

2010



# ANNUAL REPORT TWO THOUSAND TEN

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

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## **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

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## DIRECTOR'S MESSAGE



The pages of this Annual Report will reveal a list of TARDEC's accomplishments, and we are certainly proud that our people have accomplished these dynamic things and embraced our creed to be innovative, knowledgeable, always learning, and focused.

The motivation for the achievements you'll find in this report is responding to our customer: the warfighter. Our focus remains on the Soldiers and Marines who, each year, rely on TARDEC to engineer, develop and integrate solutions for ground vehicles, robotics, electronics, survivability measures and force projection systems. The portion of our creed that urges us to innovate, learn and stay focused is not simply a collection of words to print on a poster. It reminds us that we have to always be on our game to make our warfighters the best-equipped forces in the world.

And how do we ensure that? By leading the world in ground vehicle research and development, innovating to find the best solutions, integrating improvements and new technology as swiftly as possible and delivering what the men and women in the field need to safely and successfully complete their missions.

You'll find many examples of our associates' commitment to these principles in the following pages. Our dedication spans the five technology focus areas at TARDEC:

- ▶ Ground Vehicle Power and Mobility (GVPM)
- ▶ Ground Systems Survivability (GSS)
- ▶ Ground Vehicle Robotics (GVR)
- ▶ Vehicle Electronics and Architecture (VEA)
- ▶ Force Projection.

We are honored to serve in this role as the research, development and engineering (RD&E) center for the Department of Defense's (DOD's) manned and unmanned ground vehicle fleet. TARDEC's engineers, scientists and technicians are involved throughout the life-cycle of each vehicle, whether it has wheels or tracks, a driver or autonomous mobility, and no matter how it is powered. Our substantial experience, problem-solving skills and technical abilities have made us the go-to organization for ground vehicle technology innovation and integration. From our research and development work on the Fuel Efficient ground vehicle Demonstrator (FED) to our collaborative efforts on the Tactical Wheeled Vehicle Survivability (TWVS) Army Technology Objective (ATO) to the ingenuity of the Overhead Wire Mitigation (OWM) kit, our work covers a broad spectrum. We are involved in all aspects of ground vehicle RD&E and the technology solutions we develop and integrate are

making vehicles more efficient, more powerful, more maneuverable and, most importantly, more survivable.

We are uniquely positioned to perform this work due to both our highly skilled workforce and world-class equipment and facilities. Our location in Southeast Michigan — where the automotive industry first began — allows us to attract the top technical and engineering minds and enter strategic collaborations to accelerate development.

The processes we employ are every bit as essential to our successes as the people and the technology. As an organization, we have to be nimble enough to respond to ever-evolving military conditions, but also adopt proven best practices that ground us in efficient and intelligent roadmaps for delivering outcomes. We've implemented a suite of tools and processes that drive efficiency and sound decision-making across the organization.

Our development process, which we call TARDEC Gated Evaluation Track (TARGET), is based on the Stage-Gate® concept-to-launch process developed by Dr. Robert G. Cooper, a worldwide authority on product innovation. According to Cooper, our five-gated TARGET path will be the first government/non-profit process featured as a best practice. We also adhere to our own portfolio management process that evaluates the strategic importance of a

program, determines how it fits into our overall portfolio, and identifies technology gaps. Like our engineering path, the planning process is guided by a set of common, strategic steps to drive integrated practices and efficient results.

No organization is without its challenges, however, and we must continue to look for ways to do more without having more. The Army will be operating in a time of limited resources for the foreseeable future and we must find ways to adapt to this ongoing reality. At TARDEC we strive to always be good stewards of taxpayer dollars and you'll learn more in this report about the ways we're already working to meet those goals.

Every day TARDEC associates come to work knowing we are part of something incredibly important. Our job is to help ensure our Nation's warfighters successfully complete their missions and return home safely. This fact makes our work extremely rewarding and keeps us focused. Our ultimate goal is to continue delivering the most innovative and advanced ground vehicle solutions to our Soldiers and Marines so they remain the most lethal and survivable fighting force in the world.

**Grace M. Bochenek, Ph.D.**  
TARDEC Director



# OVERVIEW



It is our responsibility to ensure the courageous men and women who make up the Army, Navy, Air Force, Coast Guard and Marine Corps are as well-protected and well-equipped as possible, but it is our privilege to be a part of this extraordinary effort and contribute to the safety and security of our Nation's fighting forces.

This mission drives us every day. Our work has a larger purpose and is critical to providing warfighters with capabilities that consistently overmatch the enemy. Our passion is evident in every project we work on because we know even the smallest detail has the potential to give our military the decisive edge that can save lives and lead to success.

Each functional group within TARDEC brings core skill sets to the mission. A highly skilled workforce collaborating with government, industry and academic partners makes it possible to fulfill our objectives.

