

2011

TARDEC ANNUAL REPORT

U.S. ARMY TANK AUTOMOTIVE RESEARCH, DEVELOPMENT
AND ENGINEERING CENTER

WARREN, MICHIGAN

42.494 / -83.039

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Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE 2012		2. REPORT TYPE		3. DATES COVERED 00-00-2012 to 00-00-2012	
4. TITLE AND SUBTITLE TARDEC Annual Report 2011				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC), 6501 E. 11 Mile Road, Warren, MI, 48397-5000				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			



MISSION

The U.S. Army Tank Automotive Research, Development and Engineering Center's (TARDEC's) mission is to develop, integrate and sustain the right technology solutions for all manned and unmanned Department of Defense (DoD) ground systems and combat support systems to improve Current Force effectiveness and provide superior capabilities for the Future Force.

VISION

TARDEC's vision is to be the recognized DoD leader for ground systems and combat support systems technology integration and system-of-systems engineering across the Life Cycle.

TARDEC CREED

I am TARDEC

I am one member of a team

I have integrity

I am innovative, knowledgeable,
and always learning

I am committed, disciplined, and accountable

I am focused

I am TARDEC



On the front cover: The Rocket Propelled Grenade (RPG) Defeat System was designed to protect Soldiers and Marines from RPG threats in the field. TARDEC designed, tested and fabricated a solution that integrated RPG Nets developed by an industry partner onto vehicle platforms. The solution was brought from laboratory to integration in less than two months, highlighting our commitment to the warfighter.



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DIRECTOR'S MESSAGE

During any given year at the U.S. Army's Tank Automotive Research, Development and Engineering Center (TARDEC), there are numerous ways our work has made a difference for our country's Soldiers and Marines. Fiscal Year 2011 (FY11) was no exception.

Even as we faced budget and operational constraints, we remained vigilant in delivering state-of-the-art research and development (R&D) innovations in an operating environment that demanded U.S. forces maintain threat readiness in an era of persistent conflict, while steadily pursuing fuel efficiencies, energy independence, modeling and simulation breakthroughs, advanced and integrated architectures, and ground vehicle robotic autonomy.

As Director, I am enormously proud of each and every project we contributed to in FY11, and wish I could share the details of all of them with you. Our 2011 Annual Report will provide you with an overview of the many ways we continued to support our Soldiers and Marines to ensure their battlefield success and improve their safety.

This year, we continued to define and establish our key foundational relationships and set precedence for doing business differently, working hand-in-hand with the Program Executive Offices and Program Managers to provide the technical and engineering support they need for their vehicle platforms. We collaborated closely with government and industry partners in support of the Department of Energy (DoE) and Department of the Army's (DA) Advanced Vehicle Power and Technology Alliance (AVPTA) to find solutions that improve mobility, increase energy efficiency and yield tangible benefits for Soldiers and U.S. consumers alike.



Our partnerships with industry and academia continue to prove invaluable as we leverage the newest technology advancements to modernize our fleet. Our location in Warren, MI, just north of Detroit, places us at the heart of the automotive industry, and gives us unique access to the brightest engineering minds and best test facilities in the industry.

The relationships we've forged with the commercial automakers benefit both sides as we leverage each other's resources and technology to improve military and commercial vehicles. Southeast Michigan is also home to some of the top academic institutions in the world, and we partner extensively with them and others throughout the country to develop cutting-edge technology for automotive system advancements.

Our partners want to work with us because our associates have earned enviable reputations for delivering rapid solutions for urgent battlefield requests from Soldiers and Marines to meet emerging requirements for new capabilities. They play an essential role in developing and integrating the most advanced ground vehicle technology solutions possible so that our Soldiers maintain a distinct technological advantage. This year, we continued to develop our workforce's critical skills, encouraging them to pursue higher education, hone their expertise and prepare them for leadership roles. We continued our commitment to prepare the next generation of scientists and engineers through a variety of programs designed to educate and inspire them in science, technology, engineering and

mathematics (STEM) education. As battlefield threats continue to evolve and we plan for a future in which our warfighters must fight in diverse environments and terrains, it is imperative that we keep the Future Force in mind, and our STEM outreach programs do just that.

We do all of this while maintaining our steadfast commitment to the Soldier, and in FY11 we continued developing innovative solutions to keep them mobile and effective. Advancements in fuel efficiency and mobility ensure that warfighters keep moving on the battlefield and are able to use the advanced technological equipment inside platforms. Engineers in our Center for Ground Vehicle Development and Integration's work on the Explosively Formed Penetrant armor kits provided a solution that keeps our warfighters safe in the field, and our robotics work continues to increase the standoff distance between Soldiers and threats.

We still have milestones to reach in ground vehicle mobility, power and energy efficiencies, technology integration, survivability, force projection and sustainability. These challenges represent unique opportunities for our workforce to integrate advanced solutions and capabilities so that Soldiers and Marines are protected by the best vehicles, systems and equipment possible.

It is a duty we are honored to fulfill and one we take very seriously. We know the Army relies on our expertise and we bring dedication, commitment and passion to this mission.

We look forward to building on these developments in the coming year. Our Ground Systems Power and Energy Laboratory, scheduled to open in spring 2012, will add to our research

capabilities, with multiple world-class testing areas that will allow us to enhance our fuel efficiency and mobility research and lead to advancements that benefit the Soldier and the Nation.

Each year we strive to perform better than we did the year before and to push ourselves toward ever-greater achievements. This is not for our own sense of accomplishment, but because we know the ultimate customers — Soldiers and Marines — deserve nothing less than our best. The exciting programs you'll learn more about in this year's Annual Report all have the same ultimate goal — protecting the courageous men and women who put themselves in harm's way to protect our Nation.

Grace M. Bochenek, Ph.D.
TARDEC Director



LEAD - INNOVATE - INTEGRATE - DELIVER

LEAD

We lead by creating opportunities where none existed previously.

INNOVATE

We provide and sustain the most advanced ground vehicle systems by creating unexpected new capabilities and turning them into integrated engineering solutions.

INTEGRATE

We have the expertise to bring all the pieces together and get them to work as one through a system-of-systems approach that ensures the whole is always greater than the sum of its parts.

DELIVER

We deliver the most technologically advanced solutions possible so that our Soldiers are protected by the best vehicle systems imaginable.

OVERVIEW

TARDEC and its partners in the TACOM LCMC orchestrate the design, engineering, development, testing, validation and sustainment of the manned and unmanned vehicles that transport the Army to fulfill its global objectives. Our Soldiers, Marines, Airmen and Sailors take great risks and make profound sacrifices to accomplish their missions, and they rely on our expertise to develop the best ground vehicles and equipment in the world. TARDEC's 1,788 engineers, scientists, researchers and support staff must fulfill their duties with similar vigilance and resourcefulness to deliver solutions that give warfighters a decisive edge and dominant overmatch capabilities.

Our mission has shifted toward broader issues that affect us collectively as a Nation, such as energy efficiency and renewable energy. Whether pursuing solutions to protect Soldiers on the battlefield or applying technical skills to pressing challenges on the home front, our scientists and engineers approach each project with the same relentless commitment, passion and meticulous skill.

Our success depends on our ability to partner with private industry, academic resources and other government agencies. We simply could not accomplish all our

objectives without collaboration to distill the best blend of ideas and the most direct approach to solving challenges.

As the Army's provider of ground systems technology and integration, we apply innovative approaches and rapid technology assessments in our mission to support more than 2,800 Army, U.S. Marine Corps (USMC) and Navy manned and unmanned systems. TARDEC plays an extensive role in providing vehicles and equipment to support expeditionary overseas contingency operations. As the Nation faces mounting infrastructure challenges at home, TARDEC engineers, technicians and scientists are advancing technology to address these concerns.

TARDEC plays a lead role maturing advanced technology solutions for future systems to harness efficiencies that lead to energy security and independence. Fortunately, our organization is well positioned strategically to leverage invaluable automotive engineering resources that are the hallmarks of this region. We work closely with partners throughout government, industry and academia to seek out the best ideas, find creative solutions and make the right collaborative connections to reach our overarching goals.

TARDEC provides full life-cycle support and systems engineering expertise for all DoD ground combat and combat support vehicle systems and equipment and serves as DoD's ground systems technology integration lead.

TARDEC manages the most diverse portfolio in the Army, from combat and tactical wheeled vehicles to boats, kitchens and laundry facilities. Two-thirds of our associates are dedicated to Army vehicle and variant ground systems R&D life-cycle programs. TARDEC, along with six sister organizations, operates under the operational control of the Army Materiel Command (AMC), whose mission is to provide America's warfighters with a decisive edge, and the Army Research, Development and Engineering Command (RDECOM), whose mission is to empower, unburden and protect the warfighter.

BUDGET

TARDEC's FY11 total budget was \$475.3 million.* Of this funding, \$210.3 million was for life cycle system support, which includes direct and reimbursable operations and maintenance, Army and Army Working Capital Funds that support demonstration and validation, and engineering and manufacturing development.

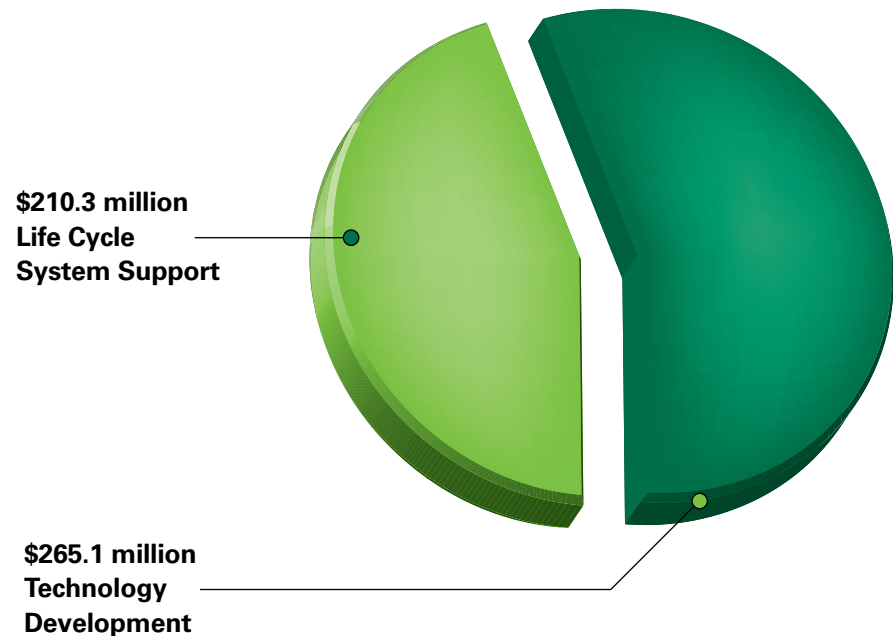
Additionally, \$265.1 million was allotted for technology development. This included \$79.7 million in R&D reimbursements, as well as a combined \$185.4 million for basic research, applied research, advanced technology development, integration and major systems development.

Basic research (6.1) efforts provide fundamental knowledge for the solution of identified military problems. Applied research (6.2) activity translates promising basic research into solutions for broadly defined military needs, short of major development projects, with a view to developing and evaluating technical feasibility.

Advanced technology development (6.3) includes all efforts that have moved into the development and integration of hardware and other technology products for field experiments and tests.

* Budget amounts are accurate as of Sept. 30, 2011.

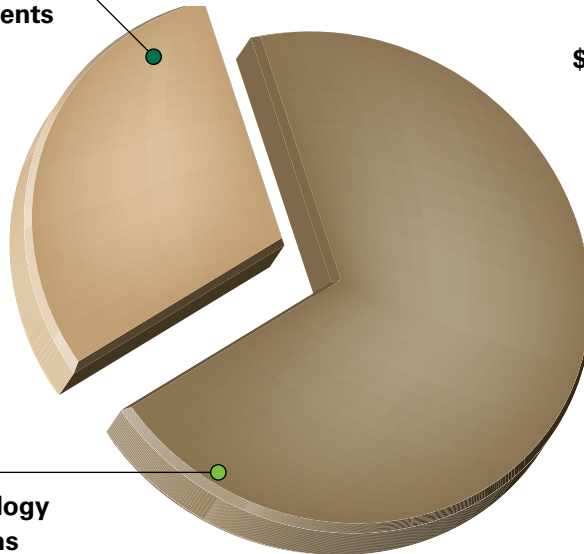
FY11 Budget



**Total Technology Development
(RDT&E 6.1-6.7 and Reimbursable)**

**\$79.7 million
R&D Reimbursements**

**\$185.4 million
Basic & Applied
Research and
Advanced Technology
and Major Systems
Development
(6.1-6.7)**

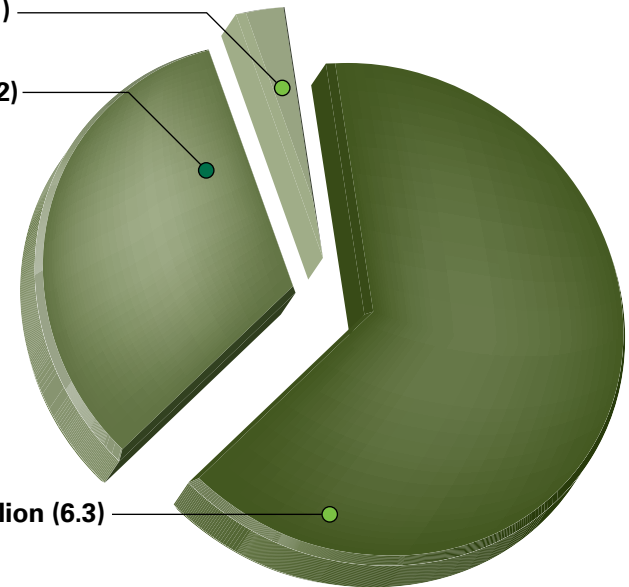


**Basic & Applied Research and Advanced
Technology Development (RDT&E 6.1-6.3)**

\$4.8 million (6.1)

\$55.6 million (6.2)

\$108.2 million (6.3)



PROVEN EXPERTISE



This organization has maintained a clear focus for more than 60 years — delivering superior technology to Soldiers — and an equally clear imperative to ensure we conduct our R&D mission with quality and consistency by hiring the best technical experts we can find.

