information, the dispenser calculates how full the hydrogen car's tank is and how much pressure must be applied to dispense the hydrogen into the vehicle.

An FCV looks similar to any other car one might see on the road. However, it differs from a conventional vehicle in two primary ways. First, its exhaust is two parts hydrogen and one part oxygen — water — that is potable with few to no contaminants. Second, if the FCV has been turned off for awhile, it will take a moment to charge before it can accelerate. Driving down the road, the only indication that it is not a standard car is the lack of engine noise. Since relatively new technologies are being used, a comprehensive safety system is in place to continuously monitor equipment for temperature, pressure and possible leaks.

The SANGB facility has been a valuable part of the hydrogen FCV development and testing process because it is one of few locations capable of providing cold-weather data for FCVs and hydrogen fueling infrastructure. This project has been, and continues to be, an example of a successful public-private partnership and shows the positive potential for technology sharing between the private sector and government.

A Kia FCV at Chevron's Hydrogen Station, part of the CRADA being performed by TARDEC, Chevron and Hyundai Kia to gather real world operational data for DOE's Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Program. The data is being collected to test the feasibility of using hydrogen as a possible alternative fuel produced at the hydrogen fueling testing station. (U.S. Army TARDEC photo by Randall Riecke.)

Carrie Deming is a Writer/Editor with BRTRC and provides contract support to TARDEC's Strategic Communications team. She has a B.A. in creative writing from The Evergreen State College.

Bill Dowell is a Senior Public Affairs Specialist with BRTRC and provides contract support to TARDEC's Strategic Communications team. He served 23 years in the U.S. Air Force as a Public Affairs Noncommissioned Officer and retired as a Master Sergeant in 2006. He is a Defense Information School graduate and attends Jones International University.

Vehicle Electronics and Architecture (VEA) Technical Area Building Strength in Early Phases

Patrick Pinter

Empowering today's Soldiers and giving them every technology advantage possible has always been the goal at the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) in Warren, MI. To better meet that goal, TARDEC formed the VEA Technical Area in January 2009 to improve its responsiveness to its enterprise partners' needs.

The VEA, part of TARDEC's Research Business Group (RBG), was established to specifically focus on hardware/software system architectures and condition-based maintenance. It was also developed in response to emerging needs from TARDEC's program manager (PM) partners to allow TARDEC to better address the PMs' requirements.

"There was a recognized need for getting back to the understanding and development of vehicle architecture and bringing that role and responsibility back into TARDEC," commented VEA Associate Director (AD) Chris Ostrowski. "It is now my job to look at this from a strategic level. My job as an AD is to develop the strategy and go out and market that strategy with the understanding of our customer needs."

TARDEC is placing a significant emphasis on meeting growing demands in the primary areas of technology development and vehicle system applications. Emerging requirements in those areas has encouraged TARDEC to assume a leadership role for these technologies' research and development.

Ostrowski's depth and breadth of experience in this field, from both government and industry, is what made the TARDEC veteran a perfect candidate to facilitate growth in this emerging area. "I was very excited when I

Both the Stryker (left) and Crusher vehicles are displayed after a recent testing session. TARDEC has placed significant emphasis on meeting growing demands in the primary areas of technology development and vehicle system applications. Forming the VEA Technical Area will help TARDEC meet current and future systems integration demands. (U.S. Army TARDEC photo by RVCA Field Support Team.)

VEA's Chris Ostrowski (center) speaks with Army LTG Rick Lynch during a testing session. Lynch commands the III Armored Corps and Fort Hood at Fort Hood, TX. TARDEC formed the VEA Technical Area in January 2009 to improve its responsiveness to partners' needs for power and distribution. (U.S. Army TARDEC photo by RVCA Field Support Team.)

was offered the position. Even before the position was created, I was a firm believer that we needed something like VEA," remarked Ostrowski. "I have been involved with developing various electronic vehicle architecture all my life, and I believe with all my heart that this organization will have lots to offer people and that we can be very beneficial to customers. We will start with small successes and create a buzz that will make people want to come to us for help in developing in the future."

Ostrowski previously served as RBG's Technical PM for Unmanned Ground Vehicles. In this capacity, he was responsible for overseeing the Robotics Vehicle Control Architecture (RVCA) for the Future Combat Systems (FCS) Army Technology Objective and the Autonomous Platform Demonstrator (APD). Ostrowski has held numerous other roles at TARDEC over the past years, including FCS (Brigade Combat Team (BCT)) System-of-Systems Common Operating Environment (SOSCOE) Director, as well as the Vetronics Electronic Architecture Team Leader. During his three years with FCS (BCT), he was responsible for executing and developing SOSCOE software through build 1.8. Ostrowski also has served as an Army Science and Technology Objective Manager, Advanced Technology Demonstrator Manager and Weapon System Technical Architecture Working Group Chair. He is also a Defense Acquisition University Program Management school graduate and Level III certified in program management.

"There was a recognized need for getting back to the understanding and development of vehicle architecture and bringing that role and responsibility back into TARDEC."

Ostrowski has experienced a transition moving into his AD role. He knows there are still plenty of challenges in front of him, but he uses his past experiences at TARDEC as a tool to help him. "Up until I became an AD, the focus was on program execution, such as cost, scheduling and performance," Ostrowski remarked. "Becoming an AD forces you to change." As it was explained to him, "You no longer do daily program management." His focus now is

on people, budget, and facilities. "As an AD, you are the idea provider and you need to think more strategically," he said. Ostrowski is no longer watching one project or team, but multiple teams spanning multiple efforts all moving simultaneously and all requiring instant feedback. "Moving from that tactical thinking to a more strategic way of thinking is going to be one of my greatest challenges moving forward," he commented.

The VEA Technical Area has been divided into two major sections — Technology Development and Applications — with multiple teams within each. "The Technology Development area feeds and builds vehicle architectures, while the Applications area takes the technologies and applies them," commented Ostrowski. The subgroups under the Technology Development and Applications umbrellas are:

- **Technology Development:**
  - Power Architecture — includes low-, medium- (hybrid-electric) and high-voltage. VEA has the objective to develop power distribution capabilities for current and future vehicles.
  - Electronics Architecture — focuses on integrating electronic items, controls, displays, communication devices and computing resources with respect to size, weight, power and other environmental issues, as well as providing power for sensors and the capability to communicate data.
  - Software Architectures — focuses on defining the significant structural elements of a software system, interactions and interfaces between elements, system behaviors, and allocation to underlying computing resources.
  - Intravehicle Data Networks — focuses on passing data among electronic devices within the vehicle. This team will develop network technologies and topologies, such as switches, routers, busses and interconnection schemas, including intravehicle wireless communications. They will also develop hardware and associated software to pass data, including video capability within the vehicle.
  - Middleware — is defined as software that enables communication among various computing elements within a vehicle and includes researching and defining standards and interfaces for the software framework overlaying the vehicle architecture.

"We will start with small successes at first and create a buzz that will make people want to come to us for help in developing in the future."

- **Applications:**
  - Condition-Based Maintenance — focuses on diagnostics and prognostics application activities and provides program leadership for specific programs, drawing analysis support from the Analytics area within the Concepts, Analysis, System Simulation and Integration group.
  - RVCA — focuses on managing the relationship with PM FCS (BCT) and developing an end-to-end control architecture for unmanned ground vehicles that uses FCS design guidelines and products.
  - APD — a large scale hybrid-electric unmanned ground vehicle testbed platform developed for use with technology integration and field testing applications.

The VEA's final component, Customer Engineers, is slightly apart from the Technology Development and Applications groups. This team's role is business development and will serve as the VEA AD's senior staff, cross-functionally representing the organization anywhere and at any level.

The VEA will be highlighted at the National Defense Industrial Association Michigan Chapter's **Ground Vehicle System Engineering and Technology Symposium** Aug. 17-21, 2009. This conference will be the technical area's first opportunity to showcase its work in an in-depth manner.

"We try to look at development of this organization like a marathon rather than a short race. Any time you start a new organization, there is a huge ramp up. Nothing is going to happen overnight," remarked Ostrowski. "Our number-one goal this year is to develop a strategic plan where we define what the VEA is, its opportunities and its customers."

Patrick Pinter is a Writer/Editor with BRTRC and provides contract support to TARDEC's Strategic Communications team. He has a B.A. in journalism and political science from Western Michigan University.

TARDEC Engages Universities in Creation of Robotics Curricula

Matt Sablan

The U.S. Army Tank Automotive Research, Development and Engineering Center's (TARDEC's) Joint Center for Robotics (JCR) and the University of Michigan-Ann Arbor (U-M), in partnership with seven other Michigan universities, unveiled the Ground Robotics Research Center (GRRC). These universities are offering students new master's degree-level engineering course work in robotics, and TARDEC is aiding in creating the curricula and university robotics activities.

The GRRC is a university, industry and government partnership. U-M's seven university partners are Lawrence Technological University (LTU), Michigan State University (MSU), Michigan Technological University (MTU), Oakland University (OU), University of Michigan-Dearborn, University of Detroit Mercy (UDM) and Wayne State University (WSU). U-M kicked off the GRRC program Aug. 11, 2008. In a GRRC overview, its director, who is also a U-M professor, A. Gallip Ulsoy, stated that the GRRC's goal is "To develop unmanned ground vehicle [UGV] and robotics research expertise and curricula and to graduate students with that expertise, at a consortium of universities in support of growing TARDEC activities in those areas, to increase the impact and speed of delivering cutting-edge technology readiness for the Soldier."