We perform best when working together as an integrated team with our partners across the Ground Systems



Enterprise, which is responsible for all aspects of designing, developing, testing, fielding and sustaining the vehicles our warfighters need to complete their missions.

Our years of knowledge and expertise mean we are uniquely positioned to synthesize the elements of the Ground Systems Enterprise as it develops mobile superiority for our Soldiers and Marines.

As the engineering lead for technology integration for the Ground Systems Enterprise, TARDEC shares vital information across this organization and

leverages our partnerships to deliver timely, cost-effective and technologically superior solutions. Our partners include:

- ▶ U.S. Army Research, Development and Engineering Command (RDECOM)
- ▶ U.S. Army TACOM Life Cycle Management Command (LCMC)
- ▶ Program Executive Office (PEO) Ground Combat Systems (GCS)
- ▶ PEO Combat Support and Combat Service Support (CS & CSS)
- ▶ PEO Integration
- ▶ U.S. Marine Corps (PEO Land Systems)
- ▶ TACOM Integrated Logistics Support Center (ILSC).



## *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.

## **ORGANIZATIONAL ROLE: RD&E PROVIDER OF FIRST CHOICE**

Whether TARDEC's scientists and engineers have to respond quickly to a call for new capabilities from the field or thoughtfully plan future ground systems and equipment, our organization must be an adaptable and innovative leader. Meeting our current and future challenges requires TARDEC to orchestrate strategies, seeking the fastest way to channel our own resources into the effort and then making the right connections with the right partners to reach the goal.

The ultimate goal does not vary — we develop and integrate the right technology solutions to improve Current Force effectiveness and provide superior capabilities for the Future Force. We provide full life-cycle support and systems engineering expertise for all DOD ground combat and combat support weapons, equipment and vehicle systems. We serve as the ground systems integration lead for DOD and work

with numerous partners throughout the Ground Systems Enterprise.

TARDEC is a member of the TACOM LCMC, which manages the most diverse portfolio in the Army. The products we support range from combat and tactical wheeled vehicles to boats, kitchens and laundry facilities. We manage that entire portfolio, with two-thirds of our associates dedicated to Army vehicle and variant ground systems research and development (R&D) life-cycle programs. TARDEC, along with six sister organizations, operates under the U.S. Army Research, Development and Engineering Command (RDECOM) — whose mission is to empower, unburden and protect the warfighter — and the Army Materiel Command, whose mission is to provide America's warfighters with the decisive edge.

As the RD&E provider for ground systems, we apply innovative approaches and rapid technology assessments to align ourselves

with those missions to support 2,800 Army, Navy and Marine manned and unmanned systems. Using a gated process that forces us to think critically, we act as quickly and efficiently as possible to integrate those solutions.

## BUDGET

TARDEC's Fiscal Year 2010 (FY10) total budget was \$637.3 million.\* Of this funding, \$196.6 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, \$440.7 million was allotted for technology development. This included \$79.9 million in R&D reimbursements, as well as a combined \$360.8 million for basic research, applied research, advanced technology development, integration and major systems development.

Basic research (6.1) efforts provide fundamental knowledge for the resolution 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.

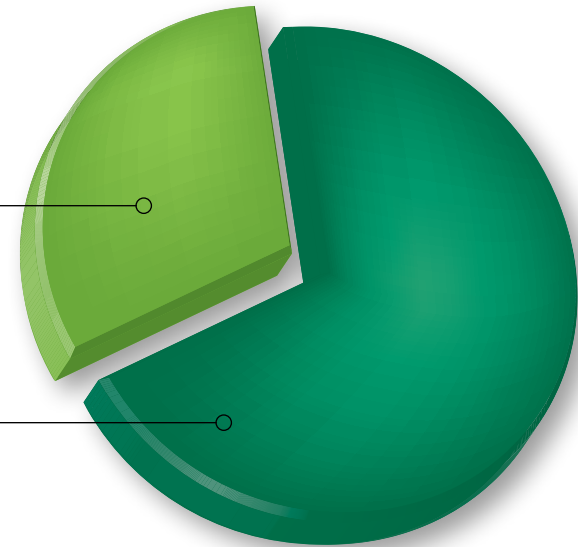
Advanced technology development (6.3) includes all efforts that have moved into the development and integration of hardware and other technology products for field experiments and tests.