TARDEC continues to refine its human capital strategy. We made several strategic personnel moves over the past year to continue placing the right people in the right positions, which will help us continue to enhance our ability to deliver the highest-quality military ground vehicle systems and rapidly respond to emerging warfighter needs.

Our associates bring advanced skills, experience and knowledge to their respective fields. We have Senior Technical Experts in each of our primary focus areas, and procured an energy specialist under the Intergovernmental Personnel Act this year.

Our key focus areas are:

- Ground Vehicle Power and Mobility (GVPM)
- Concepts, Analysis, Systems Simulation and Integration (CASSI)
- Ground Vehicle Robotics (GVR)
- Force Projection (FP)
- Vehicle Electronics and Architecture (VEA)
- Ground Systems Survivability (GSS)

Many of our engineers began their careers in the automotive industry, which strengthens our M&S expertise and provides us with greater insight into vehicle design technologies. Our collaborative approach helps us cultivate the best ideas and solutions to consistently provide engineering and technical support for the TACOM LCMC, PEOs, PMs and

RDECOM laboratories and engineering centers to enhance vehicle system capabilities for our Soldiers and Marines.

TARDEC associates bring multiple specialties to our mission. We have experts in disciplines including full-scale systems engineering and integration, hybrid-electric systems, diesel and internal-combustion engines, composite armor, lightweight materials, software interface design, M&S, robotics, alternative fuels, “green” technologies and water purification, just to name a few.

Our aptitude in design, analysis and integration allows us to holistically consider platforms from every angle and identify possible trade-offs against size, weight and power constraints. We have earned recognition for our innovative solutions, but more importantly, we are fueled by the knowledge that our work impacts the men and women who defend our Nation.

OUR ASSOCIATES

Our professional ability to provide the most advanced ground vehicle technology depends on the expertise of TARDEC researchers, engineers and other associates who closely collaborate with industry and academic partners to combine their skills and talent to support our Soldiers and Marines.

TARDEC leaders actively engage associates, instilling a common workforce vision that reflects our greater Army Values and our organizational values to lead, innovate, integrate and deliver outstanding vehicle systems to Soldiers and Marines. Our award-winning Human Capital Strategy guides our efforts to recruit, develop and retain the best associates, and to continue educating them so they remain competent, knowledgeable and equipped with the best possible attributes to perform the myriad tasks we challenge them with.

Our career and professional development programs are designed to attract and retain the top performers in their respective career fields. We actively develop our workforce's collective capabilities through continuing education, along with rotational and developmental assignments. Our recently implemented mentoring program builds



Metallurgist Midge Krueger studies test samples in TARDEC's Metallurgical and Failure Analysis Laboratory. Having a bench of recognized experts positions us to better understand all vehicular aspects prior to integration, providing accurate and excellent support to our partners. (U.S. Army TARDEC photo.)

a deeper technical bench to ensure workforce members are prepared to meet demands of key R&D positions and future leadership responsibilities.

To reinforce our position as a leading-edge science and technology (S&T) Center, we place a premium on higher learning and urge our associates to continue their education. A number of employees were actively pursuing graduate degrees in 2011 (see info box).

TARDEC UNIVERSITY

Every TARDEC associate is automatically enrolled in an institute of higher learning when they join our team. TARDEC University provides progressive, targeted education for TARDEC associates, who are required to develop their own long-term Individual Development Plans based on TARDEC's core technical fields, the required customer-based competencies and individual career goals. Our Career Development Team provides the structure and career advice needed for each employee to implement the optimal dynamic education, training and human capability plans for their individual career paths. TARDEC's professional development team acts in collaboration with the RDECOM Human Resources staff and the TACOM LCMC community.

In FY11, TARDEC increased training hours by 70 percent over FY08-10, and increased average training hours per associate by 58 percent, highlighting our workforce's commitment to increasing expertise in engineering, science, leadership and management training.

DEVELOPING OUR ASSOCIATES

At TARDEC, we don't simply hire promising associates — we want to build future leaders. In this complex business, we need to focus our professional development efforts on creating opportunities for people to develop the skills needed to advance their careers, continue their educations and excel as researchers, engineers and managers. We have several programs to inspire our associates, encourage innovation and prepare them for future leader roles.

INNOVATION FUNDS

We emphasize the importance of innovation among our R&D teams by providing the tools they need to flourish, and our Innovation Funds program supports this endeavor. This program encourages new ideas and breakthrough technologies to help the Army accelerate the pace of technology development and the integration of mature technology systems.

Five to 20 financial awards are presented annually. The funds can be used for up to one year to purchase in-house support, raw materials, equipment and limited contractor support. Additionally, award recipients can allocate the funds toward project time for team members in customer-funded organizations. At the project's conclusion, a board reviews the output for

patentability and business development potential. This program enables associates to translate novel ideas into new in-house capabilities, technologies and processes that, ultimately, benefit the warfighter.

ROTATIONAL PROGRAMS

TARDEC's rotational programs enable our researchers, scientists and engineers to work across various technical focus areas to gain experience in other disciplines. This allows us to enrich our associates' knowledge and develop a deeper bench of experts across a variety of technical areas. Associates build confidence in their abilities to apply a holistic approach to technical challenges and they're better prepared for leadership positions.

This rotational program has also extended beyond TARDEC to include industry partners like 3M, and government partners such as the Office of the Secretary of Defense. Rotational assignments better equip our managers to handle a diverse array of technical challenges and analyze problems from all angles so they can quickly create or confirm solutions that will improve safety and maintain Soldier effectiveness.

PURSUING HIGHER EDUCATION

As of October 1, 2011, TARDEC associates are actively pursuing:
39 doctoral degrees
573 master's degrees
684 bachelor's degrees

PATENTS

TARDEC leaders stress the importance of obtaining patents on the new technologies our researchers develop. In FY11, patents were awarded to TARDEC associates for:

Folding Protective Shields — Frank Petrosillo, Daniel Gennarelli, Louis Campanile and Chad Young.

Conformable Self-Healing Ballistic Armor — George A. Daniels, Paul A. Petrovich.

Multifunction Tool — Jeremy Senyk and Kenneth A. Greene.

Bidirectional Tilt Antenna Mount — John J. Schmitz.

FY 11 AWARDS

ARMY GREATEST INVENTIONS

Established by the Army Materiel Command (AMC) in 2003, the Army Greatest Inventions (AGI) award program recognizes new, innovative technological ideas and systems that improve readiness and positively impact warfighters. The Army's R&D community competes for the awards, which are selected by active-duty Soldiers who assess the nominees' importance and impact based on their field experiences. This year, TARDEC teams won three AGI Awards.

Robot Deployment System

TARDEC's Center for Ground Vehicle Development and Integration (CGVDI) earned an AGI for its part in developing the Robot Deployment System (RDS) for the RG-31 Route Clearance vehicle. The CGVDI worked with PM Assured Mobility Systems to close a capability gap that potentially endangered Soldiers. Initially, the vehicle carried a TALON robot onboard to help Soldiers inspect objects of interest or suspicious roadside debris. However, Soldiers needed to leave the vehicle to unload the robot, exposing them to enemy fire.

CGVDI engineers custom built the RDS hydraulic lift and storage system that

allows Soldiers to deploy and stow the robot from within the vehicle. The design consists of an adjustable aluminum storage box and steel frame that bolts onto the rear of the vehicle. There is also a control box inside the vehicle used to raise the RDS during transport or lower it when the robot is to be deployed.

CGVDI engineers developed an initial prototype within two months of receiving the request for assistance. They worked collaboratively with Letterkenney Army Depot to manufacture a total of 190 kits for fielding.

Overhead Wire Mitigation*

MRAP vehicles proved effective in keeping warfighters safe from threats in Iraq and Afghanistan, but their large size presented challenges as the vehicles traversed urban roadways and encountered low-hanging wires that posed potential electrical hazards to Soldiers and caused damage to the local infrastructure.

Developed by TARDEC's CGVDI, the Overhead Wire Mitigation (OWM) kit features a pair of rails made of nonconductive material that arc over both sides of the vehicle to direct the wires up and over the MRAP. Soldiers began installing kits onto vehicles in June 2009.

Landmine Blast Field Event Reconstruction Using Computational Modeling & Simulation*

Our Concepts, Analysis, Systems Simulation and Integration (CASSI) Analytics Group developed a method to reconstruct an underbody blast event using data gathered from theater. The Analytics Group employed a modeling technique that included all key blast elements — soil, charge, air, vehicle and occupants — and analyzed the phenomena of charge detonation, blast wave propagation through soil and air, vehicle structural response, crew injury and fatality risk probability.

Analysts use the M&S method to bridge the gap between controlled live-fire testing and actual field events for these complex blast events. The studies also allowed development teams to consider real-world scenarios that are difficult to simulate with other test and evaluation procedures. The findings have led to improvements in existing systems and enhanced warfighter survivability.

**Note: The OWM and Landmine Blast Event Reconstruction Using Computational M&S projects were awarded 2009 AGIs, which were presented in FY11 at the Army Science Conference.*

2010 ARMY RESEARCH AND DEVELOPMENT ACHIEVEMENT AWARDS

TARDEC engineers, along with our partners at the Army Research Laboratory (ARL), were recognized with a 2010 Army Research and Development Achievement (RDA) award for their work with *Advanced Passive Armor Technology for the Defeat of Multiple IEDs and Conventional Weapons*. The RDA was presented for collaborative research, development and engineering between ARL and TARDEC that led to a new advanced passive armor technology, which has been fielded on the MRAP MaxxPro Plus vehicle for user evaluation in theater.

The armor represents a substantial increase in capability against combinations of current threats such as rocket-propelled grenades, IEDs and small arms projectiles.

VALUE ENGINEERING AWARD

For the ninth consecutive year, the TACOM LCMC surpassed its fiscal year savings goal, amassing a record \$1.6 billion in savings and exceeding its savings goal by 884 percent through implementing value engineering (VE) proposals. In June 2011, DoD honored our Engineering Cost Reduction Team — which manages TACOM LCMC's VE Programs — and PM-Medium Tactical

Vehicle (PM-MTV) with VE awards for their achievements. As the Army continues to operate in tumultuous economic times and do more without more, these cost-saving programs are essential to keeping Soldiers effective and the Army strong.

2010 AMC SYSTEMS ANALYSIS AWARD: END-TO-END UNDERBODY BLAST

TARDEC also collected an AMC Systems Analysis Award for developing a unique end-to-end underbody blast simulation program with potentially life-saving results. This M&S capability recreates a virtual blast in a single computational run, allowing researchers to better understand the event and how materials such as soil and the charge interact with the vehicle, environment and occupants. Analysts can use the results to evaluate vehicle systems and improve the design to increase its survivability. This tool was previously recognized with 2009 AGI and Army-wide M&S awards. Members of teams that won the AMC Systems Analysis Award acknowledge that their greatest reward is knowing this capability provides Soldiers with vehicles that could save their lives in dangerous events.

OTHER FY11 AWARDS INCLUDE:

- Competitive Independent Laboratory In-house Research award — TARDEC Chief Scientist Dr. David Gorsich and TARDEC Senior Technical Expert (STE) for M&S, Dr. David Lamb.
- Engineering Society of Detroit Alpha® Award for Innovation — MRAP Egress Trainer Team.
- Women and Leadership in the Workplace Award — Sonya Zanardelli, Energy Storage Team.
- Army Suggestion Program — Kenneth Greene, for Redesign of Module Frame.
- 2010 Under Secretary Defense (Acquisition, Technology & Logistics) Workforce Development Award (Silver Award Winner) — Human Capital Strategy
- International Organization for Standardization 14001:2004 Environmental Management System Surveillance Audit

SUPPORTING DOE AND DEPARTMENT OF THE ARMY'S DRIVE TO INCREASE ENERGY SECURITY

Volatile fuel prices, environmental concerns and the ongoing risk to Soldiers in refueling convoys have made it undeniably clear: increased energy security must be a priority for our Nation and the military.

“Those countries that develop the most efficient technologies will have a world market. If we don’t get moving, we’ll be importing these new technologies rather than exporting them.”

—Dr. Steven Chu
U.S. Secretary of Energy

In July 2011, Department of Energy (DoE) and Department of the Army (DA) leaders entered into an Advanced Vehicle Power Technology Alliance (AVPTA). This partnership leverages the expertise of government, private industry and academia to explore solutions for decreasing petroleum dependence, increasing fuel efficiency and enhancing the Nation’s energy security infrastructure. The Alliance has been described as a “win-win-win” scenario that could yield benefits for the Nation, the automobile industry and, of course, Soldiers.