The GRRC was established because JCR personnel saw a need to train a future workforce in defense robotics. TARDEC JCR Director Dr. Jim Overholt and Academia Program Manager Dr. Greg Hudas advised the universities on the curricula TARDEC most needed for its growing team of robotics engineers. University faculty members then designed the necessary curricula to educate and train young engineers for challenging careers in government and industry.

TARDEC has assisted the GRRC since initial projects began in 2007. In 2008, TARDEC helped launch the GRRC. For the future, the GRRC will continue to receive support from TARDEC. This support will assist TARDEC in training the future workforce and investigating multipurpose robotics research through partnerships with academia and industry.

The GRRC's executive committee includes members from the U.S. Army and academic partners. The executive committee includes an Industrial Advisory Board (IAB) that actively participates and contributes funding through entering into research contracts with faculty (funded from Army or other sources), donating equipment, contributing staff and engaging in joint programs with students. As of Nov. 11, 2008, the following companies

An iRobot® Warrior 700™ is put through its paces during a recent training exercise. Its rugged architecture can carry payloads up to 150 pounds over rough terrain. Multifunctional UGV systems that can deliver specific robotic solutions such as this are the focus of ongoing research and development at TARDEC and its industry and academic partners. Robotic platforms such as Warrior 700 can relieve Soldiers from performing the dull, dirty and dangerous work that has become part of the modern battlefield. (Photo courtesy of iRobot.)

have expressed interest in becoming IAB members and joining with TARDEC's academic partners: A123Systems™, John Deere®, Ford® Motor Company, Foster-Miller, iRobot® Corp., General Dynamics®, Lockheed Martin® Corporation, Microsoft® Corporation, Raytheon® Company, Soar Technology, Inc. and Toyota®.

A presentation by Overholt and Hudas at the program's unveiling stated GRRC's four key elements. *First*, it will have joint management, meaning the center's strategic direction, including research areas, will be managed jointly by TARDEC, industry and the universities.

To ensure the program's strategic direction, the executive committee will develop a strategic plan to address TARDEC and the IAB's priorities. The plan will help the committee invite proposals and select projects. *Second*, projects will be critically examined to ensure relevance and impact to warfighters. *Third*, the center will deliver new breakthrough technology and demonstration projects to TARDEC and warfighters. *Fourth*, the center will ensure measurable results by using strong feedback and program management techniques to allow the center to adapt its projects to current technology needs.

In 2008, GRRC focused on developing a new professional Master of Engineering degree in robotics and autonomous vehicles. "U-M developed this new degree program as part of our effort to help develop a robotics research, education and technology regional center of excellence in Southeastern Michigan," explained Professor and Executive Director of Interdisciplinary and Professional Engineering Huei Peng. U-M's degree program was launched in the fall 2008 semester and has two students enrolled in the program.

Other programs focusing on the five GRRC engineering research thrust areas include:

- UGV architecture for intelligence, vision and user interface — researches a spectrum of autonomy and user interface activity, including safe operations, tactical behaviors, teleoperation, machine-human interfaces and other interface research areas.
- UGV energy, power and propulsion — focuses on enhancing the mobility of ground robots and improving their energy storage, harvesting and utilization. Benefits include improved mobility and autonomous operation.
- UGV dynamics and navigation, including ground and vehicle interface — improves safe operations for robots, 360-degree awareness and mobility.
- UGV reliability and manufacturing — focuses on improving the mean time to failure, which is the average amount of time before a robot requires repair or human intervention.
- UGV integration and demonstration test beds — integrates diverse ground robotic technologies from the first four research areas and delivers demonstrations to TARDEC for evaluation.

The GRRC's goal is "To develop UGV and robotics research expertise and curricula and to graduate students with that expertise … to increase the impact and speed of delivering cutting-edge technology readiness for the Soldier."

The thrust areas are part of the GRRC's 4-part vision: enabling the various technologies to make robots work well with other robots through networking and collaboration; getting robots to think and act intelligently independent of human input; and creating robots that are easier and more intuitive, allowing them to operate in any environment, at any time.

The GRRC and JCR desire continued program development to address these research thrust areas and increase the number of trained defense robotics professionals. "We are committed to working with TARDEC to develop key technologies for the next generation of robots for both civilian and military applications," Peng stated.

Thanks to the integration of research with graduate degree programs, the GRRC will assist all partners, and the IAB and TARDEC can pursue their priorities.

U-M's OmniTread OT-8 serpentine robot is undergoing formal testing in TARDEC's lab at the Southwest Research Institute in San Antonio, TX. Robots like this will be designed and studied by students entering the curriculum to determine if the resident technology will support Soldier requirements. (U-M photo by Johann Borenstein.)

TARDEC and JCR will also benefit as universities train new engineers and produce more research to maintain their educational standards. Finally, warfighters in the field will benefit from new and improved technology.

Other university partners support the GRRC in various ways:

- University of Michigan-Dearborn's Vetronics Institute Team Lead, Dr. Paul Richardson, explained the university's GRRC partnership developing, integrating and testing an Ultra-Wideband (UWB) Radio Tracking System for Soldier- and vehicle-following applications. UWB radios determine ranges within a few centimeters of accuracy by measuring transit time of very narrow pulses. Integrated onto vehicles, this technology allows tracking systems to gather information on Soldier positions, allowing vehicles to follow a designated Soldier. The University of Michigan-Dearborn includes robotics in various curricula.
- LTU currently offers a Robotics Education Concentration for its Master of Educational Technology program; a Master of Science (M.S.) in mechatronic systems engineering in either mechanical or electrical engineering at the graduate level; and an M.S. in computer science degree with an intelligent systems concentration focusing on autonomous robotics. TARDEC also serves as a member of the IAB on mechatronics. The university hosts RoboFEST, an annual autonomous robotics

OU hosts IGVC at its campus each spring. TARDEC engineers served as mentors and judges for the competition. They spoke with most of the teams about unique engineering and research opportunities at TARDEC. (U.S. Army TARDEC photo by Elizabeth Carnegie.)

competition aimed at teaching science, technology, engineering and mathematics to students in grades 5-12 and college students.

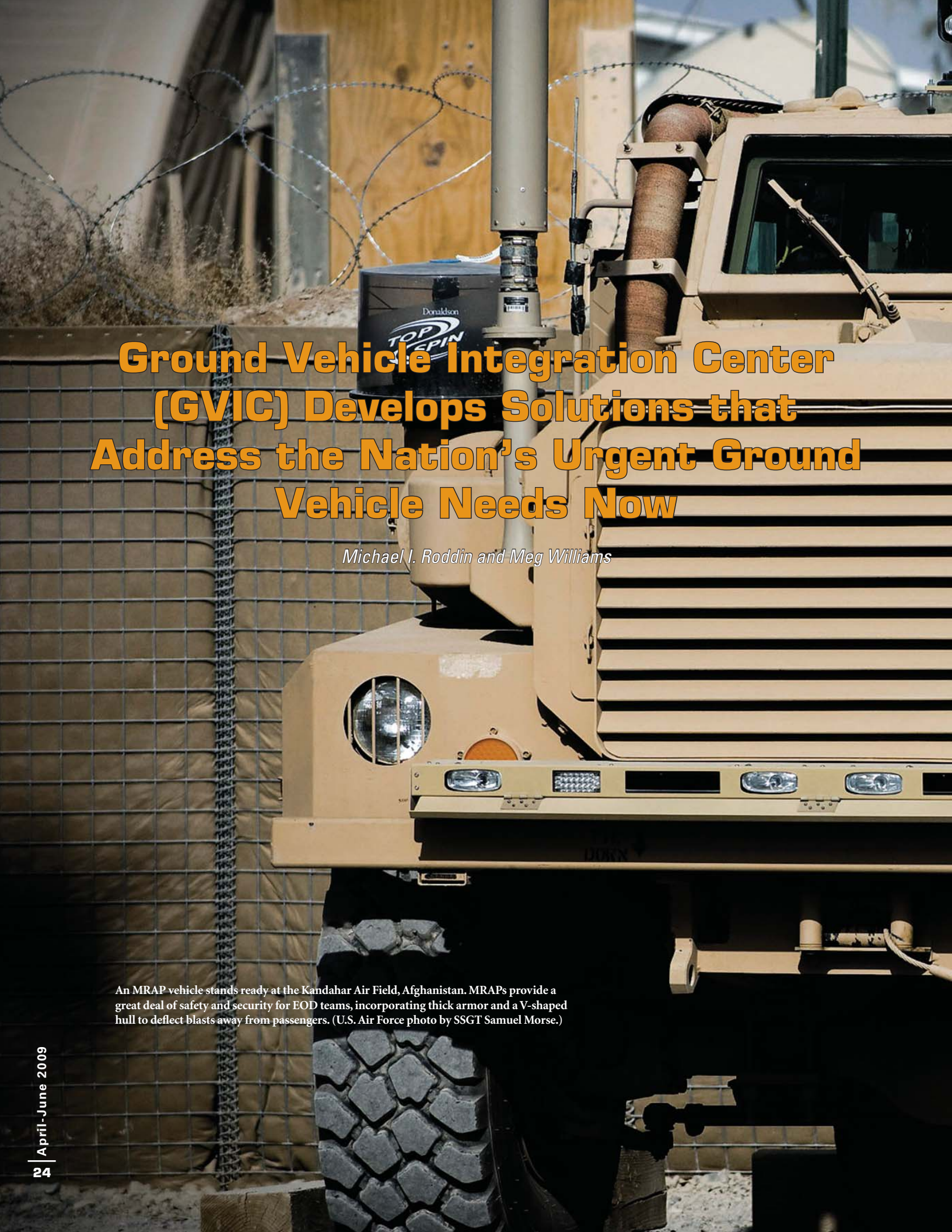
- UDM is launching a master's degree program in robotics that will be fully phased in by fall 2009. It is achieved through a fifth-year program for electrical and computer engineering (ECE) undergraduates or a 2-year graduate program. UDM's Advanced Mobile Robotics Laboratory allows faculty as well as undergraduate and graduate students to develop mobile robotics systems, with work including localization, navigation, vision/perception, motion control, advanced communication networks and wireless sensor networks.
- OU's Department of ECE offers an undergraduate major in ECE; master's programs in ECE, embedded systems and systems engineering; and a doctoral program in ECE. In fall 2009, Oakland will offer a master's program in mechatronics. The university's facilities include a Center for Robotics and Advanced Automation and the congressionally approved Fastening and Joining Research Institute, a one-of-a-kind facility. OU is currently working with the GRRC on Multiple Robot Tracking Technologies and co-founded the Intelligent Ground Vehicle Competition (IGVC) with TARDEC in 1993.
- WSU has three engineering teams led by Professors Greg Auner, Darin Ellis and Walter Bryzik, who are assisting the GRRC. This includes grants for work on developing novel optical and chemical sensors for early warning detection of improvised explosive devices; flexible architecture for human interface with warfighter machines mounted from unmanned platforms; and combustion optimization of engine-driven unmanned robotic vehicles.
- MTU has many ongoing research projects with GRRC. MTU's Mobile Robotics Laboratory facilities support research and coursework at the university. The university offers "Mobile Robotics and Multi-Robot Systems," a course described as "discussing state-of-the-art computer applications in the field of robotic systems with a special emphasis on mobile robots." Starting with a brief discussion of traditional robotics areas, the course will cover the locomotion, sensing and reasoning of mobile robots.
- MSU has the Robotics and Automation Laboratory and Smart Microsystems Laboratory. Current research projects include mobile robot control, multi-robot collaboration and optimal task distribution during multi-robot collaboration, nanorobots and nanomanufacturing, human-robot cooperation, micro robot sensing and control and various teleoperation projects. MSU has a comprehensive robotics curriculum at the graduate and undergraduate levels, with course offerings on topics such as robotics, computer vision, artificial intelligence, computer-aided manufacturing and control.