\*Budget amounts are accurate as of Sept. 30, 2010

FY10 Budget

**\$196.6 million**  
**Life Cycle**  
**System Support**

**\$440.7 million**  
**Technology**  
**Development**

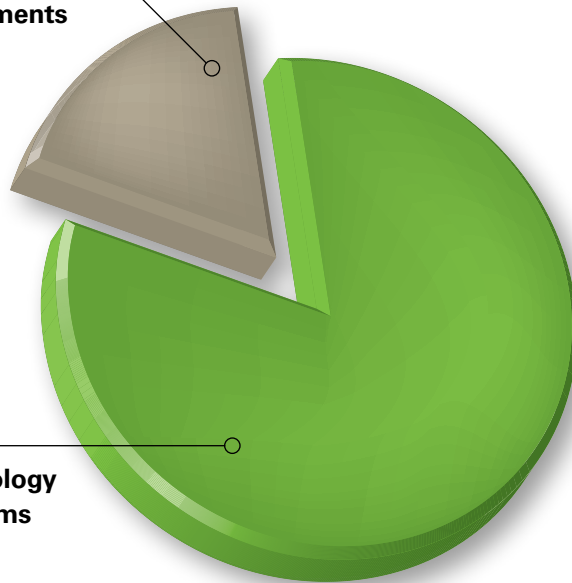




**Total Technology Development  
(RDT&E 6.1-6.7 and Reimbursable)**

**\$79.9 million  
R&D Reimbursements**

**\$360.8 million  
Basic & Applied  
Research and  
Advanced Technology  
and Major Systems  
Development  
(6.1-6.7)**

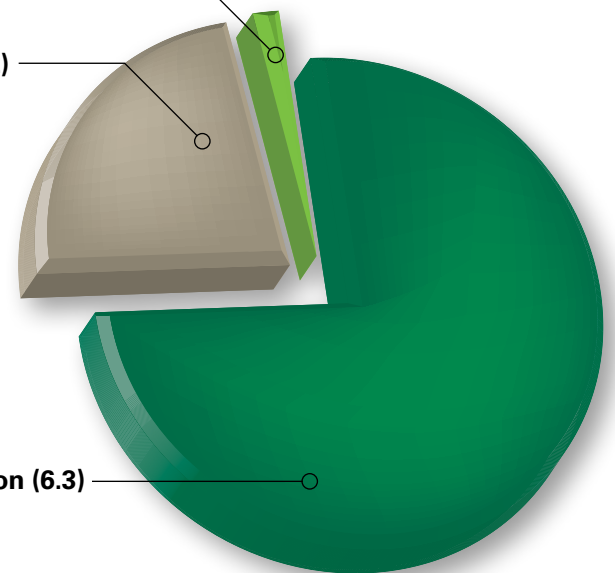


**Basic & Applied Research and Advanced  
Technology Development (RDT&E 6.1-6.3)**

**\$4.8 million (6.1)**

**\$78.9 million (6.2)**

**\$258.4 million (6.3)**



# ***OUR EXPERTISE***





For more than 60 years, TARDEC engineers, scientists, technicians and other associates have been dedicated to developing the highest quality military ground vehicle systems and rapidly responding to warfighter needs. With an impressive range of skills and aptitudes, our experts bring multiple specialties to our mission, including: full-scale systems engineering and integration, hybrid-electric systems, diesel combustion engines, armor, lightweight materials, software interface design, modeling and simulation, robotics, alternative fuels, “green” technologies and even water purification.

Each year, we set high expectations for ourselves. And each year, our teams surpass them. Our innovative approach often results in award-winning technologies. But our greatest reward is the knowledge that we’re equipping our associates to develop solutions to ease the formidable tasks faced by our warfighters and make them safer.



▲ A chemist studies a test sample in TARDEC’s Petroleum Laboratory. Each of our technical areas are staffed with associates who have the specialized knowledge to uphold our reputation as a technological center of excellence. (U.S. Army TARDEC photo.)

▲ TARDEC associates developed the two Army’s Greatest Inventions Award-winning attachments mounted on this Mine Resistant Ambush Protected (MRAP) scout truck: the Self-Protection Adaptive Roller Kit (SPARK) and the Overhead Wire Mitigation (OWM) kit. Each device enhances Soldiers’ capability to respond to potential threats in the field. (15th Sustainment Brigade photo by CPT Murray Shugars.)

# FY10 AWARDS

## RDECOM ARMY SUPERIOR UNIT AWARD

The Army Superior Unit Award recognized RDECOM and its subordinate research, development and engineering centers (RDECs) and laboratories for accelerating innovative technology and sound engineering solutions that provide U.S. forces with dominant capability wherever and whenever they need it most. RDECOM was selected for its work during the 2007 calendar year when its research centers, including TARDEC, held nine spots on the top 10 Army's Greatest Inventions (AGIs) list. That year, TARDEC's High Mobility Multipurpose Wheeled Vehicle (HMMWV) Egress Assistance Trainer and Self Protective Adaptive Roller Kit (SPARK) earned AGI recognitions.