Senior leaders announced the AVPTA’s formation during a workshop in Detroit, MI, which culminated in the signing of a charter

by Secretary of Energy Dr. Steven Chu and Under Secretary of the Army Dr. Joseph Westphal. This government partnership will eliminate redundancies by leveraging each organization’s expertise, leading to greater fuel efficiency at a lower cost.

“Mobility is the core of our military capability. On the ground, in the air and at sea, you have to be able to move. That’s where our challenge is going to be going forward, because we will continue to be a military that has mobility at its heart.”

—Sharon E. Burke
*Assistant Secretary of Defense
for Operational Energy,
Plans and Programs*

Workshop participants from government, industry and academia discussed their vision for an energy independent future and identified potential areas of common interest where knowledge, resources and budgets could be leveraged, including:

- Advanced combustion engines and transmissions
- Lightweight structures and materials

- Energy recovery and thermal management
- Alternative fuels and lubricants
- Hybrid propulsion systems including batteries
- Analytical tools (M&S).

As lead integrator for the Army’s ground vehicle community and the DA’s AVPTA lead, TARDEC supports these goals and is committed to collaborating with its partners to pursue vital solutions. Our expertise in these areas allows us to bring our knowledge to the table and work with our partners to quickly and effectively bring technology to bear that will keep our warfighters mobile and safe, lower the Nation’s fossil fuel dependency and improve the Nation’s energy infrastructure.

DoE and DA have already identified several “quick win” areas where expertise can be leveraged, including:

- Utilizing automotive technology investments in lightweight vehicle structures.
- Improving platform efficiency by

recovering thermal energy from the engine exhaust for military and passenger/commercial vehicles.

- Developing an improved test method to determine the bulk modulus of liquid transportation fuels.
- Developing a battery design suite that encompasses models ranging from electrochemical and cell level all the way to pack and system level.

“Energy and power are a priority to the Army. They are force enablers.”

— Katherine Hammack
Assistant Secretary of the Army (Installations, Energy and Environment)

This Alliance provides a historic opportunity to collaborate with partners across government, industry and academia to develop new and groundbreaking technology. Collaboration set the tone for all we did this fiscal year and, as we move forward, our commitment to this important challenge will only increase as we pursue improvements that will benefit our Soldiers and the Nation.



Communications equipment and portable generators support a training exercise at Stoval Auxiliary Army Airfield, Marine Corps Air Station, Yuma, AZ. Our work with grid-managed generation will introduce significant power management efficiencies to forward operating bases, installations and units in the field. (U.S. Marine Corps photo by Cpl. Lindsay E. Beaulieu.)

As the DA's lead in the AVPTA, TARDEC introduced several energy-related projects that are working toward critical efficiency goals.

FUEL-EFFICIENT GROUND VEHICLE DEMONSTRATOR

When TARDEC associates displayed the Fuel Efficient ground vehicle Demonstrator (FED) Alpha at the Pentagon in July, a variety of interested observers from Soldiers to Generals to senior defense officials

gravitated toward the vehicle, which houses a collection of fuel-saving components and technology. Examples of efficient equipment and systems include: low-rolling-resistance tires, a super/turbocharged 4-cylinder diesel engine, high-efficiency 6-speed automatic transmission, lightweight materials and a force-feedback accelerator pedal that promotes economical driving.

TARDEC's FED program was conceived with the idea of demonstrating, using

a systems engineering approach, what fuel efficiency is achievable in hardware operating in a realistic military environment, and at what cost. TARDEC formed two teams comprised of the brightest and best from government and industry to create two state-of-the-art fuel efficient tactical vehicle demonstrators, with the only design constraints being the requirement to achieve maximum fuel efficiency without degrading performance requirements or capabilities. At the conclusion of this effort the two demonstrators will not only show what fuel efficiency is achievable, but also inform new and existing programs and provide decision makers with additional insight in achieving improved fuel economy.

The FED program highlights our commitment to collaboration. FED Alpha development required the close partnership of several industry partners, who supplied the tires, advanced powertrain, seats and restraints that helped this project achieve a projected 70-percent increase in fuel efficiency. We look forward to the insight we will gain when FED Bravo, which was designed with the assistance of industry partners and transportation design students from the College for Creative Studies in Detroit, MI, is unveiled in 2012.



In FY11, after FED Alpha's design and build were completed, the vehicle underwent shakedown testing at the Chelsea (MI) Proving Grounds. As the year ended, Alpha had begun testing at Aberdeen (MD) Proving Ground.

ADVANCED BATTERIES

Recently, TARDEC engineers started a High Mobility Multipurpose Wheeled Vehicle (HMMWV) with a 6T lithium-ion (Li-ion) battery — marking the first time an advanced battery has powered a military vehicle. They replaced two 6T lead-acid batteries with one Li-ion battery to perform the test, ensuring gains in space, weight and power density. The battery passed one of the most pivotal tests in the conversion to a more efficient next-generation energy source for all Army vehicles.

TARDEC's Energy Storage Team has been at the forefront of new battery technology and will continue to make major contributions in the development, testing and integration of Li-ion batteries as drop-in replacements for current ground vehicles and original equipment for new platforms, such as the Joint Light Tactical Vehicle (JLTV). Engineers will continue testing by starting vehicles in extreme temperature conditions and

monitoring batteries, providing power for Silent Watch. Our advanced battery team also plays a role in the national initiative to substantially increase domestic battery production in the United States.

MICROGRIDS PROVIDE POWER EXPORT AND EFFICIENCY

New developments in microgrid technology may provide solutions for powering installations, forward operating bases and ground vehicles. These grids turn fuel and energy inputs into a single, reliable, multifunctional output. This converted energy may enable forward-deployed units and operating bases to transfer energy efficiently to a universal power source for hospitals, mission control functions and communications equipment.

TARDEC was also instrumental in installing the Army's first smart-charging microgrid at Wheeler Army Airfield in Hawaii. Aloha Microgrid 1 consists of a 25 kW solar power array, 200 kilowatt-hours (kWh) of battery storage, four plug-in electric vehicles and two 150 kW generators. This system powers four electric vehicles and has the ability to provide instant backup power to support three buildings, including the garrison headquarters, for 72 hours.

Army Aloha Microgrid 2, a 460 kW microgrid is scheduled to become operational in early 2012, will have the capability to power a 500-Soldier forward operating base. The Army Aloha Microgrid 2 includes three tiers (250 kW stationary, 150 kW semi-mobile, and a 60 kW mobile), two electric vehicles and four charging stations, 50 kW solar carport, two generators and energy module storage.

LIGHTWEIGHT MATERIALS AND ADVANCED COMPOSITES

We've become adept at rapidly developing technologies that help Soldiers and Marines counter emerging threats and complete their missions. However, technology insertion can create subsequent challenges: How do we add capabilities to a vehicle platform without having a detrimental impact on its power, performance or protection? Add-on components can dramatically increase the vehicle's weight, affecting both performance and maneuverability. TARDEC associates are investigating ways to lighten a vehicle's load, including research into lightweight materials that can be used for armor and other structural elements. Aluminum, magnesium alloys and carbon-polymer composites are materials being considered for their lightweight, energy-absorbing qualities.

CORE COMPETENCIES



Each day, our associates commit themselves to providing Soldiers with the right tools and technology to safely complete their missions. To do this, we maintain expertise in eight core competencies:

- Ground Vehicle Power and Mobility
- Ground Vehicle Robotics
- Ground Systems Survivability
- Force Sustainment
- Vehicle Electronics and Architecture
- Ground Vehicle Design, Analysis and Integration
- Ground Vehicle Engineering Technology Support
- Industrial Base Engineering

This cross-functional RD&E approach helps us understand how these factors impact each other and determine what trade-offs need to be made before integrating new technologies onto existing platforms. This allows us to develop mission-enabling capabilities without sacrificing size, weight, power or cooling elements.

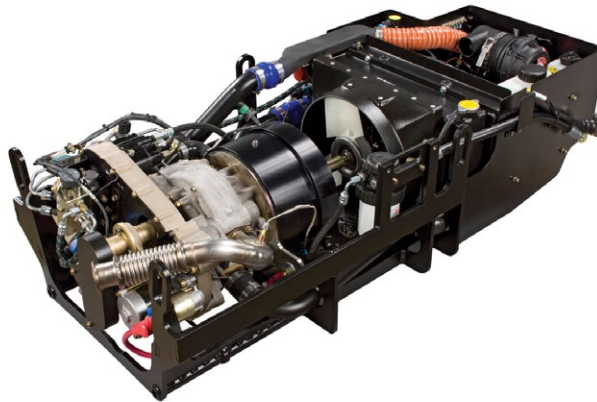
FY11 saw many new and exciting developments across these focuses that benefit Soldiers and the Nation. The following sections highlight work completed by our teams this past year.

GROUND VEHICLE POWER AND MOBILITY: KEEPING THE ARMY MOVING

For decades, Afghanistan has been viewed by armies as one of the most imposing environments on Earth because of its mountainous voids and unforgiving terrain. Operationally, that posed one of the greatest challenges for our Ground Vehicle Power and Mobility (GVPM) team.

GVPM has the daunting task of keeping the Army and Marine Corps on the move while providing the right solutions to sustain engines, suspensions, tracks and tires, dust and sand management, along with thermal management, while also providing the energy sources to keep an increasing amount of electronics and in-vehicle devices working during long missions. TARDEC engineers are meeting these challenges, allowing U.S. forces to overcome the obstacles presented by the harsh geography and travel safely to wherever their mission takes them. GVPM advancements provide lasting benefits, regardless of where the vehicles must operate. For example, engineers developed an auxiliary power unit (APU), currently being tested in the Abrams tank, to allow Soldiers to run electronic devices, such as a surveillance system or Global

Positioning System, with the main engine off. GVPM technicians tested components and developed improvements for cooling systems in the Stryker, Paladin fighting vehicle and M-ATV with the SPARK (mine clearance) attachment. They are also working with private industry to extend robot operating ranges by using propane fuel cell power. GVPM researchers also developed the tools and methodology to assess and decrease road damage caused by heavy military vehicles.



This power generation unit has a compact design to fit under the armor of an Abrams Main Battle Tank. The APU increases efficiency by supplying power to operate electronics inside the tank. GVPM ensures that the Army's ground vehicles can move to wherever they are sent. (Photo courtesy of Patrick Power Products.)

GVPM's focus is on currently fielded systems, but, increasingly, on conducting R&D for future systems, such as hybrid-electric propulsion motors, which are evaluated at our laboratories equipped with dynamometers to verify performance requirements. Power and mobility engineers also evaluate and qualify engines for alternative fuel use.

Soon, our engineers will have the capability to test ground vehicle systems in extreme heat and radiant sunlight, in fierce winds or in the grip of frigid cold. They will do it all without leaving the Detroit Arsenal. The all-new Ground Systems Power and Energy Laboratory (GSPEL) will contain multiple state-of-the-art laboratories, including the Power and Energy Vehicle Environmental Lab, which allows testing under a range of simulated weather and environmental conditions. The GSPEL will provide unprecedented vehicle testing capabilities when it opens in 2012.



An MRAP is tested in TARDEC's full-load environmental testing chamber, which simulates extreme heat and wind conditions. As vehicles are tested in diverse climates, understanding how they react to heat, cold, wind and other conditions can help us keep them operating wherever Soldiers are needed. (U.S. Army TARDEC photo.)

ADVANCED BATTERIES

TARDEC continues testing and evaluating Li-ion batteries to replace the lead-acid batteries powering today's ground vehicles, and supply auxiliary power for future tactical and combat vehicle operations.

The advantages of Li-ion batteries include superior energy density at a lower size and weight than current lead-acid batteries. Also, Li-ion batteries are expected to last at least 10 years longer than the lead-acid batteries currently in operation.

Earlier this year, TARDEC's Energy Storage Team started a Golden HMMWV with a prototype Li-ion battery — the first time a military vehicle has carried this new technology. The team removed two 88-pound lead-acid batteries from under the seats and replaced them with one 49-pound, 28V Li-ion battery. Operational reliability testing will continue with the Li-ion batteries to ensure they will operate reliably at extreme hot and cold temperatures.

TARDEC is also involved with the effort to increase manufacturing capacity in the United States to ensure a reliable, cost-effective supply of Li-ion batteries for both military and commercial use. TARDEC researchers are collaborating with industry and other government agencies to develop the technologies that will lead to substantial domestic production increases.

GROUND VEHICLE ROBOTICS: KEEPING OUR SOLDIERS OUT OF HARM'S WAY

Over the past decade, warfighters in Afghanistan and Iraq have used thousands of robots for reconnaissance, route clearance and threat defeat. Demand in the field is increasing as Soldiers and Marines become more skilled in operating their robots and recognize their life-saving benefits.

Unmanned ground vehicles (UGVs) are proving they are an essential and effective tool for route and building clearance operations. They can positively identify enemy combatants and improvised explosive devices, decreasing warfighters' exposure to potentially dangerous areas or situations. When a blast destroys a UGV in the field, there is collective relief because it usually means that a Soldier's or Marine's life has been spared.

That explains why TARDEC's Ground Vehicle Robotics (GVR) team continues to work with passion and commitment as it joins partners at Robotic Systems Joint Project Office (RS JPO) to meet urgent needs and take robotics technology deployment to the next level. Escalating robotic use in the field will likely involve Long Distance Tele-Operation that keeps human controllers at an even greater stand-off distance from potential threats (see sidebar). The RS JPO/GVR team is establishing common standards for more interoperability and acquisition value.