TARDEC continues to support these programs and, hopefully, others will follow to continue expanding the opportunities for robotics education. Hudas reiterated JCR's role and the importance of support for these curriculums, stating, "A properly trained and knowledgeable workforce in robotics will allow for efficient transition of relevant technologies to our ultimate customer — the warfighter."

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

Ground Vehicle Integration Center (GVIC) Develops Solutions that Address the Nation's Urgent Ground Vehicle Needs Now

Michael I. Roddin and Meg Williams



An MRAP vehicle stands ready at the Kandahar Air Field, Afghanistan. MRAPs provide a great deal of safety and security for EOD teams, incorporating thick armor and a V-shaped hull to deflect blasts away from passengers. (U.S. Air Force photo by SSGT Samuel Morse.)

When threats to the Mine Resistant Ambush Protected (MRAP) vehicle fleet threatened warfighters' lives, U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) engineers performed research, analysis, development and production that typically would require years' worth of effort in mere months to provide solutions. From this experience, TARDEC formed GVIC to address urgent needs and develop innovative solutions and improvements to the Nation's military vehicles. In this roundtable discussion, GVIC Director Dr. Bruce Brendle and Deputy Associate Director-Ground Systems Survivability Debbie DiCesare describe GVIC's capability insertion process.

accelerate: Can you describe GVIC's approach to vehicle integration? How does GVIC relate to TARDEC?

Brendle: GVIC encompasses everything we need to do for the warfighter across the organizations here at TARDEC and across the TACOM Life Cycle Management Command [LCMC], the U.S. Army Research, Development and Engineering Command [RDECOM] and other government agencies. It is the complete spectrum of activities required to conduct design, development, integration and testing of ground systems — manned or unmanned — from engineering changes to technology and capability insertion to full system prototypes. The important thing to remember is that GVIC doesn't do any of these steps itself, but, rather, GVIC pulls them all together into a seamless project.

Figure. The GVIC Program Management Office facilitates integrated program development across organizations, both internal and external to TARDEC, and provides a single coordination point to its customers.

This gives the customer one person to manage cost, schedule and performance across those activities.

GVIC gives TARDEC a way to link all of our capabilities internally and across RDECOM in order to accomplish systems integration for ground vehicles as depicted in the figure.

DiCesare: If you look at the whole system, from a TARDEC transformation standpoint, in both MEAP [MRAP Expedient Armor Program] and what Bruce is doing with the MRAP Capability Insertion program, we're not just looking at it as a concepts-type issue. This is not just a survivability issue. We are getting people from all the different organizations to look at total vehicular impacts.

accelerate: Can you describe some of GVIC's capability insertions?

Brendle: Debbie ran one of the capability insertions for the MEAP. Under capability insertion, the Joint Program Management Office MRAP [JPO MRAP] has established a process with two basic flows. One, called "fast-track," are things that need to get in the field urgently and don't require

"GVIC gives TARDEC a way to link all of our capabilities internally and across RDECOM in order to accomplish systems integration for ground vehicles."

major vehicle modifications. Then you have more of a systems engineering approach to something like a block upgrade where multiple things are being added and you're also improving infrastructure in the vehicle.

DiCesare: Even under fast-track, and even under MEAP, we used a modified version of the systems engineering process. So, you don't completely discount it, but you pull the pieces that are essential to get you to the end. You bring in a whole bunch of different organizations to be able to execute that process.

accelerate: Can you walk us through the process? What do you do with the vehicles once you get them?

Brendle: First, the capability insertion program has very specific requirements. Unlike MEAP it's not 'give me more protection' — it's 'install this piece of equipment.' MRAP has very specific requirements. It's all traditional government suppliers; it's all known solutions. Our challenge then is to take a variety of government-furnished equipment and conduct

the systems engineering approach to install all this equipment on a variety of vehicles with as much commonality as possible.

DiCesare: If, for example, I put a widget on one of the MRAPs, I can go ask our automotive folks or our concept folks, 'If I put widget X on, can this even fit, and what are my impacts to power, weight, cost and space claims?' I can go to my vehicular people and say, 'If I put this thing on, am I only going to be able to go two miles per hour?' I can ask, 'Now that I've put this on, have I degraded my reliability?' We're looking at total vehicular impact.

Brendle: What Debbie is describing is the analyses we conduct: weight, power, transportation, human factors, dynamics, operational effectiveness, mobility, survivability, reliability, lethality and costs. We're coordinating across the board and integrating these analyses into the overall evaluation.

Basically, you look at the requirements and assess technology to determine if you can integrate it quickly or if it makes more sense to take a longer-term approach to look at multiple items and potentially more power to the vehicle. After design is complete, you go out and test prototype integration kits. After a successful test, the PM [Program Manager] produces the kits, installs them in the field and then sustains them. This is what we're doing under capability insertion. What Debbie was getting at is how we're doing the technology assessment. Before we put something on the vehicle, we're looking at the entire system impact.

accelerate: What types of projects is GVIC working on to field equipment?

Brendle: We have three projects underway. The Capability Insertion program is for PM Development and Assistant Product Manager for Capabilities Insertion within JPO MRAP. We are adding equipment to five fielded MRAP variants. It's a complicated program because those variants have their own OEMs [original equipment manufacturers]. There are multiple versions of each variant out in the field. Some of the variants are up to 12th Low Rate Initial Production. Our goal is to maximize commonality across the fleet. We're creating solutions to integrate equipment, add power and command, control, communications, computers and intelligence architecture to all of the

Paratroopers from the 101st Airborne Division, Fort Campbell, KY, prepare to inspect their new MRAP vehicles at Camp Arifjan, Kuwait. The unit's convoy escort teams will begin to use the MRAPs to move supplies in and out of Iraq. (U.S. Army photo.)

MRAP vehicles sit in a parking area at Joint Base Balad, Iraq. U.S. Air Force security forces personnel have incorporated MRAPs into their mission to defend the base, both inside and outside the perimeter, a mission not conducted by the Air Force since the Vietnam War. (U.S. Air Force photo by TSGT Craig Lifton.)

variants, and we're trying to get as much commonality across the fleet as we can.

We are also working on two Command and Control on the Move [C2OTM] projects for two different partners. The first project is for PM Command Posts in partnership with the JPO MRAP. We're putting C2OTM equipment on three MRAP variants. We also just agreed to do the same type of work on Stryker.

accelerate: I know that TARDEC is very proud of its partnerships with other government and industry organizations. What partnerships have you already used so far in GVIC programs like MEAP?

Brendle: There are some TARDEC leads, there are some TACOM leads and there is the Army Research Laboratory [ARL] for human factors engineering assessments. We're also doing electromagnetic interference analysis on the antennas through the Communications-Electronics Research, Development and Engineering Center [CERDEC]. For at least one of the technologies, the Armament Research Development and Engineering Center is involved.

DiCesare: For example, when we did MEAP, some of the OEMs wanted to be right there in the thick of it — and it was helpful for understanding these vehicles and their capabilities. It's continuous coordination and collaboration.

accelerate: Do you still take all the traditional things into consideration: payload, protection and performance? If so, how do you balance those concerns with the additions you have to integrate?

DiCesare: Yes, we do.

Brendle: Some of that can be in the concepts stage when

"MRAP has very specific requirements. It's all traditional government suppliers; it's all known solutions. Our challenge then is to take a variety of government-furnished equipment and conduct the systems engineering approach to install all this equipment on a variety of vehicles with as much commonality as possible."

you review your operational effectiveness. It might be that I have a requirement to put something on the vehicle and, with it on, you have a change in performance. For instance, if the top speed was 42 miles per hour, now it might be limited to 35 for safety. That's the output.