## DAVID PACKARD EXCELLENCE IN ACQUISITION AWARD

The Mine Resistant Ambush Protected (MRAP) All-Terrain Vehicle (M-ATV) Source Selection Evaluation Board won a David Packard Excellence in Acquisition Award. Only two of

these awards were presented in FY10. The award recognized DOD civilian or military organizations, groups or teams that made highly significant contributions that demonstrated innovation and best acquisition practices. The team's efforts resulted in the selection of a low-risk accelerated delivery candidate for thousands of M-ATVs for quick deployment to the field.

## 2010 PRESIDENTIAL RANK AWARD

This year, TARDEC Executive Director for Product Development Thomas Mathes was recognized as a Presidential Rank Award recipient. The award is given to a select group of career members of the Senior Executive Service who have provided exceptional service to the American people over an extended amount of time. Individuals are nominated by the Secretary of the Army and evaluated by a board of private citizens. Final award recipients were approved by the President. Mathes was among 14 recognized as Meritorious Executives.

## MODELING AND SIMULATION (M&S) AWARDS

M&S allows us to see exactly how technologies will fit into a vehicle and determine what issues must be addressed before fielding. This is one of the key aspects of our work, as it ensures that we have validated a technology from all angles. TARDEC associates are experts in this field, as evidenced by the three 2009 M&S Awards they were honored with in FY10.

- **Lead Integrator for Live/Virtual/Constructive Simulation for Spin Out Enhanced Infantry Brigade Combat Team (Individual):** TARDEC Associate Kevin Hope created an M&S environment to test robotic technologies with a mix of live and simulated assets that enabled brigade-level exercises to be conducted with significantly fewer live assets, resulting in cost savings to the Army.

► **Mine Blast Effects on Ground Vehicle Structures and Crew Injury (Team):**

This award recognizes the efforts of an RDECOM-TARDEC team in researching state-of-the-art computational toolkits and developing a sophisticated methodology to evaluate mine blast effects on ground vehicle structures and crew injury risks.

- **Physiological Basis of Local Area Security and Semi-Autonomous Driving (Team):** An RDECOM-TARDEC team designed and built a human-in-the-loop, motion-based simulation experiment to study the physiological basis of local area security and semiautonomous driving. The results will help facilitate real-time understanding of Soldiers' brain functions in operational environments and allow for matching Soldiers' capabilities and advanced vehicle technologies.



RDECOM CSM Hector Marin and RDECOM Commanding General (CG) MG Nick Justice attach the Army Superior Unit Award streamer to the RDECOM flag during the Superior Unit Award ceremony. Award streamers provide a history of accomplishments and have been presented throughout the Army since before the Revolutionary War. (U.S. Army TARDEC photo.)

## OTHER HONORS

### Army Research and Development Achievement (RDA) Awards

- Outstanding Collaboration Award — Awarded to TARDEC and the Army Research Laboratory (ARL) for the TWVS ATO.
- Outstanding Collaboration Award — Awarded for Sensor Enhanced Armor: A New Technique for Evaluating Armor Health.
- Outstanding Technical Achievement Award — Awarded to TARDEC and ARL for the Thrown Object Protection System (TOPS).
- International Organization for Standardization (ISO) 14001:2004 Certification — Environmental Management System (EMS). This was the fourth consecutive year EMS received ISO 1400:2004 certification.

### 2009 Defense Standardization Distinguished Achievement Award

Awarded to TARDEC Electrical Engineer Martin Snyder for his work in the design, development, testing and final project certification of the world's first 24-volt military vehicle headlamps using only light-emitting diodes.



# TARDEC'S COMMITMENT TO ITS EMPLOYEES

Warfighters need a variety of strengths to succeed, and an increasingly imperative one is technology. To succeed in making rapid advances in science and technology (S&T), we need a highly skilled and flexible workforce that believes in continuous improvement.

In FY10, we implemented a Human Capital Strategy to ensure that we continue meeting the ongoing demand to recruit, develop and retain outstanding associates. This means more than hiring qualified employees, but also engaging and educating them so they remain competent, knowledgeable and bring the best possible attributes to this challenging job. It means we continually pursue top talent to supplement our staff of engineers, scientists and technicians. It also requires that we recruit, train, reward excellent performance and innovation, and encourage collaboration across functional and organizational boundaries.

We design our career and professional development programs to attract and retain the top people in their respective career fields. We help

our workforce develop collective capabilities through continuing education, along with rotational and developmental assignments. Our recently implemented mentoring program builds a deeper technical bench to ensure the entire workforce remains prepared for the demands of key R&D positions and leadership roles.

To reinforce our position at the leading edge of S&T, we place a premium on higher learning and urge our associates to continue their educations. A number of our employees were pursuing graduate degrees in 2010 (see info box).

## TARDEC UNIVERSITY

Through TARDEC University, our Career Development Team provides the structure to implement TARDEC's dynamic education, training and human capability plans in collaboration with the RDECOM Human Resources staff and the TACOM LCMC community. TARDEC University prepares and executes human resource planning and management programs for a technically and ethnically diverse workforce.