A TALON robot demonstrates its ability to destroy improvised explosive device firing units without subjecting Soldiers to danger. Unmanned ground vehicles have been critical in keeping our Soldiers out of harm's way and putting distance between them and threats. (U.S. Army photo.)

The GVR team is a leader in the efficient development, acquisition and integration of robotic capabilities. Our experts leverage the best available technology from industry, academia and government to build and sustain robust robotic capabilities. Through autonomous perception and navigation, intelligent tactical behavior, and command and control, GVR further develops the Army's ability to foresee, diagnose and avoid possible battlefield threats.

Robots sift through debris piles and examine suspicious packages. They go into empty buildings to ensure locations are secure before Soldiers enter. They conduct dull, dirty and dangerous tasks, while allowing Soldiers and Marines to remain at safe stand-off distances and focus on the mission.

Our team has been heavily involved in developing the technologies to identify and neutralize possible threats. UGV-mounted chemical detection systems allow Soldiers to monitor vehicles and buildings and determine whether they may be exposed to hazardous materials. The Tanglefoot payload — a wire rake dragged behind a small UGV platform — provides a low-cost solution to detect IEDs.

Improved vehicle autonomy systems are a growing need, and we are focused on further increasing the stand-off distance between Soldiers and potential threats. We collaborated closely with RS JPO, the Joint IED Defeat Organization (JIEDDO) and U.S. Army Special Operations Command on the Supervised Autonomy to Neutralize and Defeat Improvised Explosive Devices (SANDI), which can lead a convoy of mobile troops and keep Soldiers farther away from potential danger using tele-operated controls. We envision a future where vehicles operate autonomously, individually or in convoys, allowing safer supply transport as Soldiers focus on their respective missions.

Early in FY11, we conducted the second Robotics Rodeo at Fort Benning, GA, which allowed us to view the latest robotics technology and receive user feedback during a series of platform demonstrations. The event provided an

opportunity for our engineers and industry partners to communicate face-to-face with the men and women who use these systems, and receive feedback about which capabilities work and which ones need improvement. For more information about the Robotics Rodeo, see page 43.

In an unprecedented collaborative project, we partnered with Australia's Defence Science and Technology Organisation on the Multi Autonomous Ground-robotic International Challenge (MAGIC 2010), which brought five collegiate teams from around the world to Australia to compete. This jointly planned initiative provided an extraordinary opportunity to work with students and faculty to talk about military robotic needs. For more information on MAGIC, see page 46.

LONG DISTANCE TELE-OPERATION

To avoid deadly encounters in the field, Soldiers can dispatch UGVs to inspect and defeat threats from the safety of an armored vehicle. But what if these systems could be operated far from the battlefield, possibly at bases in Europe or the United States?

TARDEC's Long Distance Tele-Operation system allows the UGV controller to access a secure web portal and log into the system. Miles away, the UGVs have already been dialed in. Once connected, the operator selects a platform from a drop-down menu and is directed to a user interface screen that includes a variety of commands and a video link with the platform. The robot is operated through the Internet using a cellular data signal.

During system testing, operators successfully controlled UGVs at the Detroit Arsenal from Selfridge Air National Guard Base, MI, and Fort Benning, GA — 860 miles away. Our researchers continue to address latency issues and other challenges that will allow UGVs to safely navigate obstacles across the globe, but the first steps have been taken in developing technology that may improve Soldier situational awareness and keep them far from immediate danger.



An MRAP crosses a dangerous bridge that is known for bomb detonation just outside of a village in Afghanistan. The MRAP is equipped with the SPARK mine roller and the Thrown Object Protection System, both designed by TARDEC engineers to protect Soldiers from threats in the field. (Photo by SPC Theodore Schmidt)

GROUND SYSTEMS SURVIVABILITY: SAVING SOLDIERS' LIVES

When men and women volunteer to serve in the military, they understand the risks. Our Ground Systems Survivability (GSS) team applies innovative solutions to minimize those risks and protect our men and women while they serve, focusing on the Soldier first and designing protective layers around them. GSS team R&D is driven by our motivation to return our service men and women safely to their duty stations and families. Survivability measures keep units fully staffed and mission-ready in the field, which helps our forces accomplish their objectives faster.

TARDEC's Survivability team has adopted an occupant-centric approach that starts inside the vehicle with Soldiers — our most valuable asset — and designs systems that help them survive a variety of attacks, including gunfire, rocket propelled grenades, mines and IEDs. The following examples illustrate this approach.

Sensor-enhanced armor protects Soldiers from incoming rounds and provides real-time feedback on the armor's condition after it's been hit. This year, we continued our pioneering work in this study, which allows us to better understand how materials react without destructive testing.

Embedded, tiny piezoelectric transducers in armor plates provide a measurement of pressure or force on the material, which allows Soldiers to monitor armor health from inside their vehicles in real time.

We also engage non-traditional partners to better understand vehicle protection. For instance, our engineers have opened a dialogue with NASCAR safety engineers to begin studying their progress in protecting racecar drivers from the dramatic crashes we see in news media. These crashes usually end with the driver walking away from a heavily damaged vehicle. Connections like this give us greater insight into proven techniques that could keep our Soldiers safe in a rollover or blast event.

In our Survivability laboratories, we research the latest in life-saving materials and technologies. Our Laser Laboratory studies how to protect Soldiers from threats to their situational awareness. Our Survivability and Ballistics Laboratory is committed to improving transparent armor and protecting Soldiers from ambushes.

Continued work with the Tactical Wheeled Vehicle Survivability (TWVS) program allowed us to develop protection systems that will help vehicles and convoys stay mobile. This year, we worked closely with

Soldiers in TWVS testing, collecting their feedback on possible solutions and asking what additional refinements they could use.

GSS also continues to work on solutions to help Soldiers avoid being detected while preparing for operations, and hit and kill avoidance to keep Soldiers and Marines safer from threats when engaged in a fight. From improved armor systems to more secure occupant restraints, we address all levels of protection and work with our partners to ensure system integration that increases occupant safety without sacrificing vehicle size, weight and performance. The GSS mission is to deliver solutions that give Soldiers and Marines a distinct advantage on the modern battlefield.

UNDERBODY BLAST MODELING

A blast event occurs in the blink of an eye. In that moment, a series of complex phenomena occur involving the weapon, vehicle, occupants, dislodged soil and air. Understanding what takes place in that brief window is crucial to designing systems that will keep Soldiers safe when they encounter a mine or IED.

Our underbody blast simulation studies — an unprecedented end-to-end examination of bombing events and countermeasures — use advanced computational models, real battlefield data and lab demonstrations to lend insight into how to improve survivability in vehicles. Computer simulations isolate the milliseconds of the event, capturing the interaction of air, soil and debris and allowing science to do what science does best — objectively dissect the chaotic effects and intelligently determine how to mitigate them. Physical simulations allow us to better gauge Soldiers' responses to the physical phenomena they may encounter in those intense situations.

These developments have been invaluable in designing ground vehicles that are more survivable and provide life-saving benefits to Soldiers patrolling in combat zones. This indispensable work continues, and our simulations have become part of Soldier training to prepare them for the potential dangers inherent in war zones.

FORCE SUSTAINMENT: MEETING VITAL NEEDS

Our Force Projection Technology (FPT) team's responsibilities are as clear as the water they purify for Soldiers, span wider than the bridges they build and are as fundamental as the fuels and lubricants they supply to the field for ground vehicles and equipment.

FPT engineers focus on sustaining troop basic needs, regardless of deployed location, to complete their missions. The expertise they provide includes:

- FPT is the DoD executive agent for ground fuels and lubricants. Our technologists research, develop and provide engineering support

for ground fuels and lubricants, synthetics, petroleum storage, and distribution and analysis equipment.

- FPT is the DoD lead for water supply and wastewater treatment. Our engineers are experts in water treatment, storage, quality analysis and handling equipment.
- FPT engineers help develop and support military bridging and materiel handling equipment.
- FPT supports combat engineering equipment, mechanical countermine and counter-IED equipment.
- FPT introduces and fields new fuel and lubricant technologies, while ensuring products meet performance standards and environmental requirements.

FPT engineers fielded several requests for bridging projects in FY11.

- The Bridging Team partnered with CGVDI to develop the Army's Line of Communication Bridge (LOCB). PEO Combat Support and Combat Service Support (PEO CS&CSS) approved PM Bridging funding for TARDEC to design and develop a 50-meter dry-gap LOCB



An associate checks levels at TARDEC's Fresh Water Treatment Test Facility at Selfridge Air National Guard Base, which has the capability to operate small- to full-sized water treatment systems and components. Treatment facility researchers develop the equipment and capabilities to provide deployed Soldiers with clean water solutions, regardless of where their missions take them. (U.S. Army TARDEC photo.)

system that includes pier sets, ramps, walkways and ground bearings.

- The Bridge Testing Lab at Selfridge Air National Guard Base received software and hardware upgrades designed to, among other things, predict and analyze bridge component performance.
- Combat Engineering (CE) Team members investigated methodologies to improve combat engineer fleet energy efficiency. Working with TACOM PM CE/Materials Handling Equipment (MHE) and the Navy, TARDEC assessed backhoe loader and hydraulic excavator duty cycles, and will demonstrate an advanced hydraulic control system in early FY12.
- TARDEC associates proposed an in-house effort to design and fabricate initial Versatile Tank and Pump Unit prototypes. Designing the replacement system in-house gives the Army more control over cost, performance and schedule.
- TARDEC developed, tested and procured the Iron Scrape 2.0 as a rapid response to an RDECOM request for technology to counter a growing command wire IED threat.
- Our CE Team processed Urgent Material Release on Water Well Drilling Rigs. These systems were immediately deployed to Afghanistan and Africa to support ongoing contingency operations and humanitarian missions.
- Tests with our Single Common Powertrain Lubricant Program have led to a candidate product that can achieve a 2-percent fuel economy improvement while maintaining performance for transmissions, engines and hydraulic fluids. Logistics will be simplified, too, because only one product will be needed to support equipment worldwide under all weather conditions.
- The Army Petroleum Laboratory tested more than 1,000 bulk fuel samples, tank samples, delivery samples and samples from aviation crashes to determine if deployed fuel is meeting performance specifications.

WATER PURIFICATION

This year, TARDEC's Water Treatment and Handling Equipment Team joined forces with PEO CS&CSS's PM Petroleum and Water Systems to field the Expeditionary Water Packaging System (EWPS) in Iraq and Afghanistan.

The EWPS is a mobile unit used to manufacture, fill and cap bottles from any approved, pure water source. In this case, reverse osmosis water purification unit-treated well water is pumped/delivered into a 2,000-gallon HIPPO water holding tank. From there, it goes into the EWPS where it is bottled and capped.

This year alone, the EWPSs that have deployed to Afghanistan produced more than 5 million 1-liter bottles of purified drinking water. New technology tested in 2011 is expected to double that capacity in the near future.

The EWPS supports the Army's mission to provide life and mission water sustainment to Soldiers and remote units in tactical environments. This capability reduces or eliminates the re-supply of bottled water to remote forward operating bases that normally have to rely on premium delivery by air or potentially dangerous ground convoys. Truck resources can then be used to move other needed items into theater, as a result, putting fewer Soldiers into harm's way, and significantly reducing logistics resupply requirements.



VEHICLE ELECTRONICS AND ARCHITECTURE: KEEPING THE ARMY CONNECTED

In an era of persistent conflict, maintaining a technological edge means supplying the tools Soldiers and Marines need to communicate with each other, conduct surveillance and defeat emerging threats through electronic means. The Army and Marine Corps are aggressively developing versatile architectures for a growing bank of electronic devices.

Our Vehicle Electronics and Architecture (VEA) team creates technical solutions to address the challenges of integrating vehicle architecture and electrical power systems. VEA also builds expertise through its various systems integration laboratories (SILs), which support modernization efforts, technology demonstrations, simulation and evaluation, and systems integration. VEA's subject-matter experts (SMEs) have organized into three main teams — Electrical Power, Vehicle Architectures, and SILs and Customer Support.

VEA's successes include designing and integrating the Vehicular Integration for Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance/Electronic Warfare (C4ISR/EW) Interoperability (VICTORY) system. VICTORY reduces size, weight

and power issues by embedding electronic systems directly into vehicle platforms using a framework architecture, standard specifications and design guideline input.

The Electrical Power group SMEs provide power architecture and management, electrical power components R&D and auxiliary systems.

The Vehicle Architectures group SMEs manage electromagnetic environmental effects, intra-vehicle data networks, computers and component thermal, and comprise the VICTORY architecture team (see sidebar).

The SILs and Customer Support group provide expertise to the program management offices and engineering support to the PM-Heavy Brigade Combat Team, PM -Stryker Brigade Combat Team, JPO -MRAP, PEO CS&CSS and the Integrated Logistics Support Center.

Opposite page: SGT Shawn Osborne troubleshoots the wiring in the door of an armored vehicle in Iraq. Internal vehicle electronics and systems architectures are primary focus areas for TARDEC's VEA experts. (U.S. Army photo by SFC John Laughter.)



VICTORY: DEVELOPING MODERN, MODULAR ARCHITECTURE

Vehicle interiors have limited space for communications, computers, targeting, situational awareness aids, armor, remote weapons systems and other devices. Each system demands more space, weight and power and may require redundant elements, such as multiple displays — leaving less room for crew or mission-essential equipment. Through an Army-wide program, DoD is creating a standardized vehicle architecture to promote system interoperability and eliminate “bolt-on” hardware, giving Soldiers ample room to operate their vehicles.