DiCesare: And you say, yeah, but if it saves my life, I don't care.

Brendle: I think the one thing that you could say is that this process gives you a lot of data to enable the PM, with TARDEC supporting it, to do risk mitigation and management.

accelerate: If you have variants, for each variant do you go through every step?

Brendle: In large part, yes.

DiCesare: We did for MEAP.

accelerate: There are seven different MRAP variants. All the testing and design work must be a huge project?

Brendle: MRAP Capability Insertion is more complex than other things we would expect to see through GVIC. Just the way MRAP was fielded — multiple manufacturers, multiple variants — they had to do that to meet schedule, making the program complex.

DiCesare: But they will have to do all those analyses — the vehicle variants' properties and performances are very different. So, you're right. It's a big effort.

Brendle: A lot of things are complementary, too. If you install widget X on vehicle A, putting widget X on vehicle B is a little bit easier than putting it on vehicle A, because you already had your learning curve.

accelerate: How do you choose which variant comes first?

Brendle: That's the PM's decision.

DiCesare: Whatever priorities they have, that's the order in which we'll execute.

accelerate: So what else does GVIC do during these capability insertions?

Brendle: Design is just one part of our overall process. After we complete the design, we're building prototypes in-house, creating the drawings and working with the PM to have it built by the depots and put in the field. We also help support the testing, spare parts, drawings and depot work. By far, the biggest part of our job is understanding the requirement and coming up with the first product out the door.

DiCesare: The MEAP covered all that. We actually produced a bunch of the first kits here [at TARDEC]. We were involved in all of that.

Brendle: Our intent is to take it through initial production. For what we're doing for capability insertion, we're doing six per OEM. Our goal is to create the drawing packages and send them to the depots or OEMs to produce.

DiCesare: In some cases, if there was an urgent requirement, we might go to the Prototype Integration Facility and say: 'Look, we need 70 of these things. Can you get them for us?' That was the case in MEAP.

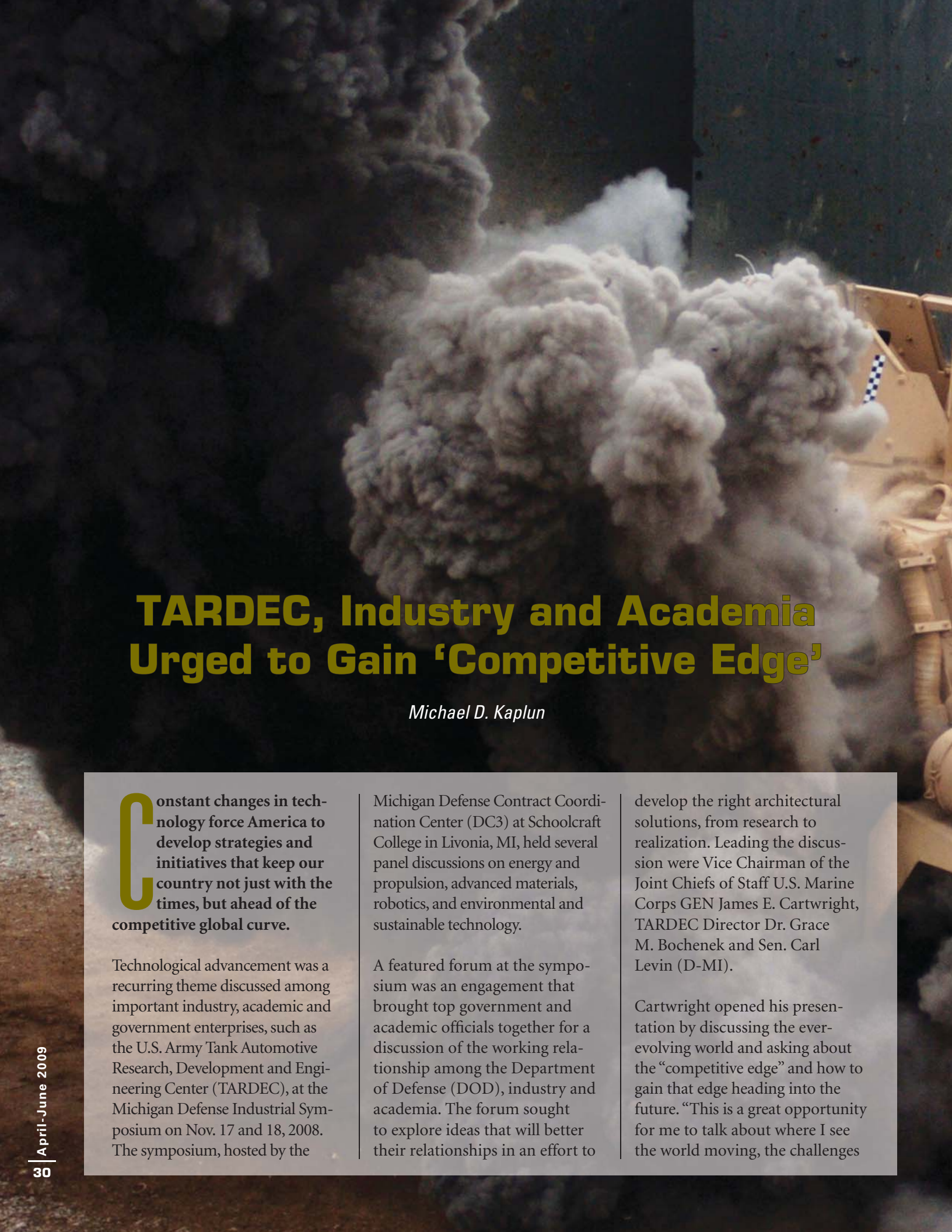
accelerate: How many people work for GVIC?
Brendle: We are a small organization of about 10 people primarily focused on program management. We are heavily leveraging TARDEC's systems engineering group to standardize processes.

accelerate: What project management tools does GVIC use to manage these large projects?

Brendle: GVIC uses an integrated work breakdown structure to manage projects, Microsoft Project and TARDEC's Advanced Collaborative Environment as its primary tools. When we assign work and costs to a cost center, we create a work package. GVIC is going to start tracking costs historically so that we can get a better idea early on in the program development stage of what it takes to execute a program. An example of this is the MRAP C2OTM — we took the whole MRAP Capability Insertion effort's integrated master schedule budget — a complicated process of many vehicles and many technologies — and we input the C2OTM required. From that we compiled a much smaller program of six months and a fraction of the cost. Then we showed this to the cost center to validate that we were taking the right approach.

Michael I. Roddin is the TARDEC Strategic Communications Director and *accelerate* Editor-in-Chief. He has B.S. degrees in English and journalism from the University of Maine and an M.S. in marketing from the University of Southern California. Roddin is a former Army Advertising Program Manager and 3-time Army Keith L. Ware Journalism Award recipient. In 2005, he was selected by the Secretary of the Army for Editor-of-the-Year honors.

Meg Williams is a Publications Manager with BRTRC and provides contract support to TARDEC's Strategic Communications team. She has a B.A. in English from the University of Michigan and an M.S. in marketing from Johns Hopkins University.



TARDEC, Industry and Academia Urged to Gain 'Competitive Edge'

Michael D. Kaplun

Constant changes in technology force America to develop strategies and initiatives that keep our country not just with the times, but ahead of the competitive global curve.

Technological advancement was a recurring theme discussed among important industry, academic and government enterprises, such as the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC), at the Michigan Defense Industrial Symposium on Nov. 17 and 18, 2008. The symposium, hosted by the Michigan Defense Contract Coordination Center (DC3) at Schoolcraft College in Livonia, MI, held several panel discussions on energy and propulsion, advanced materials, robotics, and environmental and sustainable technology.

A featured forum at the symposium was an engagement that brought top government and academic officials together for a discussion of the working relationship among the Department of Defense (DOD), industry and academia. The forum sought to explore ideas that will better their relationships in an effort to develop the right architectural solutions, from research to realization. Leading the discussion were Vice Chairman of the Joint Chiefs of Staff U.S. Marine Corps GEN James E. Cartwright, TARDEC Director Dr. Grace M. Bochenek and Sen. Carl Levin (D-MI).

Cartwright opened his presentation by discussing the ever-evolving world and asking about the "competitive edge" and how to gain that edge heading into the future. "This is a great opportunity for me to talk about where I see the world moving, the challenges

A Mine Resistant Ambush Protected vehicle undergoes testing at the Aberdeen Test Center in Maryland. Technological contributions from industry and academia will lead to vehicle system and robotics advancements that will ensure TARDEC delivers solutions that lead to significant advances in protection, performance and payload. (U.S. Army photo.)

A side view of a Combat Tactical Vehicle Advanced Concept Technology Demonstrator developed under an Office of Naval Research collaborative contract. Cartwright, Levin and Bochenek led a forum that discussed and encouraged this type of partnership among government, industry and academia to develop the right architectural solutions from research to realization. (U.S. Army TARDEC photo.)

we will have in the 21st century and what it is that we, as a Nation, are going to have to prepare ourselves for in the 21st century," he stated.

Cartwright asserted that most of our laws are based on a 30-year industrial cycle. Today, however, this construct has been decreased to 30 months or even 30 days, with developments such as the improvised explosive device. This yields to a greater need for quicker processes. "We have got to develop new weapons in those cycles, and we have to integrate across the research and development [R&D] base, to the information base, to the industrial base," he said. "The only way we are going to be able to find the competitive edge is to be able to integrate all of those processes in a way that is meaningful."