In FY10, TARDEC associates took part in a total of 278,650 hours of training, highlighting our workforce's commitment to increasing expertise in engineering, science, leadership and management training.

## HIGHER EDUCATION AMONG ASSOCIATES

As of June 30, 2010, TARDEC associates, including Student Career Experience Program (SCEP) student employees, are actively pursuing:

- ▶ 34 doctoral degrees
- ▶ 156 master's degrees
- ▶ 87 bachelor's degrees
- ▶ 42 advanced undergraduate courses (not toward a degree).

### INNOVATION FUNDS PROGRAM

We emphasize the importance of innovation among our research and development teams by providing the tools they need to excel. The newly established TARDEC Innovation Funds program supports this endeavor. Our senior scientists and technical staff launched this program to encourage new ideas and breakthrough technologies to help the Army accelerate the pace of development.

Five to 20 financial awards may be given annually. Funds are good for one year and may be used to purchase in-house support, raw materials, equipment and limited contractor support. Additionally, funds may be allocated toward project time for team members in customer-funded organizations. At the project's conclusion, the output is reviewed by a board 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.

### ADVANCING OUR ASSOCIATES

As our workforce's expertise matures, we recognize the importance of providing associates with opportunities to advance into future leadership roles.

To further develop our technical expertise, this year we placed Senior Technical Experts (STEs) across several TARDEC technical focus areas. The STEs are responsible for technical development in their selected areas, giving them a crucial role in developing and managing TARDEC's S&T community.

Also, we continue to implement the Factor IV Program, which provides career advancement opportunities for associates who are committed to further developing their knowledge and understanding as a researcher or evolving new and improved products and processes as a developer. By taking

advantage of these opportunities, researchers may move into a higher position, such as an STE. This year, 15 associates were recertified through the Factor IV Program.

The STE positions and the Factor IV Program reflect TARDEC's commitment to advanced automotive technologies, science and research, and tie into the Nation's goal of pursuing S&T research advancements.

# ***EQUIPPING THE WARFIGHTER***



# FOCUS ON SYSTEMS ENGINEERING AND SYSTEMS INTEGRATION

***“For Systems Engineers,  
the timeline has collapsed.  
The response loop in  
conventional warfare  
was measured in years.  
The response loop for  
counter-insurgency  
warfare is measured in  
months or weeks.”***

**(Source: Panel Briefing by Stephen  
P. Welby, Deputy Assistant  
Secretary of Defense for Systems  
Engineering, March 2010)**

At TARDEC, systems engineering and integration isn't simply our emphasis, it's a cultural imperative — a part of our DNA. Applying systems engineering methods and principles ensures that the technologies we develop and deliver to the warfighter have been thoroughly tested and analyzed and will work as intended on the battlefield. That's why it's the essential core function of everything we do.


Systems engineering can be defined a few different ways. Some describe it as the technical process used to facilitate integration functions; others think of systems engineering as the function and systems integration as the application. For TARDEC associates, systems engineering means meeting joint requirements with traceability. During the design process, we 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 affect all ground vehicles for the Army and Marines, not

just a single platform. And a successful integration solution means we introduce a capability to the entire fleet, rather than narrowing down the task to a specific function on a specific vehicle.

## **SYSTEMS ENGINEERING AND THE WEAPON SYSTEMS ACQUISITION REFORM ACT (WSARA)**

WSARA, first passed by Congress and signed by President Obama in 2009, stresses the importance of systems engineering in all DOD programs. TARDEC has led with a systems engineering approach and was already structured to meet these directives.

The act emphasizes the need for systems engineering to accurately estimate a program's operational requirements, life cycle costs and acquisition or production schedules. It states that systems engineering provides the robust analyses and technical assessments needed for informed decision-making and an efficient acquisition process.

 A Soldier checks the weapon on his turret during vehicle inspection. TARDEC systems engineers led the development of a gunner's restraint system with added protection to keep the Soldier secure in case of blast or rollover. (U.S. Army photo by SFC Peter Mayes.)

TARDEC demonstrated its fidelity to this process when it integrated a Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) electronics package for five models of MRAP vehicles (also known as MRAP's Digital Backbone). That multistep, gated process begins with a thorough analysis of what's required to perform the integration, which groups will support the project, and an upfront discussion of challenges.

Subsequent stages include modeling and simulation; an analysis of the components' size, weight, power and cooling requirements; engineering design; the technical data package, which includes a materials list; prototype drawings for the fabrication stage; and then production. The software development happens parallel to the fabrication phases.