VICTORY is a system-of-systems engineering initiative that provides standards and guidelines to make vehicle systems and mission equipment follow a baseline architecture that adheres to standards, such as data formats, protocols and open network-based frameworks. VICTORY 1.0 specifications were released in July 2011. The specifications remain a living document, which will be updated as new capabilities and requirements evolve.

GROUND VEHICLE DESIGN, ANALYSIS AND INTEGRATION:

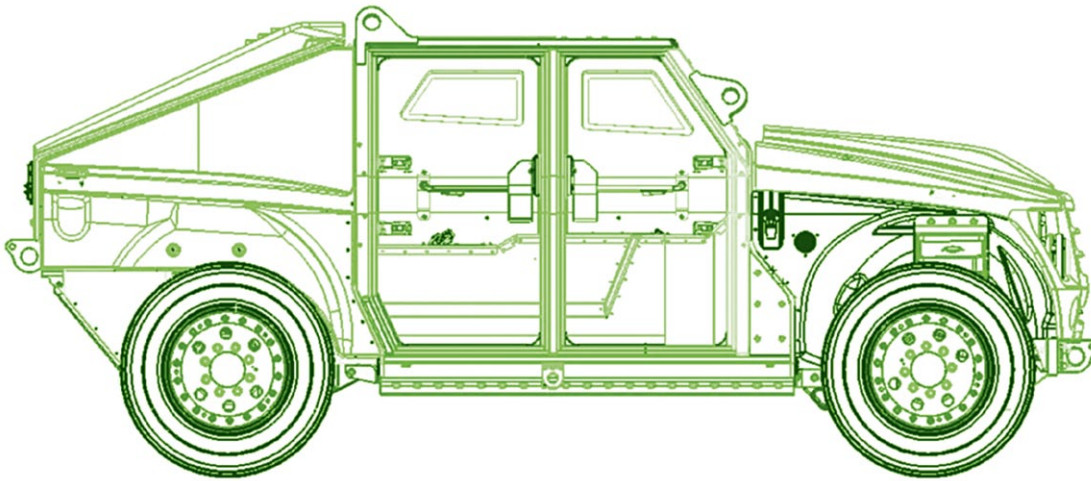
The Army subjects its vehicles to punishing duty cycles, duress and hazards during their life cycles. Ground vehicles must be able to endure artillery fire, bomb blasts, harsh road conditions, extreme temperatures and rugged terrain. TARDEC engineers dedicate themselves to making each vehicle capable of withstanding those types of conditions and fulfilling its most important purposes: protecting our Soldiers and Marines while keeping them highly mobile.

Our SMEs apply years of engineering and integration expertise to ensure that every technology meets the Army's stringent standards. We use a system-of-systems approach to determine how new technology will be integrated, and the impact that insertion will have on the rest of the vehicle. This results in a detailed, methodical process allowing for successful integration that will not disrupt the vehicle's vital functions or negatively impact performance.

Our CASSI M&S work complements CGVDI's efforts. Leveraging the data

gathered through CASSI and working closely with the PEOs and PMs to meet their requirements, CGVDI regularly develops innovative solutions to address the unexpected challenges our Soldiers and Marines encounter.

When services such as CASSI and CGVDI can be combined to resolve a challenge, TARDEC becomes a one-stop shop for all our partners' design, analysis and integration needs. We're able to offer a large array of services at a significant cost savings to the Army and Marine Corps. Most importantly, we're able to perform these duties rapidly, efficiently, economically and to standard so that the technology is integrated and delivered to those who need it that much faster.





The JRaDS 40-ton variant recovers an MRAP vehicle in theater. The trailer can be used to recover overturned or damaged vehicles, avoiding costly equipment loss and allowing Soldiers to get back on the road quicker. (U.S. Army photo.)

JOINT RECOVERY AND DISTRIBUTION SYSTEMS

The Joint Recovery and Distribution Systems (JRaDS) family of trailers is a perfect example of how unconventional thinking and collaboration brought about a new capability, making a significant impact in the field.

With little commonality among Army trailer variants, it was difficult finding the right trailer to complete a targeted task or meet specific mission needs. TARDEC, along with the U.S. Army Transportation Command and the U.S. Army Combined Arms Support Command, developed JRaDS to meet as many needs as possible including transport, freight-loading and vehicle recovery.

There are two specific types of JRaDS trailers and a Tactical Intermodal Logistics Trailer being deployed for recovery operations. The first is a 40-ton, 58-foot-long trailer designed for vehicle extraction. The second trailer is capable of recovering a variety of vehicle systems and aircraft on a wider trailer bed. The capabilities of the JRaDS trailers could completely change the way goods are distributed in theater by shortening delivery times and transporting items directly to where they need to go without having to rely on MHE availability upon destination arrival.

GROUND VEHICLE ENGINEERING SUPPORT: DESIGNING QUALITY AND DURABILITY

Just as our ground vehicles use navigation systems to stay on course, our innovation and engineering efforts would lose direction without an effective systems engineering and integration process. Systems engineering drives TARDEC's success in delivering quality systems that can be managed through a long life cycle. Engineering support is a TARDEC core competency we have adopted to guide processes that help us manage our overall portfolio of programs and steer development as we deliver products and capabilities to Soldiers and Marines.

With a validated stage-gating process to establish consistent paths for technology design and implementation, TARDEC maintains a structured engineering and development approach to guide projects from concept to sustainment to disposal.

Applying systems engineering methods and principles ensures that TARDEC technology has been thoroughly tested and analyzed, and will work efficiently and reliably once it is integrated on or in a vehicle system. Systems engineering ensures joint requirements

are traceable, and are a core function of every program we implement.

“We may be working on the next generation of batteries, the next generation of engines, the next suspension or the next material for armor. As we develop these innovations, it’s important for us to have fundamental systems engineering principles so that we can set the right targets for delivery and integration of the technology.”

— Dr. Grace M. Bochenek
TARDEC Director

During the design process TARDEC associates employ systems analysis and evaluate trade studies to determine the optimal technical approach. Good decision-making upfront, with common applications in mind, leads to solutions that could positively impact all Army and Marine Corps ground vehicles. Successful integration solutions introduce capabilities to an entire family of vehicles, rather than narrowing down the task to a specific function on a specific vehicle.

Adapted to meet TARDEC's R&D needs, our process is called TARDEC Gated Evaluation Track — TARGET.

This process helps us accelerate new technology development that helps our troops accomplish their missions. This five-phase, five-gated, system reduces timelines, manages risk, standardizes program management techniques, moves the right technology forward, leverages systems engineering best practices and embeds enabling tools that help engineers stay focused through the entire development process.

Each stage gate prompts decision makers to collect data, analyze it and then choose the most beneficial action:

- Gate 1 — define goals and conduct needs analysis.
- Gate 2 — validate customer requirements, prepare technology readiness assessment, identify potential partners and determine success criteria.
- Gate 3 — design and development, with initial demonstrations.
- Gate 4 — validation, with robustness and reliability demonstrations, deployment and integration plan.
- Gate 5 — technology transition and deployment.



Our joint partners can tap into our well of knowledge to strengthen their programs and increase their chances of long-term success when they come to TARDEC for their systems engineering needs. The following Engineering Support tools have led to best results:

- The Dynamic Object Oriented Requirement System helps track a program's requirements.
- Risk Recon assists in identifying and mitigating potential risks.
- Testing and evaluation procedures expose any concerns before a system is fielded.
- Configuration management creates a baseline, leading to sound decision-making based on current and accurate data.

WELDING: HOLDING IT TOGETHER

Even as new processes and capabilities develop, welding remains a reliable and cost effective part of vehicle design, fabrication and production. Comprised of welding engineers, material experts and a seasoned Certified Welding Inspector, TARDEC's welding team brings years of welding knowledge to the workforce and plays a vital role in ensuring that government and industry partners adhere to proper welding processes, codes and standards so that precision welds perform, even in extreme conditions.

To create more consistency when it comes to welding armor materials, the team is developing an armor ground combat vehicle welding code to replace outdated code specifications. Our welding engineers are committed to providing current information through a series of training classes on welding inspection fundamentals. Associates also travel to theater to address needs as they arise and help remedy vehicle cracks and structural breaks. The addition of a trained metallurgist also enhances knowledge as the team helps partners write welding codes and specifications for new materials or contracts.

We are proud to provide this level of expertise, ensuring that all Army ground vehicle welds meet the same high standards and conform to code specifications.

INDUSTRIAL BASE ENGINEERING: KEEPING LEGACY VEHICLES MOVING

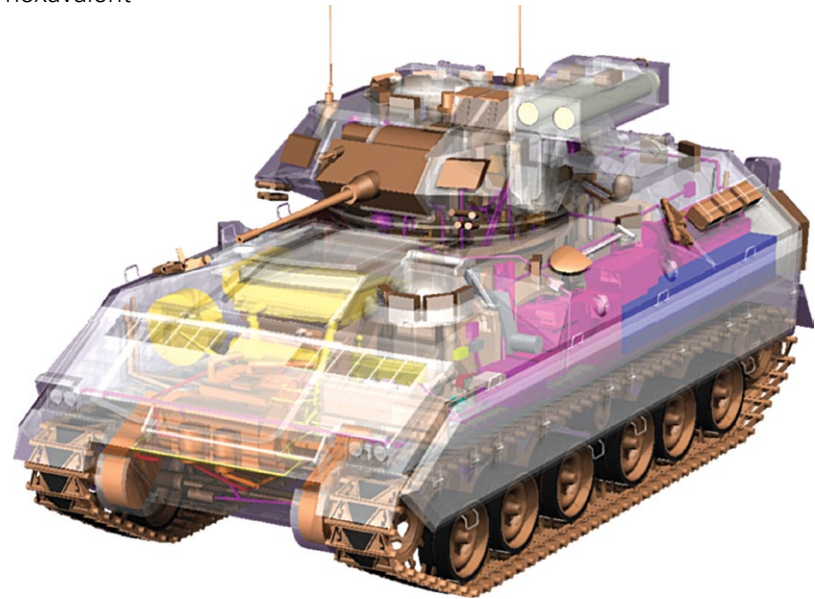
Army ground vehicles have long life spans, which results in a wide-ranging need for replacement parts. TARDEC's Industrial Base Engineering Team (IBET) ensures that those parts will be manufactured and available for deployment when Soldiers need them.

IBET supports the TACOM LCMC industrial base mission with equipment, processes and industrial engineering support to monitor, investigate, resolve and document these types of challenges. The IBET provides support to the TACOM LCMC Industrial Base Integration Team, Advanced Manufacturing Technology group, Depot Liaison Rotation program and other TACOM LCMC-wide programs and organizations that manage this enterprise. Our IBET keeps the LCMC aware of issues that may arise within the industrial base, such as potential replacement parts shortages, and works to ensure platform information remains up to date in databases built for this activity.

Our industrial base mission also includes value engineering initiatives, sustainment engineering support, and integrated collaboration and analysis processes. We are currently engaged in a Common Automotive/TACOM LCMC Industrial

Base Sector Study, which helps focus the supply strategy. Our efforts have also included environmental projects, such as replacements for cadmium/hexavalent chromium parts (high purity aluminum) in support of depot initiatives to reduce exposure to potentially hazardous chemicals. Cadmium had been used frequently in the past for corrosion protection, but it has possible environmental hazards.

A recent initiative, the Sustainment Engineering Risk Assessment, gathers data to identify trends that may indicate risks to platform sustainment. These assessments, along with other industrial base analyses, provide our partners with information that allows them to make informed, fact-based decisions about how to provide the supplies to keep vehicles healthy and reliable.



This CAD drawing of a Bradley shows a variety of internal systems' connections. TARDEC'S IBET work includes providing engineering and sustainment support to ground vehicle platforms, such as the Bradley. (U.S. Army image.)



Anniston Army Depot provides new Assault Breacher Vehicles for the U.S. Marine Corps. TARDEC's liaison exchange program has included Anniston Army Depot and increased communication and enabled support between the organizations. (U.S. Army photo.)

DIMINISHING MANUFACTURING SOURCES AND MATERIAL SHORTAGES (DMSMS) PROGRAM

When an agency manages more than 3,000 ground systems, many of them will begin to show signs of age. Legacy materials, parts and manufacturing sources can become harder to find as systems reach the end of their planned life cycles. To meet this need, TARDEC partnered with the TACOM LCMC and its regional partners with Automation Alley to set up the congressionally funded DMSMS program.

The DMSMS program serves as a single point of access and communication with the Nation's commercial industrial base to keep track of industry health and capabilities. This program provides TARDEC with industry and government partners to find emergency replacement parts and software to keep ground vehicles operating as intended.

The partnership identifies current suppliers who can meet their goals, but also makes an effort to engage companies that have the capacity to perform the work but have not historically done business with the government.

RAPID WARFIGHTER SUPPORT



It would be impossible to estimate the number of lives saved and life-altering injuries prevented by the urgent and determined work of our rapid response engineering teams. While we have no method of collecting such data, we know without question that the work performed by CGVDI and the Quick Reaction Cell (QRC) has led to breakthrough technologies that position Soldiers and Marines as highly survivable, extremely lethal and increasingly more sustainable.