"Technology changes so rapidly that we have to find new ways to drive innovation into our capabilities every day."

At the center of this integration is a coupling between innovation and capital, which exists in the industry-academia partnership. This coupling relates to what the military refers to as "Joint." Cartwright emphasized the importance of making the country's capabilities, systems and innovation more Joint in today's world. "How do we live in this world of constant change, find the opportunity to break out, grow the people we need, foster the invention, have enough middle management that we can grow the senior management we need and oversee the enterprise day-to-day?" he asked. "The systems we build have to be able to integrate on a combined level. They have to be able to integrate on a Joint level."

Cartwright also noted that with integration comes the necessity for stronger interagency relationships, particularly between industry and academia. Improving this infrastructure will help improve productivity and efficiency. "If we bring together the R&D base of the military with the innovation and academic credentials of a major university and put them together with an acquisition hub … we get a much quicker cycle time to change," he explained. A more complete architecture will yield to improved adaptability and preparation for continued forward steps.

The ability to change is an essential component of the military. The general stated that adaptability within the Army comprises the individual, training and discipline on one level; a modification in materiel capabilities on another level; and innovation, or "building new," on the final level. Using these parts helps toward realizing goals on a national level. "We have to have the tight integration across industry, academia, the military and the government — if we don't have that, we will always be chasing the solution," Cartwright confirmed. This tight integration keeps plans on track to, ultimately, help warfighters and the country. "We're just staying competitive, and the competitive edge will be fleeting — it will go quickly, so we are going to have to be ready

to stay ahead of it," he continued. "If we don't work hard to give [warfighters] the opportunity to succeed, then we shortchange this Nation," the general concluded.

Following Cartwright, Bochenek explained how TARDEC uses fundamental and applied research to provide technical integration capabilities for its ground vehicle systems. "TARDEC does the right technology solutions and investments. Not only do we do technology development, we are also responsible for all of the engineering support and service support for all of the ground vehicles within the United States Army," Bochenek stated.

University students prepare their robots for four different challenges at the 16th Annual Intelligent Ground Vehicle Competition, May 30-June 2, 2008. Government enterprises such as TARDEC hope to leverage their expertise with industry and academia. (U.S. Army TARDEC photo.)

She elaborated on TARDEC's integration of ground vehicle work, which includes sensors and communications equipment. In addition, TARDEC has an automotive center that does its own integration. "TARDEC's National Automotive Center is a conduit to connect industry to the appropriate parts of our organization. Again, it's about bringing the right expertise to solve problems and put solutions on platforms to develop the next-generation capability," Bochenek explained.

TARDEC has begun developing the next capability through its new Ground Systems Gateway, which aims to drive integration between DOD, industry and academia. Specifically, the gateway will be a portal on TARDEC's Web site, where members of industry and academia can submit ideas. TARDEC associates will review the ideas and capabilities from an architectural standpoint to find the right solutions for ground vehicles. Ideas can be sent to **groundvehiclegateway@conus.army.mil**.

"From that gateway we will have a structure so that if you have an idea, you bring it into that gateway where [ideas] will get evaluated and fed to industry," stated Bochenek.

Bochenek also explained the importance of academia and industry working together to foster ingenuity. "Technology changes so rapidly that we have to find new ways to drive innovation into our capabilities every day," Bochenek said. For innovations and initiatives to be realized, partnerships must be strengthened. "The innovation comes from not only internal expertise and the technical understanding of these complex issues, but also the right partnering with industry and academia," she continued. "It's up to us [industry, academia and government] to leverage each other's expertise to bring these ideas to fruition over time."

Levin offered his thanks to the dedicated and professional servicemen and women guarding freedom's frontiers and encouraged industry and academia members to become involved with federal government contracting and procurement opportunities through DC3. "What you're involved in is making the country more secure. You're involved in promoting the economy of this state and involved in not just securing the country, but trying to get those technologies into weaponry to secure our troops and give them everything they need to succeed," he said. DC3's mission is to increase federal government contracting and procurement opportunities for Michigan companies, which will create new jobs and investments in the state, but also leverage Michigan's significant engineering and automotive expertise.

The forum, along with the entire symposium, conveyed many ideas and initiatives that will advance the United States in the world market place. Continuing to advance technological developments and staying ahead of the competitive global curve keep our country protected, productive and prepared for inevitable challenges — domestically and overseas.

Michael D. Kaplun is a Junior Writer/Editor with BRTRC and provides contract support to TARDEC's Strategic Communications team. He has a B.A. in English and Media and Society from Hobart and William Smith Colleges.

TARDEC's Christopher Scott Achieves Excellence at the 2009 Black Engineer of the Year Awards (BEYA) Conference

Michael D. Kaplun

Christopher Scott grew up in Detroit, MI, under the care and guidance of loving parents. "My parents did everything in their power to help me, while making many sacrifices for me to be successful," he said. To the joy of Scott and his parents, success became a reality at the 23rd BEYA Science, Technology, Engineering and Mathematics Global Competitive Conference held Feb. 19-21, 2009, in Baltimore, MD.

Chairman and CEO of Career Communications Group, Inc., Dr. Tyrone Taborn (left), greets TARDEC's Christopher Scott (right) onstage at the "Modern-Day Technology Leadership Luncheon" on Feb. 20 in Baltimore, MD. Scott was honored at the 2009 BEYA Conference for his exceptional work and ability to shape the future course of engineering, science and technology. (U.S. Army photo by RDECOM's Joe Ferrare.)

Scott, an engineer with the U.S. Army Research, Development and Engineering Command's (RDECOM's) Tank Automotive Research, Development and Engineering Center (TARDEC) in Warren, MI, was among the distinguished honorees at the annual BEYA Conference. The event, which convenes prominent figures from different branches of the government to learn, network and exchange ideas throughout the engineering community, recognizes individuals who have achieved exceptional career gains in government and industry, as well as lifetime achievement and pioneering feats.

TARDEC's Christopher Scott received a Department of the Army Commander's Award from MG Paul S. Izzo, RDECOM Commanding General, in addition to his 2009 BEYA Conference honor. The honor specifically cites Scott's achievements and exemplary performance as "keeping with the highest tradition of government service and reflects great credit upon him, [RDECOM] and the Department of the Army." (U.S. Army photo.)

"It is a great triumph to be recognized for the hard work that I put in during college and on the job to support the U.S. Army," stated Scott, a 26-year-old graduate of the University of Detroit-Mercy. "In addition to winning this award, the acknowledgment and respect TARDEC has shown me since I became an engineer for the organization further indicates the integrity and professionalism that TARDEC represents as a whole."

The TARDEC engineer was honored in the category of Modern-Day Technology Leaders during the "Modern-Day Technology Leadership Luncheon" on Feb. 20. The category encompasses men and women of color who are exceptional in their performances and will help shape the future course of engineering, science and technology.

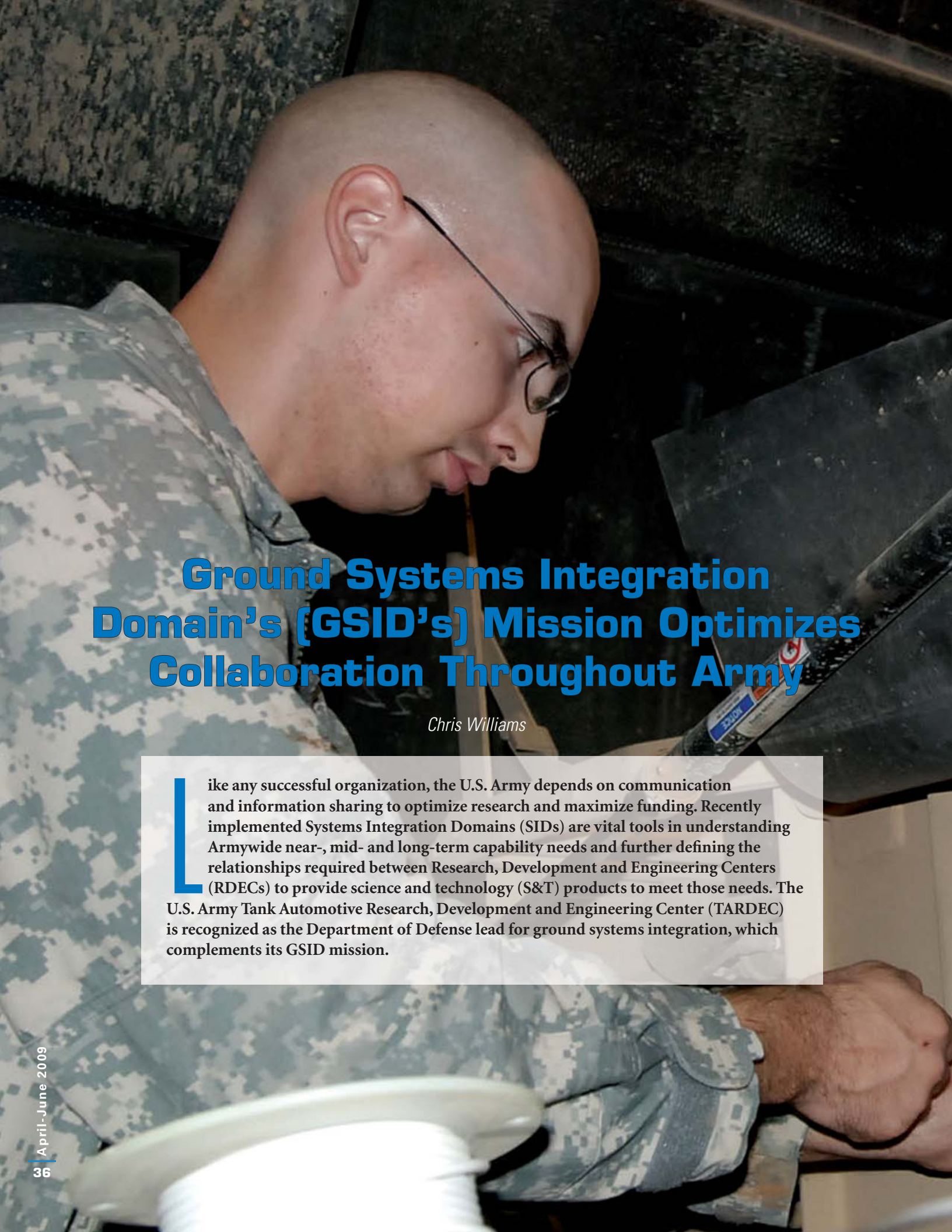
"Professionally, the BEYA achievement allowed me to represent a great organization at a national conference in a positive manner," Scott said. "I took an oath when I became a government employee, and being able to support our Nation and to be selected nationally for doing good work is a great privilege."