TARDEC's process mirrors many cornerstones of the WSARA, which calls for an increased awareness and understanding of how systems engineering can help ground vehicle

programs, particularly new or large ones, end in success and with more predictable results. It is not simply being disciplined for the sake of being disciplined. The time investment at the beginning of the process results in a better engineered product or system with fewer design or capability challenges later on.

### **TARGET: OUR RECOGNIZED PRODUCT DEVELOPMENT PROCESS**

In private business, Stage-Gate® was conceived as a streamlined, rapid idea-to-launch sequence of decision points for developing new products for the market. TARDEC adopted a stage-gating process called TARDEC Gated Evaluation Track (TARGET) to accelerate the development of new technology to aid warfighters.

Much like the widely adopted model established in the business world, TARGET is a five-phase, five-gated system to reduce timelines, manage risk, standardize program management techniques, and move the right technology forward. But in the Army's case, the gated track has been tailored to leverage systems engineering best

practices and embed enabling tools that help engineers stay on track through the entire development process.

Dr. Robert G. Cooper, one of the world's foremost experts in product innovation, has recognized the TARGET process as a best practice for a government organization adopting a concept-to-operational process.

Each one of the stage gates prompts decision makers to collect data, analyze it and then choose the most beneficial action.

Gate 1 is the idea stage with a thorough needs analysis; Gate 2 includes validating customer requirements, technology readiness assessment and success criteria; Gate 3 involves the design and development phase; Gate 4 mainly focuses on validation; and Gate 5 is the technology transition and deployment stage.

Other Army R&D processes run parallel to the TARGET roadmap and strengthen strategic project planning.



## TARGET

TARGET provides the operational roadmap for product and technology development by establishing logical work clusters and leveraging community best practices, including:

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

Refurbished M2A3 Bradley Fighting Vehicles line up prior to returning to the 2nd Battalion, 8th Cavalry Regiment, 1st Brigade Combat Team, 1st Cavalry Division, motorpool. RESET and RECAP programs are part of a system's lifecycle. Through systems engineering, we plot out how to make sure vehicles not only begin their service life with superior technology, but also maintain effectiveness throughout their service. (U.S. Army photo by 2LT Seth Model.)



For instance, Portfolio Management allows planners to evaluate each program to determine how it fits into the organization's overall portfolio. The integrated strategic planning process helps coordinate programs across ground systems and aligns acquisition and testing to other schedules.

The DOD's technology readiness level system — which measures a technology's progress toward being fielded — also has been synched to the Stage-Gate process.

To guide engineers through this construct, TARDEC's systems engineering team developed the systems engineering capability tool — a knowledge management tool used by the Army Knowledge Online/Defense Knowledge Online community. The systems engineering team aligned this capability tool to the TARGET process, giving systems engineers a framework for submitting the required data at the right time to comply with this efficient product development process

and work through the five gates. With the effective use of key facilitation tools, TACOM LCMC's engineers will begin to deliver critical new technologies that incorporate standardized systems engineering processes through the product's life cycle. TARDEC's Systems Engineering Process Team is also building the Interactive Reference Guide, a process asset library containing knowledge and best practice information with a "how-to" guide on systems engineering.

As the TARGET process matures, the content in the capability tool will be further refined and aligned to facilitate early implementation of systems engineering with rigor. These efforts will provide cutting-edge and potentially life-saving capabilities for the Current and Future Forces.

### **SYSTEMS ENGINEERING WORKSHOP**

Because of its adherence to the systems engineering process, TARDEC has become a trusted voice in this discipline. The organization's System Engineering group exercised its leadership role by

conducting a workshop to illustrate the variety of tools and services it can offer to its prominent customers in the ground vehicle enterprise.

The workshop focused on four main areas: requirements, risk, testing and evaluation, and configuration management. Our engineers explained the benefits of the Dynamic Object Oriented Requirement System and the Risk Recon tool (see sidebar) in managing the design process.

Systems engineering often takes years of experience to understand and execute properly. The workshop helped spotlight TARDEC as a one-stop shop for any customer who needs systems engineering services, saving both time and expense.

## OUR SYSTEMS ENGINEERING EXPERTISE



A Soldier performs preventive maintenance on an M2A2 Bradley Fighting Vehicle. By applying sound systems engineering processes, our engineers can ensure that product and technology development complements a balanced life cycle approach to meeting current and future Soldiers' vehicle requirements. (U.S. Air Force photo by TSgt Brian E. Christiansen.)

By coming to TARDEC for their systems engineering needs, our partners know they are tapping into a wealth of knowledge that will strengthen their programs and give them a greater chance of long-term success. Here's an overview of tools we offer that lead to the best results:

- ▶ The Dynamic Object Oriented Requirement System helps track a program's requirements.
- ▶ A Risk Recon tool 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.