CENTER FOR GROUND VEHICLE DESIGN AND INTEGRATION

When requests come in from the battlefield they are typically urgent in nature and require creative solutions in the quickest turnaround time possible. TARDEC's CGVDI specializes in exactly that type of project and is the first point of contact when PEOs and PMs need assistance. CGVDI works closely with them and the QRC to address Soldier and Marine high-priority requirements.

The CGVDI is a hub of ingenuity where the most effective and innovative solutions are often the simplest, using materials intended for other purposes in unique ways. Our experts work diligently to develop the best defense against any threat or resolution to any challenge. The award-winning technologies created in the CGVDI save the lives of Soldiers and Marines each and every day.

CGVDI teams played a significant role in developing the Robot Deployment System (RDS) for RG-31 MRAP vehicles. The RDS has been named one of 10 Army Greatest Inventions Award winners for 2010. RDS allows Soldiers to transport, deploy and operate road clearance robots safely, inside their vehicles, rather than having to leave the vehicle and expose themselves to enemy fire. Soldiers can deploy a TALON robot using an attached elevator with a ramp to inspect areas where IEDs may be hidden while they remain safely inside their vehicle.

CAIMAN EFP ADDS PROTECTION

When our adversaries in Iraq began targeting the MRAP Caiman Plus variant with EFPs, Joint Project Office MRAP made an urgent request for help. At TARDEC, the CGVDI began to design and fabricate a prototype solution to defeat this potentially deadly threat.

What they developed — turning an armor panel horizontal to protect the doors without limiting ingress or egress from the vehicle — was an uncomplicated yet effective solution that made an immediate impact for U.S. forces in the line of fire. The CGVDI worked closely with TACOM LCMC depots to produce the kits and ship them to Iraq for mounting on the vehicles. Knowing kits were needed quickly, our engineers worked around the clock, through a power outage, a summer heat wave and on the Fourth of July holiday to ensure they met the delivery date. Due to their dedication, the first kits were fielded just three months after the initial request for assistance arrived.

CGVDI produced the first 100 kits last summer while two Army depots ramped up their production capacity. The EFP protection kit offers another example of a swift, effective response to reduce an immediate threat to Soldiers and Marines.

QUICK REACTION CELL

The QRC receives requests directly from Soldiers in the field. Each call for assistance requires new technology, expert knowledge, competence and, most importantly, speed. The QRC has built an enviable record of delivering these imperatives rapidly to eliminate recurring threats in the field and potentially save lives. The QRC evaluates requirements and coordinates resources to provide solutions that offer the best possible battlefield protection in the quickest amount of time, usually within six months or sooner.

In FY11, the QRC completed 142 Requests for Information (RFI) and seven RFI projects. Solutions for many of these RFIs were completed within 30 days. The QRC also worked with:

- TARDEC Mine Countermine Team, PM Assured Mobility Systems and PM Rapid Equipping Force to deliver 42 Husky Iron Scrape 2.0 systems to Afghanistan to allow route clearance patrols better IED detection and neutralization.
- PM Sets, Kits, Outfits and Tools to deliver 70-plus MRAP Work Platforms that will make MRAP fleet maintenance/service easier and safer.
- TARDEC Survivability Office, CGVDI, PM Heavy Tactical Vehicles, RDECOM Field Assistance in Science and Technology Center and RDECOM to build a Heavy Equipment Transport Automatic Fire Extinguisher System prototype. This will be tested at the U.S. Army Test and Evaluation Command.

MRAP BLADE

The MRAP Blade is a plow-like grading tool that attaches to the exterior of the MRAP and safely fills holes left from exploded roadside bombs. Prior to its fielding, Soldiers were exposed to small arms fire when they left the vehicle to manually fill holes. The Army fielded a material solution in less than 90 days from the time the QRC received the RFI. Three weeks of that was shipping time. All feedback was positive, and the units that used MRAP Blades for the Operational Assessment had no complaints.



COLLABORATION AND RAPID RESPONSE BUILD BRIDGES

Our warfighters' ability to stay mobile and respond to threats in any environment is both a trademark and a key battlefield advantage. This year, our engineering associates were put to the test when they received an urgent request to help Soldiers and Marines maintain mobility: build a bridge over Afghanistan's Helmand River in three months to beat the rainy season before the water surged and made the river uncrossable.

Marines operating in Afghanistan's Helmand Province anticipated the region's rainy season. Historically, the 715-mile long Helmand River would triple in width and increase in intensity, making it impossible to drive or raft vehicles across without endangering warfighter lives. Working with the U.S. Navy 3rd Naval Construction

Regiment to determine gap width, water speed and depth, the Afghan-based team decided the best solution was to anchor an improved ribbon bridge (IRB) using overhead cable systems (OCS). The complication? The legacy equipment available in theater was rusted, ill-maintained or otherwise unavailable.

In less than two months, TARDEC Bridge Team engineers, working with the TACOM LCMC's New Equipment Training team and other government and industry partners, located the necessary equipment and shipped it to theater. The joint team also collaborated closely with the Army Engineering Research and Development Center to understand the river embankment's soil characteristics to best secure the cables and anchor system which would be crucial to keeping the OCS standing. Once the

calculations had been finalized and the materials arrived in theater, Soldiers and Marines — following a training plan developed by the New Equipment Training team — began constructing the OCS to secure the IRB in place. The new bridge was completed in early February.

Originally calculated to secure an IRB in currents of up to 11 feet per second (fps), the Army-designed OCS was tested beyond its limits and held firm in raging water of 15 fps and 18 fps. In previous years, rains had prohibited Marines from crossing the Helmand, but the joint solution proved that legacy equipment could be used effectively despite the demanding conditions. This rapid bridging response is a testimony to the ingenuity, efficiency and collaborative approach TARDEC brings to every project supporting Soldiers, Marines, Sailors and Airmen.



MANY PARTNERS, ONE MISSION



You have read about how TARDEC supports Soldiers and Marines. Our associates apply technology, engineering expertise and diligence and are among the best and brightest in their respective fields. They are consistently recognized for the innovation and commitment they display in their daily mission. Their diverse skills and talents across an array of core competencies allow us to apply a holistic approach to ground vehicle technology integration and understand how new capabilities impact the entire platform upon integration.

But we can't do it alone. To effectively support the men and women who put their lives on the line daily for our Nation, collaborating with a broad range of partners is essential. By working together across government, industry and academia we can effectively and efficiently develop solutions that keep Soldiers and Marines mobile, lethal and ready.

TARDEC is a TACOM LCMC enterprise partner. Our daily business involves close collaboration with vehicle and equipment PMs, serving as an honest broker and trusted partner to develop and integrate innovative ground vehicle solutions for their products. We also work closely with RDECOM's other RD&E centers to leverage expertise and ensure that the

technologies we develop are properly integrated onto vehicle systems.

Government collaborative governance partnerships across DoD resulted in formation of the Joint Center for Ground Vehicles (JCGV). Through the JCGV, Army and Marine Corps engineers and PMs will coordinate their efforts and resources to ensure that Soldiers and Marines have ground vehicle systems that drive mobility and make them technologically dominant in theater. We also partner with the Office of Naval Research to meet Navy and Marine Corps needs for fuel-efficient vehicles and installations.

Our location in the Detroit area puts us at the heart of the U.S. automotive industry. Many of our R&D objectives — including enhanced fuel efficiency, advanced vehicle electronics and new propulsion and powertrain technology — are the same as our industry partners. Collaboration with the automotive industry has been a vital part of our processes from the start, and we continue to work with automotive companies and original equipment manufacturers to leverage expertise and quickly develop new solutions.

We also leverage the expertise of our academic partners, working with universities

to advance research, particularly in the areas of M&S. Multiple specialties across our Nation's universities present a unique opportunity for us to gain knowledge and information while also working alongside students and faculty to contribute to their continued education and development as engineers, scientists and technologists.

GOVERNMENT PARTNERSHIPS

JOINT CENTER FOR GROUND VEHICLES

In an era of persistent conflict, operational and mobility requirements continue to emerge for the Army and Marine Corps. Both services can benefit by working together on new technologies and sharing engineering resources and research data. To put that plan into action, the Army and Marine Corps have formed the Joint Center for Ground Vehicles (JCGV) to give all member organizations a better structure to communicate, develop technology, align business processes, share lessons learned, manage portfolios and set up a governance board to direct priorities. By reaching across military agencies to collaborate within the JCGV, TARDEC can now work more closely with all the PEOs responsible for ground vehicle systems.

Comprised of the TACOM LCMC, TARDEC, PEO CS&CSS, PEO GCS and PEO Integration from the Army, with PEO Land Systems, the Office of Naval Research and the Marine Corps Systems Command, the JCGV provides a framework to ensure timely information is shared across the agencies. Collaboration on this scale means the JCGV can focus jointly on all ground vehicle systems by developing a comprehensive strategy for addressing the near- and long-term needs of our Soldiers and Marines.



Marine Cpl. Daniel Pizzaro and Cpl. Chris Lopez, motor transportation operators with Charlie Company, 3rd Assault Amphibian Battalion, perform a maintenance check on a Mine-Resistant Ambush-Protected All-Terrain Vehicle engine at the Division Licensing compound. The collaboration involved in the JCGV is making vehicles more effective and efficient for Marines and Soldiers. (USMC photo by Lance Cpl. Alfred V. Lopez.)

The JCGV builds on the lessons learned and success of other Joint programs such as the MRAP Capabilities Insertion Program and the JLTV program. This initiative is moving things to the next level by focusing on commonality across platforms and shared analytical services. Outcomes achieved will enable JCGV leaders to speak with one

voice on behalf of the ground vehicle communities' emerging requirements.

JOINT LIGHT TACTICAL VEHICLE

TARDEC is continuing to support the JLTV Program — a next-generation family of light tactical vehicles. JLTV is a core PEO CS&CSS program to develop an advanced, modular ground vehicle with protection similar to an MRAP, but with HMMWV-like maneuverability. This year, JLTV reached Milestone A, which allowed the project to move on to the Technology Development Phase involving prototype performance and reliability testing.

TARDEC associates provided their M&S expertise plus alternative analyses. While our entire organization has provided support, the pivotal teams included: CASSI, Powertrain, Visualization and the Software Engineering Center. Other internal teams have contributed to this ongoing partnership to deliver a vehicle that meets both Marines' and Soldiers' needs.

We worked closely with the Marine Corps from early concept development to the design phase, from welding requirements for the physical vehicle to ongoing physical tests. Our reliability and maintenance experts are also helping JLTV engineers find ways to ensure the vehicle's long-term sustainability. Our ongoing partnership with the Marine Corps has led to comprehensive system-of-systems level



analysis that has brought the program through the Technology Demonstrator phase and informed future requirements.

After a year and 20,000 miles of testing, the hard work is coming to fruition. The JLTV program's success, and our partnership with the Marine Corps, underscores the concepts behind the JCGV. Through the JCGV, all services will benefit from TARDEC's integrated support across vehicle system development and design processes.

ROBOTICS RODEO

Soldier and technologist exchanges were prime motivators for the 2nd Robotics Rodeo, held at Fort Benning, GA, and hosted by TARDEC and the U.S. Army Training and Doctrine Command (TRADOC). The Robotics Rodeo also gave Army, Marine Corps, Navy and Air Force members the opportunity to interact directly with manufacturers, programmers and designers to assess the status of private sector robotics development. More than 45 robotics manufacturers and developers displayed the latest advancements in unmanned vehicle technology with demonstrations that included explosive ordnance disposal, route reconnaissance, surveillance and clearance capabilities.

TARDEC engineers and industry manufacturers had the opportunity to talk directly with the users we are committed to protecting and tailor our approach to provide Soldiers and Marines with systems that unburden, enable and protect the men and women who defend our Nation.

In addition to displays and demonstrations, TARDEC and TRADOC held the "Robotic Technology Observation, Demonstration and Discussion" sessions, which allowed military representatives to see robotic capabilities up-close, compile information that will lead to requirements development and determine which systems could be considered for an urgent needs deployment.

INDUSTRY PARTNERSHIPS

NATIONAL AUTOMOTIVE CENTER

Encouraged by the advantages of collaboration, TARDEC worked with the Secretary of the Army to create the National Automotive Center (NAC) in June 1993. The NAC acts as the principal and primary point of contact between TARDEC and private industry, non-profit agencies, universities, and other government agencies and research centers to focus on automotive-related technology and applications to military ground vehicles.

NAC associates specialize in dual-use technology — capabilities that have potential uses in the commercial market as well as in the military. The NAC aggressively accelerates program development for energy conversion and storage systems, hybrid drive trains, transmission systems, alternative fuels and fuel cells, light-weight materials, safety systems and robotics.

The NAC continued its groundbreaking work on vehicle-to-grid and grid-to-vehicle power transfers. TARDEC engineers helped develop and demonstrated the Electronic Power Control and Conditioning (EPCC) module at Camp Grayling, MI. EPCC is a microgrid system that can serve as a power source for vehicles or buildings, and can also receive power from a plugged-

in vehicle or from alternative energy sources such as solar and wind power.

As ground vehicles mature technologically, microgrid system development for Forward Operating Base power production/management requirements will multiply the Army's ability to achieve energy independence and maintain sustainability in remote locations.



The NAC participates in DoD's Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) program, a joint capabilities technology integration agreement with the departments of Homeland Security and Energy, and other private sector R&D organizations.