The luncheon, sponsored, in part, by Gulfstream Aerospace Corporation, The Boeing Company, Raytheon Company, the U.S. Air Force and U.S. Navy, highlighted the next generation of leaders being cultivated to keep the Nation strong, competitive, safe and prepared for the future. Among the speakers at the luncheon was the U.S. Air Force's Dr. David M. Jerome, Air Force Research Laboratory Sensors Directorate Director at Wright-Patterson Air Force Base, OH. "We are confident that your exemplary performance will be a shining beacon to others who will want to exhibit your passion and dedication to our country," Jerome remarked to the honorees.

More than just being recognized, Scott will use the BEYA experience to build on his role as a mentor for underprivileged youths in Detroit anticrime and educational projects. "The insights I want to share with underprivileged youths is to follow your dreams," he said. "Do not be concerned with the stereotypes and social stigmas that media outlets and statistics may place on you for various reasons. One can go as far and become as successful as he or she desires — you just have to do your best and remain positive."

And, thanks in large part to the annual event and his parents, remaining positive and determined is exactly what Scott will do. "The BEYA Conference taught me that with dedication, commitment and discipline, you can do what ever you want to in your career, education and personal life," he remarked. "I am very blessed to still have both of my parents here on Earth. Their seeing me receive the award was a joy to my and their hearts."

Michael D. Kaplun is a Junior Writer/Editor with BRTRC and provides contract support to TARDEC's Strategic Communications team. He has a B.A. in English and Media and Society from Hobart and William Smith Colleges.



Ground Systems Integration Domain's (GSID's) Mission Optimizes Collaboration Throughout Army

Chris Williams

Like any successful organization, the U.S. Army depends on communication and information sharing to optimize research and maximize funding. Recently implemented Systems Integration Domains (SIDs) are vital tools in understanding Armywide near-, mid- and long-term capability needs and further defining the relationships required between Research, Development and Engineering Centers (RDECs) to provide science and technology (S&T) products to meet those needs. The U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) is recognized as the Department of Defense lead for ground systems integration, which complements its GSID mission.

"SIDs are vital pieces of the U.S. Army Research, Development and Engineering Command [RDECOM] Technology Integration Concept [TIC], recognizing the true roles of the RDECOM RDECs to deliver integratable capability to the Soldier," explained Clifton Boyd, TARDEC GSID Program Manager. TIC includes a set of technology teams, referred to as Technology Focus Teams (TFTs), that work with SIDs to create an S&T portfolio that will expedite technology transition to better address Soldier battlefield requirements.

SIDs are organized across the RDECs and include the Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance SID; Effects SID; Soldier SID; Air SID; Chemical, Biological, Radiological, Nuclear SID; and GSID. TFTs are utilized across seven technical areas: human dimension and training; mobility; power and energy; logistics; network; survivability; and lethality. By bringing the subject-matter experts across these areas together, they can better understand each

The GSID mission incorporates all phases of a product's life cycle, including sustainment, which accounts for approximately 70 percent of a weapons system's cost. The GSID domain includes the ILSC to ensure that planning, development and transition include a product's life cycle's logistical phase. Here, a Soldier from 1st Sustainment Brigade installs new flood lights on a Mine Resistant Ambush Protected vehicle. The GSID wants to ensure Soldiers have the spare parts, components and supplies they need, when and where they need them most. (U.S. Army First Sustainment Brigade photo by James E. Brown.)

"If we can identify the common problem, we can do a little bit of research and affect a lot of systems out there."

technology focus area and its affect across the various domains. "Across the domain you have issues for each one of these technologies, and, as a domain organization, you try to express to all these other domain organizations what your needs are," explained GSID Chief Engineer Joseph Urda. "You do that in conjunction with your life cycle management partners, program executive officers and project managers and all the people who manage the systems."

GSID is not an organization, but rather a new thought process about work already being done. "It's the same physical organizations just taking a different view through the data — nobody's job has changed. What we're trying to do is look at the synergy between all the activities that happen between various programs," Urda clarified.

GSID's mission is to align ground system community stakeholders to facilitate technology planning, development and transition by integrating S&T as well as acquisition program cost, schedule and performance parameters. The goal is to increase collaboration across the systems, improve efficiency and maximize research across SIDs to get the right product to Soldiers, from the right sources, at the right times. GSID's mission encompasses the entire ground systems, acquisition, user and logistics communities, including the associated strategies, personnel, processes, tools and metrics used to create products for warfighters. "This is a game changer. This takes us to a whole new level," noted TARDEC Director Dr. Grace M. Bochenek at a GSID orientation meeting held at the Detroit Arsenal, MI, in October 2008.

To develop ground systems that meet Soldiers' needs, TARDEC officials must be aware of developments throughout the Army's S&T community. Implementing the GSID mission allows TARDEC employees to know what occurs throughout the domain and helps other SID officials understand how those developments impact their

TARDEC Director Dr. Grace M. Bochenek discussed creating partnerships during the GSID conference Oct. 27, 2008, in Warren, MI. Bochenek is adamant about getting the right products from the right sources to the right Soldiers. (U.S. Army TARDEC photo by Rhonda Wilt.)

TARDEC GSID Program Manager Clifton Boyd believes that SIDs are vital pieces of the RDECOM TIC for delivering integrative capabilities to Soldiers. (U.S. Army photo by La Shara McCallum.)

respective systems. "Batteries are the classic example," explained Urda. "Everybody needs better power, lighter batteries, better duration and all the things you need batteries to do. But everybody has a different requirement for their batteries — different size, different shape, different charge and discharge requirements — and it's hard to tie that into a single, overarching requirement to build one battery for the whole Army."

The process is designed to facilitate cooperation among domains and TFTs to highlight areas where research and development can be leveraged. "Through this process we can demonstrate that we are maximizing our investment. Each of our customers has a set of capability needs — they need to go faster, they need lighter weight, they need better battery power. When you look across the domains, you see similar systems that have similar problems," stated Urda. "If we can identify the common problem, we can do a little bit of research and affect a lot of systems out there."

Survivability research, for instance, results in materials that impact the power, space and weight available within a system. Systems, such as the High Mobility Multipurpose Wheeled Vehicle, risk becoming overloaded when mobility decreases as new technologies are added. To maximize the system's capabilities and create a better vehicle that can effectively meet Soldiers' needs, collaboration among TFTs and SIDs is essential to understanding how changes in one area affect the system as a whole. "To understand what impact any one system has, you have to talk to everyone who's affected by it," Urda said.

"[GSID] covers every base, in conjunction with other domains."