# TECHNOLOGY FOCUS AREAS



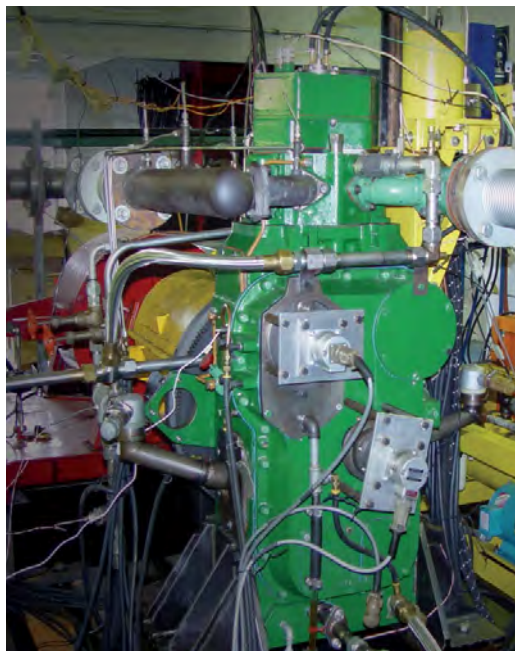
The Nation relies on our warfighters to ensure our security. In turn, warfighters depend on TARDEC and other R&D centers to provide them with the right tools and technology to maintain their decisive edge.

TARDEC delivers technological solutions in five focus areas: Ground Systems Survivability, Ground Vehicle Power & Mobility, Vehicle Electronics and Architecture, Ground Vehicle Robotics and Force Projection. Each area has made significant accomplishments driven by the skills and talents of world-class engineers, scientists and researchers who achieve faster solutions by collaborating with partners. Together, we never lose sight of our mission: to provide superior capability for current and future forces.

▶ A vehicle is prepared for testing in TARDEC's Full Load Cooling Test Chamber. The test chamber replicates climate conditions and allows engineers to test vehicles at high-temperature extremes. (U.S. Army TARDEC photo.)

## GROUND VEHICLE POWER AND MOBILITY: KEEPING THE ARMY ON THE MOVE

A top priority for GVPM is to develop fuel-efficient vehicle systems that power vehicles and electronics while maintaining performance that enables our Soldiers and Marines to succeed on the battlefield.



TARDEC's Single-Cylinder Engine Laboratory allows researchers to isolate cylinder combustion to better understand engine performance and behavior. Researchers are currently studying data gathered in the laboratory to understand how alternative fuels react during combustion events. (U.S. Army TARDEC photo.)

TARDEC is on the front line of meeting the strategic Army Energy Security Goals: reduce energy consumption (especially petroleum-based fuels), increase energy efficiency across platforms, increase our use of alternative and renewable energy, assure access to sufficient energy supplies, and reduce impact on the environment.

The energy storage team is developing a 28-volt lithium-ion (Li-ion) battery that offers better power density, more endurance and longer shelf life than the current 12-volt lead-acid batteries used in 95 percent of Army ground vehicles. The advanced Li-ion batteries will offer these improvements at the same size and weight as current lead-acid 6T batteries.

Non-primary power engineers help develop auxiliary power units to provide engine-off electrical power for vehicle electronics. These units could be instrumental in meeting the demands for power as necessary electronic devices are integrated into vehicles.

Whenever we load new electronic systems

onto a platform, we must recalibrate the balance of space, weight, power and cooling requirements. GVPM uses the Hybrid Electric Reconfigurable Movable Integration Testbed to obtain a clear picture of how electronic component integration affects these ratios before any new device is integrated.

GVPM also operates world-class laboratories, including an environmental chamber where researchers can test a vehicle system's durability and reliability in any climate and weather conditions.

The thermal management team conducts research into reducing heat in vehicle systems. We look for opportunities to coordinate these efforts with the Air Force and Navy, which have similar challenges in how to prevent heat from disrupting performance.

Other key initiatives at GVPM include improving tracks and suspensions for tracked vehicles such as the Abrams tank and Bradley Fighting Vehicle; advanced fluids research; and research into hybrid, electric and fuel cell technologies.



# EVENT FOCUS

## RENEWABLE ENERGY RODEO AND SYMPOSIUM: EVENT PROPELS OVERALL STRATEGY

Energy efficiency alone will not address the Army's challenges in the future. Forces and military bases alike need power and energy to be available, reliable, secure and mobile to conduct and sustain military operations.

The Renewable Energy Rodeo and Symposium (RERS) provided an important launching point for the Army and its partners to assess our strategy to meet current energy needs and project what our warfighters — and the Nation as a whole — will require to decisively reduce dependence on foreign oil and achieve energy security. We partnered with Fort Bliss, TX, to produce the RERS, on June 8-9, 2010.

During the 2-day event, more than 400 industry and government representatives gathered to discuss current energy challenges, view emerging technology demonstrations and work toward energy solutions for installations, forward operating bases and vehicle platforms.