In the area of alternative fuels, NAC researchers helped develop and qualify synthetic and renewable fuel blends, working with TARDEC's

GVPM engineers to qualify engines to operate on these JP-8 blends

The Hybrid Truck Users Forum (HTUF), operated under collaborative partnerships between the NAC and non-profit clean transportation agency CALSTART, held its 11th annual members conference this year. HTUF continues to work with truck manufacturers to speed the commercialization of fuel-efficient hybrid technology into medium- and heavy-duty work trucks. Once proven, the technology can be integrated into the military's non-tactical vehicle fleet on bases around the country.

GROUND VEHICLE GATEWAY ALWAYS OPEN FOR BUSINESS

The NAC manages the Ground Vehicle Gateway, which provides a mechanism to accept submissions or proposals from private industry, academia or other government agencies that have an idea and want to work with TARDEC in developing potential technology. Through the NAC, TARDEC actively searches for products or applications to fill technology gaps, add new capabilities and improve overall military vehicle performance. The Gateway offers an online resource to evaluate new proposals, inventions and specific technology insertion activities.

Submitters can access the Gateway at <https://tardec.groundvehiclegateway.com>. Visitors fill out a simple template to submit their solicitations. They can return to the site at any time to check the status of their submission. Since the Gateway debuted two years ago, TARDEC SMEs have processed more than 700 submissions, and provided responses to each submitter.

AUTOMOTIVE INDUSTRY CONTINUES WORK WITH THE ARSENAL OF DEMOCRACY

The Army's drive to propel ground vehicle technology forward during World War II and the automotive industry's production know-how merged to create one of the most stirring success stories in American history. This fusion of military engineering with industrial might helped seal an epic victory over enemies on two fronts and earned Detroit its "Arsenal of Democracy" status during that time.

Our facility was embedded at the heart of this historic period. The melding of engineering assets that began 70 years ago remains dynamic and productive today. Collaboration among TARDEC, the automotive industry, suppliers and area defense contractors continues to reap benefits for the Soldiers and Marines who depend on ground vehicle technology

to achieve their objectives. Our ties run deep, and nearly every technology and capability we have is augmented by the automotive industry. The industry's dedication, knowledge, and research and engineering capabilities time and again have supported American forces in theater.

Our interests routinely intersect. For example, we currently collaborate with General Motors (GM) to research fuel-efficient engines and advanced transmissions. They've helped us supply fuel-cell-powered vehicles to bases from Virginia to Hawaii. Our partnership agreements with original equipment manufacturers for a variety of automotive systems help us use our funding more efficiently and deliver high-impact technology in areas of mutual interest. These dual-use technologies will continue to benefit Soldiers and the Nation, and offer unmatched technical excellence.

GVSETS BRINGS PARTNERS TOGETHER

The Ground Vehicle Systems Engineering and Technology Symposium (GVSETS) provides opportunities to exchange dialogue, debate and display the latest technological advancements. In August, more than 1,110 government, industry and academic representatives converged at the 3rd Annual GVSETS in Dearborn, MI, for three days of panel discussions, paper presentations and networking opportunities.

DoD, DoE and private industry leaders participated on a variety of panels and presentations, highlighting the need for improved operational energy, the success of the JCGV and the value of strong systems engineering practices.

During a two-day series of mini-symposia, SMEs presented papers detailing the latest advancements in robotics, mobility, systems engineering, M&S and VEA. Several of our collaborative partners displayed the latest technological breakthroughs in the exhibit hall.

Innovation begins with collaboration, and GVSETS provided the opportunity to meet with our government, industry and academic partners to begin developing effective solutions.

ACADEMIC PARTNERSHIPS

As high-fidelity M&S studies empower systems engineers to design more fuel-efficient, survivable ground vehicle systems, our academic partnerships open doors to the latest developments in this growing field of study.

AUTOMOTIVE RESEARCH CENTER

Through our contractual partnership with the Automotive Research Center (ARC), TARDEC associates have crucial access to cutting-edge academic research and critical data from focused in-lab testing and validation. Established in 1994 at the University of Michigan in Ann Arbor, the ARC is an Army Center of Excellence for advancing the technology of high-fidelity simulation for military and civilian ground vehicles. ARC members include several colleges known for their M&S expertise. All ARC projects operate under a Research Quadruplet Unit, or “Quad” concept, which requires that each project include a graduate student, faculty advisor, military contributor and industry researcher to ensure a successful outcome for all projects and research endeavors.

This year’s key research projects focused on improved mobility with energy-efficient propulsion systems, engine combustion behavior modeling and micro grid power balancing. The ARC also collaborated

with government and industry to better understand the effects of blast events on vehicles, so ARC researchers can help improve Soldier survivability. Work conducted through this partnership has improved warfighter safety and effectiveness, and provided students with real-world research opportunities that lead to superior automotive technology solutions.

SIMBRS

TARDEC M&S engineers also partner with Mississippi State University (MSU) to address essential safety and reliability concerns. MSU manages the Simulation Based Reliability and Safety (SimBRS) Consortium, which provides M&S research to our CASSI team. Input also comes from consortium partners in private industry and affiliated universities, whose research is directed to enhance CASSI capabilities.

SimBRS augments CASSI research by enlisting SMEs in the following specialties: warfighter-based survivability simulations; M&S validation, verification and accreditation; systems integration and optimization; multiscale, multiphysics modeling for vehicle dynamics and structural reliability, durability and survivability; and the simulation of fluid-structure interactions. Research conducted through the SimBRS Consortium has benefited the Army and

Marine Corps since 2008, when we began the five-year partnership with MSU.

Assigning these research projects to the same organization allows us to address needs across the portfolio. We have the flexibility to focus work on the most important problems that need solutions, and also provide students with an opportunity to conduct research that has real-world application.

MAGIC

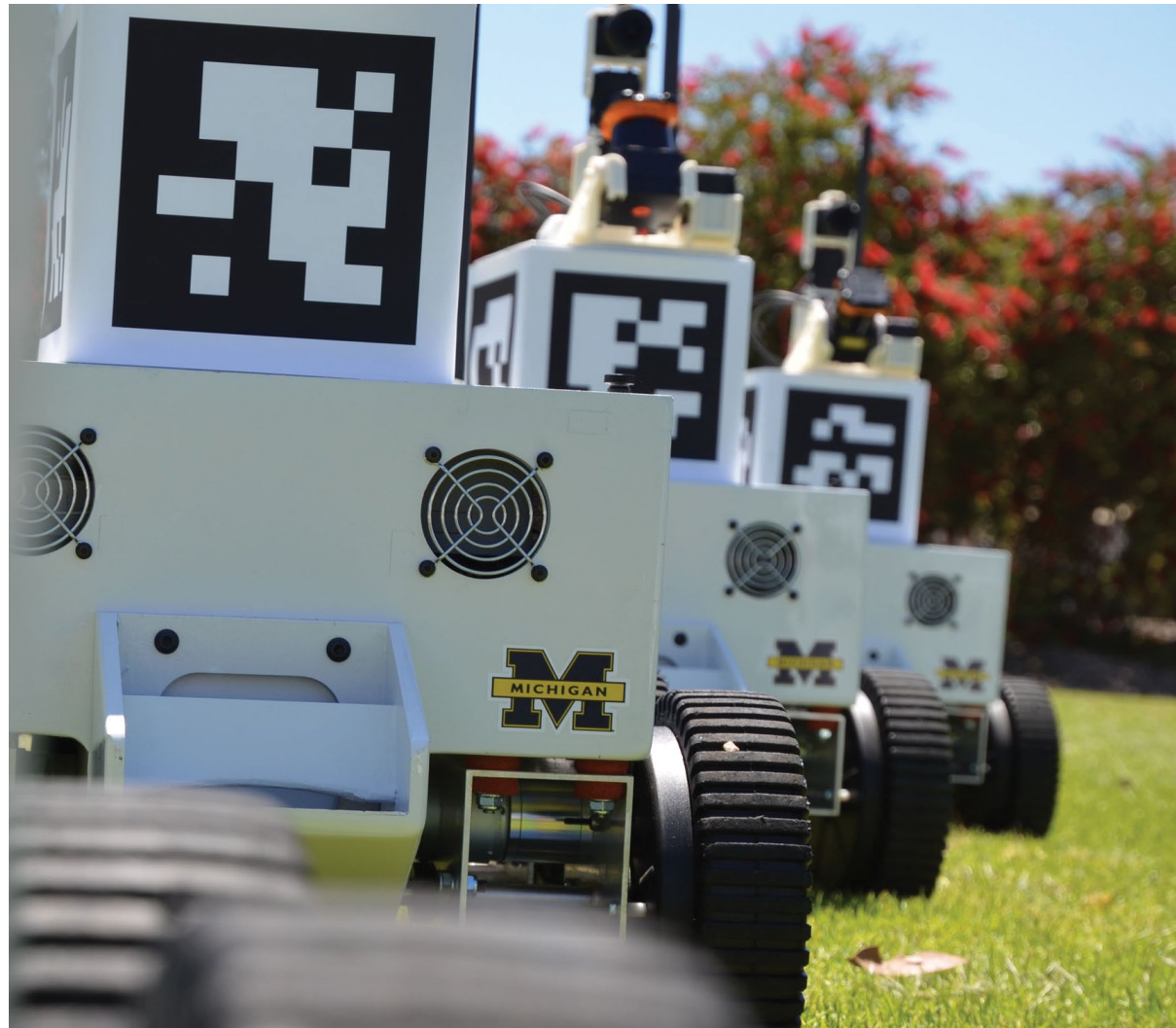
One of our greatest success stories this past year involved an international robotics competition among five college teams from three countries taking on the dynamic challenge of programming UGVs to work autonomously in groups of at least three.

The Multi Autonomous Ground-robotic International Challenge (MAGIC 2010) was a collaborative effort hosted by Australia’s Defence Science and Technology Organisation (DSTO) and TARDEC. The MAGIC collaboration spanned more than two years, and culminated with five finalists selected to compete for research grants totaling \$1 million in the Nov. 8-13, 2010, competition in South Australia. Five college teams from Turkey, Australia and the United States were down-selected from more than 20 international competitors. The final

competition required teams to program their robots to navigate a 250,000-square-meter indoor and outdoor course within 3.5 hours. Judges graded the teams on various factors, including the maps they produced and the time they took to complete three increasingly complex challenge phases. Judges penalized teams for any amount of time they had to manipulate their robots manually.

A University of Michigan team captured first place in the inaugural competition, collecting the \$750,000 first prize. Second place (\$250,000) went to the University of Pennsylvania team, and Team RASR from Gaithersburg, MD, took third place (\$100,000).

MAGIC exemplifies our associates' collaborative spirit, working with governments, universities and industry partners worldwide to inspire future researchers and engineers to develop next-generation, fully autonomous UGVs.



GIVING BACK

We are grateful for everything our community does to enable us to provide cutting-edge technology to Soldiers, and we continually look for ways to give back to our neighbors and the Nation. We have participated in the TACOM LCMC Small Business Fair in our attempts to begin partnerships with a growing number of small business technologists and entrepreneurs.

TARDEC associates also contribute to the Combined Federal Campaign, the world's largest annual workplace charity campaign. But our commitment runs deeper. This year, we participated in the Heroes Alliance, an event designed to encourage children to pursue education in Science, Technology, Engineering and Mathematics (STEM) fields. We have continued our traditional support for the Detroit Public Schools by encouraging experts to speak to students. TARDEC participated in the North American International Auto Show's "First Look for Charity" in Detroit, an annual event that benefits a variety of worthy causes. Additionally, TARDEC has continued to provide support to the Junior Science and Humanities Symposium. These are just a few of our philanthropic and community-focused efforts.

WORKING WITHIN THE COMMUNITY

While we strive to serve our men and

women in uniform, Soldiers, their families and veterans are also part of our extended family. Together, as a partner in our communities, we hope to continue building upon our established relationships and find ways to work toward worthwhile goals.

Our associates participate in outreach efforts to local and regional schools, supporting events for elementary- to university-level institutions. We open our doors to summer hires, training the future workforce, introducing them to systems engineering and our passion for what we do and who we do it for. TARDEC's visitors range from Boy Scout Troops to high school robotics classes, and from Reserve Officers' Training Corps students to community educators and administrators. These visits illustrate the far-reaching roles we play in developing next-generation technology for our Soldiers and Marines, and helping educators introduce new instructional tools and techniques to integrate STEM principles into classroom learning environments and academic curricula.

We have joined the TACOM LCMC in pursuing a greener working environment. Sustainability programs reduce the negative impact we have on our environment, and we have promoted recycling, energy-saving and environmental awareness programs to better educate our associates and their families.

Together with the TACOM LCMC, we are reducing the amount of waste products and energy the Detroit Arsenal uses, and showing that we are good stewards of the resources entrusted to our care.

DETROIT ARSENAL ENERGY SAVERS

Saving energy is a U.S. Army imperative, but one might think that means primarily shipping the technology to fields of operation. We don't. We know that any energy we can save at TARDEC helps our overall cause as well as saving energy in the field.

With that commitment in mind, we're planning to add a 500 kW SIL microgrid at Building 200C that will provide power to the MRAP and Stryker SILs as well as the Detroit Arsenal parking lot lights. A 500 kW Beta, Electric Power Control and Conditioning Unit will be installed adjacent to Building 200C with an 80 kW power output to supplement the current utility power feed to improve Detroit Arsenal energy self-sufficiency. The solar energy produced will be used first with the utility source as the backup. Also, a minimum of 200 kW hours of lithium-ion batteries and an 80 kW diesel generator will provide back-up power in case of a blackout and depletion of renewable energy.