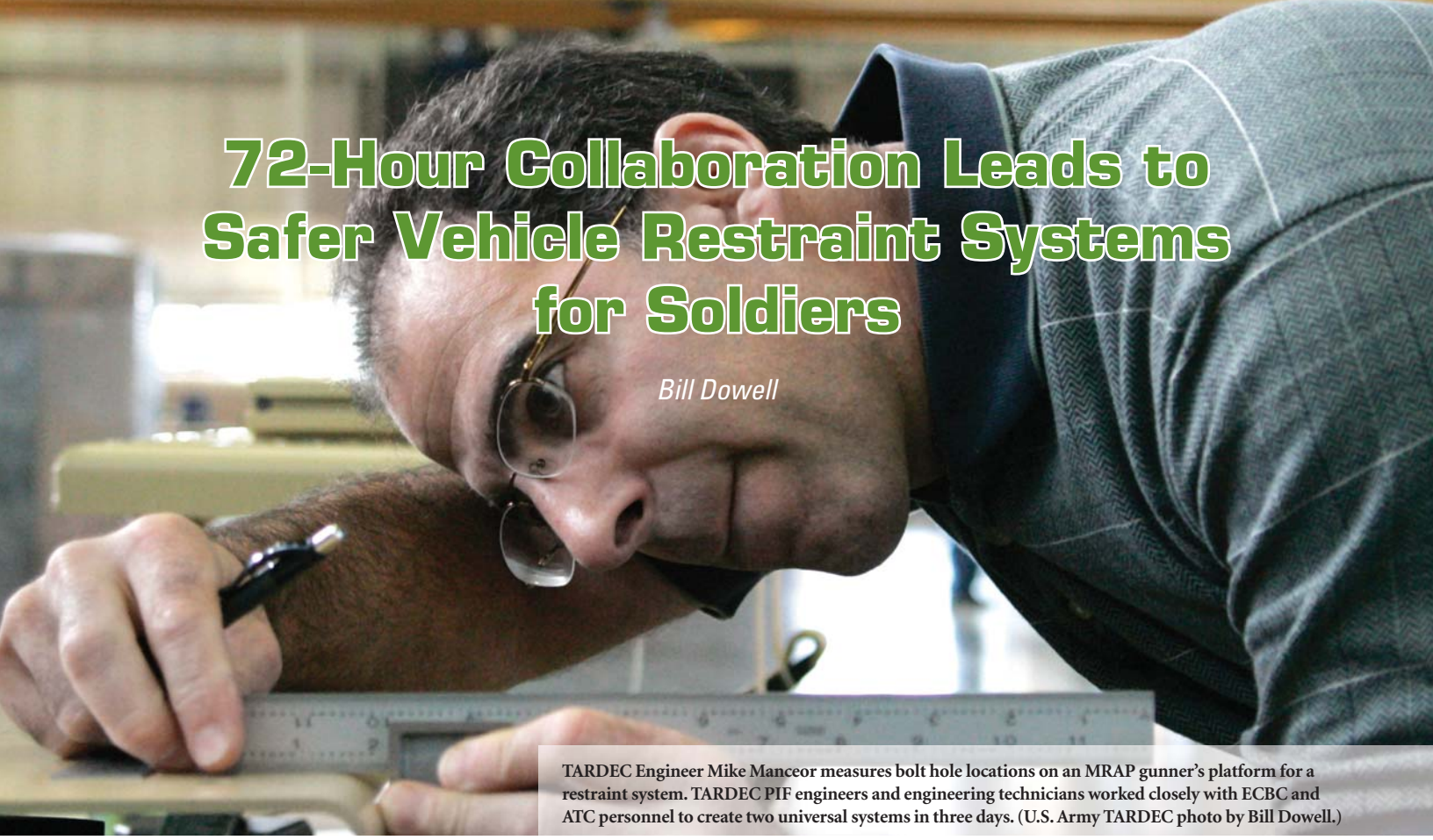
The GSID mission encompasses each phase of a system's life cycle. Historically, greater focus had been placed on programs in the development phase, which had well-defined, researchable needs. The GSID mission recognizes S&T's impact on the entire acquisition life cycle. "Approximately 70 percent of a weapons system's cost is in sustainment," stated Urda. "The big cost is in keeping gasoline, fan belts and oil filters running and maintained. The system that maintains it, the Integrated Logistics Support Center (ILSC), is about 60 percent of TACOM Life Cycle Management Command. But they don't have the traditional easy research topics and yet are severely affected by every new system that comes along because they have to absorb the logistics, repairs, maintenance and all the things the new gizmo causes," Urda emphasized. "One interesting part of GSID is that part of the domain is the ILSC. That's another unique thing about the holistic view of what the GSID does. It covers every base, in conjunction with other domains."

Prior to the SID's implementation, communication between domains was challenging, slowing knowledge sharing about S&T developments across the RDECs. Urda admitted that strengthening collaboration among RDECs and Army labs is one of GSID's greatest challenges. "The issue is that you have to get people to work together that haven't traditionally worked together to express what the capability needs are of the different domains," he stated. "In the end, it is about getting the right capability to the Soldier at the right time," concluded Boyd.

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

72-Hour Collaboration Leads to Safer Vehicle Restraint Systems for Soldiers

Bill Dowell



TARDEC Engineer Mike Manceor measures bolt hole locations on an MRAP gunner's platform for a restraint system. TARDEC PIF engineers and engineering technicians worked closely with ECBC and ATC personnel to create two universal systems in three days. (U.S. Army TARDEC photo by Bill Dowell.)

Seventy-two hours to save Soldiers' lives. Seventy-two hours to assess, design, fabricate, integrate, test, adapt and produce a universal restraint system to ensure gunners won't be thrown from Mine Resistant Ambush Protected (MRAP) vehicles in the event of an accident or vehicle rollover.

That was the task U.S. Army Tank Automotive Research, Development Engineering Center (TARDEC) engineers and technicians were given the evening of Sept. 24, 2008, to protect turret gunners on the MRAP, who are positioned at a gunners hatch in the top of the vehicles.

The TARDEC Prototype Integration Facility (PIF) immediately began adapting an existing 5-point restraint harness and retractor used in the High Mobility Multipurpose Wheeled Vehicle (HMMWV). "There were several challenges to overcome," said Senior Engineer Mike Manceor. "No drawings or computer-aided design [CAD] models were available, and no two MRAP variants share the same bolt hole patterns."

Designers had to climb into vehicles and physically measure the hole patterns. Designers Jim Mason and John Maniaci assisted Senior Engineer Joe Siwicki make detailed drawings from the measurements he took. In the meantime, collaborative efforts were coordinated with the Edgewood Chemical Biological Center (ECBC) PIF and Aberdeen Test Center (ATC), both located at Aberdeen Proving Ground (APG), MD. While TARDEC engineers were developing designs, fabricating and integrating a prototype for one of the seven MRAP variants, the TARDEC Advanced Collaborative Environment Team worked to make the CAD data available to the team. At the same time, the Research, Development and Engineering Command's PIF Advocate Gary Doggett traveled to ATC, offering support where needed.

On Sept. 26, 2008, less than 48 hours after receiving the tasking, TARDEC's MAJ Anh Ha and CW3 Jason Greegor led a team of TACOM Life Cycle Management Command (LCMC) Soldiers in conducting a human factors operational evaluation to assess the design and provide feedback from a user perspective. The physical testing and human factors engineering were coordinated with TARDEC's Physical Simulation Team, the TACOM LCMC Safety Office and ATC.

TARDEC PIF Project Engineer Floyd Helsel made 10 kits Friday, and Siwicki arrived at APG Saturday to guide ATC technicians in the installation of Helsel's kits, which had been delivered overnight.

From left: TARDEC Engineers Mike Manceor, Keith Sheridan and Jim Mason measure and record current bolt hole locations to ensure a universal MRAP Gunner Restraint System will fit another variant. TARDEC employees worked closely with ECBC, APG, ATC and LCMC personnel to ensure the systems were safe for Soldiers. (U.S. Army TARDEC photo by Bill Dowell.)

The entire TARDEC team worked through the weekend, and Siwicki worked with ECBC and TARDEC engineers to develop, fabricate and integrate a solution for one variant not available at TARDEC. With the basic concept already developed and ECBC so close to APG, this solution seemed the best for changes and deliveries of prototypes and testing.

Within 48 hours, TARDEC's design engineers were ready to make design changes following the testing, and PIF engineering technicians were ready to fabricate any new components should test results indicate a fix was needed. "Everything progressed smoothly and we felt prepared for any contingency," stated TARDEC PIF Associate Director Jim Soltesz. "It was an outstanding team and collaborative effort."

By Sunday evening two basic designs, one for five of the vehicles and another for the remaining two, were complete. ECBC fabricated mounting hardware, and engineers from each PIF pooled drawing updates. Former RDECOM Commanding General MG (Ret.) Fred D. Robinson Jr. issued the following note: "This is great work by the whole team. It also shows how far we have come as a command when [TARDEC] engineers are tied in with the ECBC … to maximize time and effort."

The push had ended, but work continued. TARDEC provided designs and 50 Gunner's Kit platform plates to Blue Grass Army Depot Sept. 28, 2008, and supported Rock Island Arsenal, IL, with manufacturing. Designs, prototypes and a bill of materials for all vehicles were completed, and kits were fabricated, assembled and shipped to theater. The new restraint systems will ensure the safety of all turret gunners in vehicle accidents and rollovers.

PFC James Anderson, a member of the 1st Battalion, 161st Infantry Regiment, tries on the gunner restraint system for his MaxxPro™ MRAP vehicle before heading out on a convoy. Adapted from the existing 5-point harness used in HMMWVs, the new system is designed to fit the different MRAP variants. (U.S. Army Photo by SPC Michael Behlin.)

Bill Dowell is a Senior Public Affairs Specialist with BRTRC and provides contract support to TARDEC's Strategic Communications team. He served 23 years in the U.S. Air Force as a Public Affairs Noncommissioned Officer and retired as a Master Sergeant in 2006. He is a Defense Information School graduate and attends Jones International University.

TARDEC Engineers Nab Best Paper Award at 26th Army Science Conference (ASC)

Meg Williams

At the Defense Manufacturing Conference on Dec. 2, 2008, in Orlando, FL, Deputy Assistant Secretary of the Army for Research and Technology (DASA (R&T))/Army Chief Scientist Dr. Thomas H. Killion (center) is briefed on an Auxiliary Power Unit (APU). The APU's 10 kilowatt-hour diesel powered rotary engine was designed for the M1 Abrams Main Battle Tank's under armor compartment. The APU will be used in place of the main engine for powering the tank's electrical loads while in a stationary watch mode to reduce fuel consumption and engine noise. (U.S. Army photos by Richard Mattox.)

Several U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) engineers, scientists and researchers took part in the 26th ASC held Dec. 1-4, 2008, in Orlando, FL.

The highlight for TARDEC was Senior Research Engineer Dr. Peter Schihl and Mechanical Engineer Laura Hoogterp winning the Best Paper Award for their Power and Energy technical session presentation "On the Ignition and Combustion Variances of Jet Propellant-8 and Diesel Fuel in Military Diesel Engines" presented at the awards banquet and closing ceremony Dec. 4. The conference theme was "Transformational Army Science and Technology: Harnessing Disruptive S&T for the Soldier."

TARDEC Scientific Presentations

TARDEC Chief Scientist Dr. David Gorsich, Sudhakar Arepally, Karrie Hope, Stephen Genter and Kari Drotleff presented their work on "Application of Mathematical Modeling in Potentially Survivable Blast Threats in Military Vehicles" at the Advanced Modeling and Simulation parallel technical session Dec. 2.

The following day James Soltesz and Starlett Burrell presented a poster about the "[High Mobility Multipurpose Wheeled Vehicle] Improvements 'Monster Garage©'" Program at the conference's parallel technical session on Force Protection/Survivability.

At the Dec. 3 Nanotechnology parallel technical session,

TARDEC's Senior Research Engineer Dr. Pete Schihl and Mechanical Engineer Laura Hoogterp received the Best Paper for Power and Energy award at the 26th Annual Army Science Conference Dec. 4, 2008. From left, U.S. Army Director of Research and Laboratory Management, Office of the DASA (R&T) Dr. John A. Parmentola, Schihl, Hoogterp and DASA (R&T)/Chief Scientist Dr. Thomas H. Killion.

Autonomous Systems is one of seven technology/research areas the 26th ASC is emphasizing as part of its conference theme, "Transformational Army Science & Technology — Harnessing Disruptive S&T for the Soldier." Shown here, TARDEC's Chris Mocnik (left) explains the Robotic Vehicle Control Architecture for Future Combat Systems to DSO National Lab's Zi Jing Bay and Hikaru Fujishima.

TARDEC's Dr. Grant Gerhart and Dr. Elena Bankowski, along with Oakland University's Professor Andrei N. Slavin and Vasil S. Tiberkevich, presented "Control and Optimization of Coherence of a Nano-sized Spin-torque Microwave Oscillator for Military Nano-electronics."

At this same session, TARDEC's Basavaraju Raju, along with MKP Structural Design Associates, Inc.'s Dongying Jiang, Yushun Cui and Yuanyuan Liu and the University of Michigan's Jheng-Dong Ma, presented a poster on "Simulation and Design of Nanocomposite for Application in Ballistic Protection." Another poster, the "Bulk Nanocomposites Produced by Thermally Activated Severe Plastic Deformation" presented during this session was researched by the U.S. Army TACOM Life Cycle Management Command's Jose Mabesa, along with M3TechCenter, LLC's Dr. Song Zhang, Jie Bai and Kelly Shue; Wayne State University's Dr. Xin Wu and Dr. Gang-yu Liu; and New Jersey Institute of Technology's Leonard Dauerman. Gerhart and the U.S. Army Research Laboratory's John Miller co-chaired the Dec. 4 parallel technical session on Autonomous/Unmanned Systems. During this session, TARDEC's Robert E. Karlsen and Turing Associates, Inc.'s Gary Witus presented their findings on "Learning to See: Research in Training a Robot Vision System." Additionally, TARDEC's Dr. Jim Overholt and Dr. Greg Hudas, along with the Massachusetts Institute of Technology's Karl Iagnemma, Martin Udengaard and Genya Ishigami and the Illinois Institute of Technology's Matthew Spenko, Sinan Oncu and Imad Khan, presented their work on "Design and Development of an Agile, Man Portable Unmanned Ground Vehicle." Four TARDEC researchers, Paul L. Muench, Joseph Alexander, Sean Hadley and Steven Starkey, also presented a poster on "Bipedal Walking."

On Dec. 4, Gorsich co-chaired the Immersive Technology parallel technical session with the U.S. Army Research Institute's Dr. Stephen Goldberg. At another parallel technical session, Physical/Engineering Processes: Theory and Analytical Modeling, Gorsich and TARDEC's David A. Lamb, in conjunction with of the University of Wisconsin–Madison's Dr. Dan Negrut and Makarand V. Datar, presented "A Framework for Uncertainty Quantification in Nonlinear Multi-body System Dynamics."

Gorsich and Lamb led a second presentation on "The Use of Copulas and Most Probable Point-based Dimension Reduction Method to Assess and Mitigate Engineering Risk in the Army Ground Vehicle Fleet." The University of Iowa's Kyung K. Choi, Yoojeong Noh and Ikjin Lee also took part in this research.

The conference provided an excellent opportunity for TARDEC associates to showcase their work, network with and learn about cutting-edge research being done by others in their respective fields.

ASC Online

TARDEC's Bob LaPolice explained, "The Panel of Command Sergeant Majors was excellent from a 'where the rubber meets the road' perspective. And the exoskeletons offer a truly paradigm-changing technology for infantry Soldiers that would free them from the physical challenges of their equipment and greatly expand their capabilities and protection."

If you would like to watch videos of the impressive speeches, go to http://www.asc2008.com/.

Meg Williams is the Publications Manager for *accelerate* magazine and is a Project Manager with BRTRC, providing contract support to TARDEC's Strategic Communications team. She has a B.A. in English from the University of Michigan and an M.S. in marketing from Johns Hopkins University.

accelerate Writer Guidelines

accelerate is a quarterly professional journal published by the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC), DOD's Ground Systems Integrator.

The editorial office address is:
Editor-in-Chief
U.S. Army TARDEC
6501 East Eleven Mile Rd.
Bldg. 200A, Rm. A-1108, MS #206
Warren, MI 48397-5000

Editorial staff phone numbers are:
(586) 582-0288/(586) 838-2302
Fax: (586) 838-2360
e-mail: **accelerate@conus.army.mil**

Purpose
To instruct members of the ground systems community about relevant technology; research development and engineering; and innovative business processes for managing technology; and to disseminate other information pertinent to the professional development of the ground systems workforce.

Subject Matter
Subjects may include, but are not restricted to, research and development initiatives, engineering integration initiatives, program accomplishments, technology developments, business transformation, policy guidance and technology excellence. All articles must be in compliance with security, export control and operations security (OPSEC) requirements. Our Soldiers deserve the technological overmatch being developed today. We owe it to the warfighters to field not only systems that work, but systems that are uncompromised.

OPSEC Review Process
All articles prepared by government employees must be reviewed and approved by the responsible supervisor, must undergo a security classification, export control and OPSEC Review (STA Form 7114) and must be approved for public release (Distribution A: Distribution Unlimited). All articles prepared by a contractor or an academician under contract to the U.S. government must be reviewed and approved by his/her Contracting Office Technical Representative (COTR), must undergo a security classification, export control and OPSEC review (STA Form 7114) and must be approved for public release (Distribution A: Distribution Unlimited). An individual may use his/her organizational OPSEC Review Form. If the individual does not have access to an OPSEC Review Form, then the TACOM LCMC STA Form 7114 will be used and be attached to the author's submission.

Submission Procedures
Articles must not exceed 1,600 words. Manuscripts are to be prepared in Microsoft® Word and should be approximately eight typed, double-spaced pages using a 20-line page and Times New Roman 12-point font.

A minimum of three photos, illustrations or charts should accompany each article to help illustrate a process or technology in files separate from the manuscript. The photographs should focus on the technology and not individuals. Any copyrighted photographs, illustrations, charts or other material must be accompanied by a consent/release from the copyright owner. They are subject to the same review process as the article.

Given counterterrorism and counterintelligence concerns, personally identifiable information about who has participated in a project, and where tests have been conducted must be protected. Photographers' names and organizations are to be included for each photo submitted. Artwork must be accessible for editing and not embedded in the manuscript. Photos may be color or black and white. Illustrations must be black and white and must not contain any shading, screens or tints. Illustrations and photographs may be submitted via e-mail to **accelerate@conus.army.mil**. All electronic photo files must have a minimum 300-dpi resolution and be in TIFF or JPEG format. The higher the resolution, the better. If they do not meet this requirement, glossy prints of all photos must be submitted via U.S. mail, FedEx, etc., to the address listed on this page. Photos and illustrations will not be returned.

Acronyms used in manuscripts, photos, illustrations and captions must be kept to a minimum and must be spelled out on first reference.

Articles submitted to *accelerate* will not be accepted if they have been scheduled for publication in other magazines.

All submissions must include the author's and photographer's mailing address, e-mail address and office phone number.

Biographical Sketch
Include a short (approximately 65 words or less) biographical sketch of the author(s) that includes current position, educational background and acquisition or other certifications, if applicable. The biographical sketch must also undergo an OPSEC review and will not include information about security clearances or special access programs.

2009-2010 Submission Dates

Issue	Author Deadline
October-December 2009	July 30, 2009
January-March 2010	Oct. 30, 2010
April-June 2010	Jan. 29, 2010
July-September 2010	April 30, 2010
October-December 2010	July 30, 2010

Editor's Note: *Space constraints, changing priorities and articles with perishable information may be referred for publication in TARDEC* S&T News Update *monthly.*

TARDEC

accelerate —
Faster. Sleeker. Better.

Get the word out about your program.
WRITE FOR *accelerate* TODAY!

Are you researching new technology? Have you faced and overcome engineering challenges and created innovative designs that will aid Soldiers in theater? If you have, TARDEC, the Nation's laboratory for advanced military automotive technology, wants to publish your story. Discovered a solution to a problem? Worked on new, exciting technologies? Share with your peers and publicize your work with us. We're seeking articles for *accelerate's* October-December 2009 issue and want your voice to be heard.

TARDEC, as DOD's Ground Systems Integrator, is at the forefront of technological innovation. That is not possible without you — engineers, researchers, scientists, technicians, anyone involved with the process. *accelerate* is your vehicle — so, help us get the best component parts under the hood and on our pages. Write for *accelerate* today!

Submit your article or photo images to: accelerate@conus.army.mil.

Interested in monthly updates about TARDEC's technology partnerships and innovations? Sign up to receive *S&T News Update* monthly here: http://www.tardec.info/stnews/subscribe.cfm.

IN THIS ISSUE

TARDEC

6501 E. Eleven Mile Rd.
Warren, MI 48397-5000
http://tardec.army.mil/

US ARMY RDECOM