Other energy efficiency projects designed in FY11 include:

- Installing a 5 kW mobile solar generator and charging station for a Ford Escape Smart Plug-In Hybrid Electrical Vehicle (PHEW) in front of the Building 200A lobby.
- Adding a 100 kW Tactical Mobile Vehicle Charging System that will charge up to four PHEWs without being connected to the installation's power grid.

STRONG CITIES, STRONG COMMUNITIES

As part of President Barack Obama's "Strong Cities, Strong Communities" initiative, the program's goals are to inspire creators, doers and entrepreneurs to strengthen the manufacturing sector and build a more networked community of empowered leaders, corporations and students who actively connect with one another to better leverage capabilities.

This year, we were privileged to stand alongside other Michigan companies as part of the state's "Make in Detroit" program, which aims to generate economic growth and community development.

Our complex got its alias, "Arsenal of Democracy," by playing a lead role in ground vehicle and equipment production during World War II. We want to help make



Detroit manufacturing history again by helping the local economy recover after a tumultuous downturn. The "Make in Detroit" program allows TARDEC to work more closely with our industry partners and engage future scientists and engineers so that they'll have greater opportunities to apply their talents, interests and expertise.

DEVELOPING FUTURE SCIENTISTS

SCIENCE, TECHNOLOGY, ENGINEERING AND MATH

Our most important present goal is protecting our Nation's troops. Another important endeavor we are committed to is encouraging young people to choose STEM and other technology-related studies. Our country has fallen behind the rest of the world in developing professionals in these areas, and we know that staying competitive in the global marketplace will require more students pursuing careers in STEM fields.

Associates reach out to the country's future engineers, scientists and technologists by volunteering in several STEM-related programs. Each program is designed to engage students and begin conversations about the possible STEM-related careers waiting for them after college. Whether speaking directly with students in classrooms or at Army events, or engaging them through hands-on programs like eCYBERMISSION, Junior Science and Humanities Symposium or the Intelligent Ground Vehicle Competition, we know that the best way to spark interest about these exciting careers is to give students a chance to try it firsthand and turn to our associates as mentors.

We have launched various programs during the last several years to promote

these subjects to students of all ages and show them the multitude of careers available in these fields. In 2011, TARDEC initiated a series of Michigan STEM Collaboration meetings with a cross-section of government, academic and industry representatives from Southeast Michigan. The main goal of our STEM efforts — which also includes the Michigan Department of Education, Society of Automotive Engineers, National Defense Industrial Association and community organizations, among others — is to leverage existing resources to promote STEM goals.

TARDEC's community outreach activities usually involve our associates working side-by-side with students so they can learn the various types of engineering and scientific professions available to them. We encourage our associates to volunteer as mentors through the National Defense Education Program, which allows civilians who work in defense laboratories to play a key role in encouraging U.S. students to both pursue STEM studies and then take their place as the next generation of government researchers. We also engage students pursuing relevant degrees at colleges and universities, such as we did this year when we challenged automotive design students at the College for Creative Studies in Detroit to work

with TARDEC engineers to meet design requirements for a FED vehicle prototype.

Cultivating students' interest in STEM subjects early on shows them the range of possibilities that will open up to them and will eventually lead to more students pursuing advanced degrees in these disciplines. That means more innovation and creative thinking for future technology developed here and at other important R&D agencies. We're planting the seeds now to grow the next generation of world-class inventors, engineers and scientists.

SUMMER HIRE PROGRAM

As TARDEC associates develop advanced systems such as hybrid-electric vehicles, fuel-efficient energy modules and advanced robotics, we have a prime opportunity to attract students to technology careers.

The highly competitive Summer Hire Program attracted 206 applicants from 60 colleges, of which 49 students were selected in 2011. Fourteen students were selected from more than 180 applicants representing 130 high schools. Through our Summer Hire program, we target the best and brightest prospects to support Soldiers and Marines as a part of our future workforce. A high percentage of these students return to TARDEC for



Bluefield State University students prepare their robot, "Archon," for IGVC's challenging courses as the competition rages on at IGVC. (U.S. Army TARDEC photo.)

additional training while in college and full-time careers following graduation.

Ultimately, the program does more than just build tomorrow's workforce. "We embed critical technical and project management skills in the students. At the same time, we contribute to ensuring U.S. students are prepared to move into careers in engineering,

math and science," explained TARDEC Educational Administrator and Corporate University Dean Pame Watts.

SUMMER HIRES SPEAK BACK

- Macomb Community College sophomore Kristen Florence plans to transfer to Michigan Technological University to study mechanical engineering. "I'm used to having constant oversight from our professors. Here, we got a lot of freedom to do what we wanted, and they really loved it when we brought suggestions to them."
- University of Michigan junior nuclear engineering major Emily Cizmas stated she learned a lot about the engineering process and how organizations work together on projects. "Seeing how things work around here is really what I learned the most about."
- Cass Technical High School (Detroit) senior Vivian Madu spent the summer working on several STEM-related programs. "It changed my attitude on what classes I'll take to prepare for college." She now plans to take computer-aided drafting and chemistry classes and to switch her college major to engineering. "The biggest thing that sticks in my mind was to pay attention to my science, technology, engineering and mathematics skills, and to take opportunities to learn those skills."

All three students hope to return to TARDEC in 2012 to build on their experiences from 2011.

CONCLUSION



This year, our Nation commemorated the 10th anniversary of the September 11 terror attacks. While we still mourn those who were lost that day, we take strength in seeing the unity and determination shown in the years following. TARDEC and its partners have been working vigorously over the past decade to supply our Soldiers and Marines with the ground vehicles, electronic architecture, robotics, fuel and water sustainment, and other materials they have needed to succeed in their respective missions. Overseas contingency operations are always unpredictable, but our engineers have remained adaptable, innovative and driven to maintain warfighter technological dominance on the battlefield or when supporting humanitarian and disaster-relief operations.

The past 10 years have challenged our organization in unprecedented ways. Our engineers have become more focused and resourceful under operationally demanding circumstances. We have implemented analytical business processes and streamlined the systems engineering process to build efficiency, rapid response and ensure quality products and deliverables.

Our job now is to build on our gained knowledge and agility to deliver solutions, codify streamlined processes, and make these new tools and methodologies the standard, repeatable practices of our future. Using these capabilities, we will forge new ground in our ability to address space and weight challenges that stem from electronics and survivability systems improvements. Through advanced energy-efficiency technology, we can “buy back” more of the mobility and performance that keep our fighting forces effective, while preparing for emerging threats with innovative, occupant-centric survivability techniques. As we follow this path, we will continuously sharpen our modeling and simulation capability, setting the solid foundation in requirements validation, product development and informed decision-making within the Army.

Whether we’re pursuing new challenges with our government partners or working with the ground systems community to engineer the best possible combination of maneuverability, survivability and sustainability, TARDEC associates will continue to be guided by the principles we’ve fully embraced: to lead, innovate, integrate and deliver.

APPENDICES

APPENDIX A: TARDEC LABORATORIES, FACILITIES AND TEST EQUIPMENT

TARDEC operates several world-class laboratories, and our state-of-the-art testing equipment helps us best develop and qualify technologies prior to integration. This capability will be greatly enhanced with the addition of the Ground Systems Power and Energy Laboratory, a collection of multiple state-of-the-art laboratories opening in 2012.

For more information about our laboratories, facilities and test equipment, please visit our website at: <http://tardec.army.mil/testing.aspx>.

APPENDIX B — WORKING WITH TARDEC

There are many ways to do business with TARDEC. The most effective way to learn of TARDEC and other Army solicitations, requirements and market surveys is through the Federal Business Opportunities website at <https://www.fbo.gov/>. Also, information on business opportunities may be found at the TACOM Acquisition website at <http://contracting.tacom.army.mil/opportunity.htm>. Two of our most common partnership vehicles are Cooperative Research and Development Agreements (CRADAs) and the Small Business Innovation Research (SBIR) program.

COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENTS

CRADAs are established between federal laboratories and commercial, academic or nonprofit partners to facilitate technology transfer between the parties for mutual benefit. Under a CRADA, the partner may contribute resources such as personnel, services, property and funding to the effort. The government can contribute all the above except funding.

The Stephenson-Wydler Technology Innovation Act of 1980 made technology transfer part of every federal laboratory's mission. The act facilitates the technology transfer from federal laboratories to non-federal parties and provides outside organizations with a means to access federal laboratory developments.

Subsequent legislation provided significant new authorities for federal laboratories to establish CRADAs with private companies as well as public and nonprofit organizations. It also allowed for negotiating licensing arrangements for patented inventions made at the laboratories.

SMALL BUSINESS INNOVATION RESEARCH PROGRAM

The SBIR program is a congressionally mandated program established in 1982 (with subsequent reauthorizations in 1986, 1992 and 2000–2008) to increase small business participation in federal R&D. The dual-use SBIR Program's goal is to tap into the small business community's innovation and creativity to help meet government R&D objectives. At the same time, these small companies are developing technologies, products and services that can be commercialized through sales in the private sector or back to the government.

GROUND VEHICLE GATEWAY

Submit proposals or inquiries to TARDEC using a simple online template at the Ground Vehicle Gateway: <https://tardec.groundvehiclegateway.com>. Submissions will be forwarded to and reviewed by a TARDEC technology expert in the relevant field.

APPENDIX C — ACRONYM LIST

AGI.....	Army Greatest Inventions	GCV	Ground Combat Vehicle
APU	Auxiliary Power Unit	GVPM	Ground Vehicle Power and Mobility
ARC	Automotive Research Center	GVR	Ground Vehicle Robotics
ARL.....	Army Research Laboratory	GSPEL	Ground Systems Power and Energy Laboratory
AMC	Army Materiel Command	GSS	Ground Systems Survivability
AVPTA	Advanced Vehicle Power and Technology Alliance	GVSETS.....	Ground Vehicle Systems Engineering and Technology Symposium
CASSI	Concepts, Analysis, Systems Simulation and Integration	HMMWV.....	High Mobility Multipurpose Wheeled Vehicle
CGVDI.....	Center for Ground Vehicle Development and Integration	HTUF	Hybrid Truck Users Forum
C4ISR/EW.....	Command, Control, Communications, Intelligence, Surveillance, Reconnaissance/Electronic Warfare	IBET.....	Industrial Base Engineering Team
CRADA.....	Cooperative Research and Development Agreement	IED.....	Improvised Explosive Device
DA.....	Department of the Army	IRB.....	Improved Ribbon Bridge
DMSMS.....	Diminishing Manufacturing Sources and Material Shortages	ISO	International Organization for Standardization
DoD	Department of Defense	JCGV	Joint Center for Ground Vehicles
DoE.....	Department of Energy	JIEDDO	Joint IED Defeat Organization
DSTO.....	Australian Defence Science and Technology Organisation	JLTV	Joint Light Tactical Vehicle
EFP	Explosively Formed Penetrant	JRaDS.....	Joint Recovery and Distribution System
EPCC	Electronic Power Control and Conditioning module	kW	Kilowatt
FED.....	Fuel Efficient ground vehicle Demonstrator	kWh	Kilowatt-hours
FP	Force Projection	Li-ion.....	Lithium-ion
FPT	Force Projection Technology	LDTO	Long Distance Tele-Operation
FY	Fiscal Year	LOCB.....	Line of Communication Bridge
		MAGIC.....	Multi Autonomous Ground-robotic International Challenge
		M-ATV	MRAP All-Terrain Vehicle


MHE	Material Handling Equipment	SimBRS	Simulation Based Reliability and Safety
MRAP.....	Mine-Resistant Ambush-Protected vehicle	SME.....	Subject Matter Expert
M&S.....	Modeling and Simulation	S&T.....	Science and Technology
MTV.....	Medium Tactical Vehicle	STE	Senior Technical Expert
NAC	National Automotive Center	STEM.....	Science, Technology, Engineering and Mathematics
OCS	Overhead Cable System	TACOM LCMC	U.S. Army Tank automotive and Armaments Command Life Cycle Management Command
OWM.....	Overhead Wire Mitigation	TARDEC	U.S. Army Tank Automotive Research, Development and Engineering Center
PEO	Program Executive Office	TARGET.....	TARDEC Gated Evaluation Track
PEO CS & CSS.....	PEO Combat Support and Combat Service Support	TRADOC	U.S. Army Training and Doctrine Command
PEO GCS.....	PEO Ground Combat Systems	TWVS	Tactical Wheeled Vehicle Survivability
PEVEL	Power and Energy Vehicle Environment Lab	UGV	Unmanned Ground Vehicle
PM.....	Product/Program Manager	USMC.....	U.S. Marine Corps
QRC.....	Quick Reaction Cell	VE	Value Engineering
R&D.....	Research and Development	VEA	Vehicle Electronics and Architecture
RDA	Research and Development Achievement	VICTORY	Vehicular Integration for C4ISR/EW Interoperability
RD&E	Research, Development and Engineering		
RDECOM.....	U.S. Army Research, Development and Engineering Command		
RDS	Robot Deployment System		
RFI	Request for Information		
RS JPO.....	Robotics Systems Joint Project Office		
SANDI	Supervised Autonomy to Neutralize and Defeat IEDs		
SBIR	Small Business Innovation Research		
SIL	Systems Integration Laboratory		






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