Several of our own researchers, developers and scientists spoke on a variety of panels and showcased the work we do to improve fuel economy and provide power to our warfighters.

Renewable and alternative energy sources will play much larger roles in providing power to installations and vehicles as the Army resolves to consume less fossil fuel and improve efficiency with the sources we have. RERS played a connective role in the progression of steps as the Army brings its overall energy strategy into focus.

Previous to RERS, the Army Capabilities and Integration Command (ARCIC) issued a Power and Energy Strategy White Paper (April 2010) that provided a framework to guide development of power and energy capabilities supporting the Army's requirements ranging from current to long-term needs.

The Energy Rodeo came next, bringing together key players for discussions and demonstrations that heightened the focus on energy capabilities and

challenges. These steps parlayed into an Initial Capabilities Document (ICD), which clearly outlines the challenges for the Army and our partners. The ICD defines current capabilities, how to optimize our assets, capability gaps, and the status of research into new technology. The ICD presents the energy picture in practical, operational terms by looking at it from the perspective of a Brigade Combat Team and its supporting functions. In the field, we must determine how to supply power and energy to decentralized forces that conduct operations for extended periods of time and over extended distances.

Collaboratively studying all potential solutions and addressing incremental advancements is crucial to solving the bigger picture of reducing energy consumption and providing Soldiers with the power they need to stay effective. Our partnership with Ft. Bliss provided an opportunity for experts on both the installation and vehicle sides to dialogue and brainstorm solutions covering all areas of energy needs and allowed our industry and academic partners to view areas for collaboration and innovation.

The Advanced Ground Mobility Vehicle, displayed at the Renewable Energy Rodeo and Symposium, is a technology demonstrator with hybrid-electric drive and advanced/integrated survivability features. (U.S. Army TARDEC photo.)



### **GROUND VEHICLE ROBOTICS: KEEPING SOLDIERS FARTHER FROM DANGER**

Unmanned ground vehicles (UGVs) — robots — often relieve Soldiers from the dull, dirty and dangerous jobs they have to do.

For instance, UGVs have been deployed to the field to provide life-saving capabilities such as improvised explosive device (IED) removal, route clearance, chemical detection and enhanced surveillance that allows warfighters to complete important missions from safe distances.

Small UGVs equipped with cameras and grippers can locate a suspicious package on a roadside or in a building and then an operator can direct the robot to pick up and carry the object to another location. Soldiers can perform these tasks from a safe distance, often viewing the robot's activity on a computer screen. If an IED detonates and destroys a robot, the Army can replace it. A Soldier's life has far greater value.

TARDEC's Ground Vehicle Robotics (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. This team solves operational requirements that call for intelligent, autonomous ground systems capable of engaging threats while interacting with system operators. Through autonomous perception and navigation, intelligent tactical behavior, and command and control, GVR further develops the Army's ability to foresee and diagnose possible battlefield threats.

Examples include the Tanglefoot payload, developed with the Robotics Systems Joint Project Office and our industry partners, to provide systems with enhanced capabilities for recognizing and defeating IEDs. Through collaboration with industry partners we have also developed a Standoff Explosive Detection System that uses chemical, biological and explosive sensors to assist in explosive ordnance detection in the

field. New understanding of batteries for robotics systems allow us to equip platforms with enhanced capabilities, such as extended surveillance.

TARDEC has also made advances in autonomous vehicles that can perform dangerous tasks, such as transportation of ammunition or supplies, casualty evacuation, remote deployment of smaller UGVs and unmanned aerial vehicles, and large scale IED removal. Construction machines can also be operated remotely while maintaining all the functions of a manned multi-purpose loader.

The Autonomous Platform Demonstrator (APD) is a nine-ton, 6-wheel-drive, skid-steer vehicle that can travel at speeds up to 50 mph. In collaboration with Carnegie Mellon University, TARDEC engineers designed the APD to develop, integrate and test next-generation unmanned ground vehicle technologies, including hybrid-electric drive systems, advanced suspension technologies, thermal management systems, power management systems and UGV safety systems.



## ARMY APPOINTS FIRST SENIOR RESEARCH SCIENTIST FOR ROBOTICS

In July 2010, the Army issued a Capability Development Document that calls for common robotic platforms, rather than stand-alone systems, that fit into five modular ground robotics capability sets:

- ▶ Soldier transportable systems — Small and light enough for one person to carry.
- ▶ Crew served — The robot's operational system can be carried by two or more Soldiers.
- ▶ Vehicle transportable — Larger robots transported by another vehicle.
- ▶ Self-transportable — Autonomous

systems that drive themselves to the task, including Soldier follower models, medium wingman for small brigades, and heavy wingman for heavy brigades.

- ▶ Applique systems — Add-on systems that provide unmanned capability to a current manned vehicle.

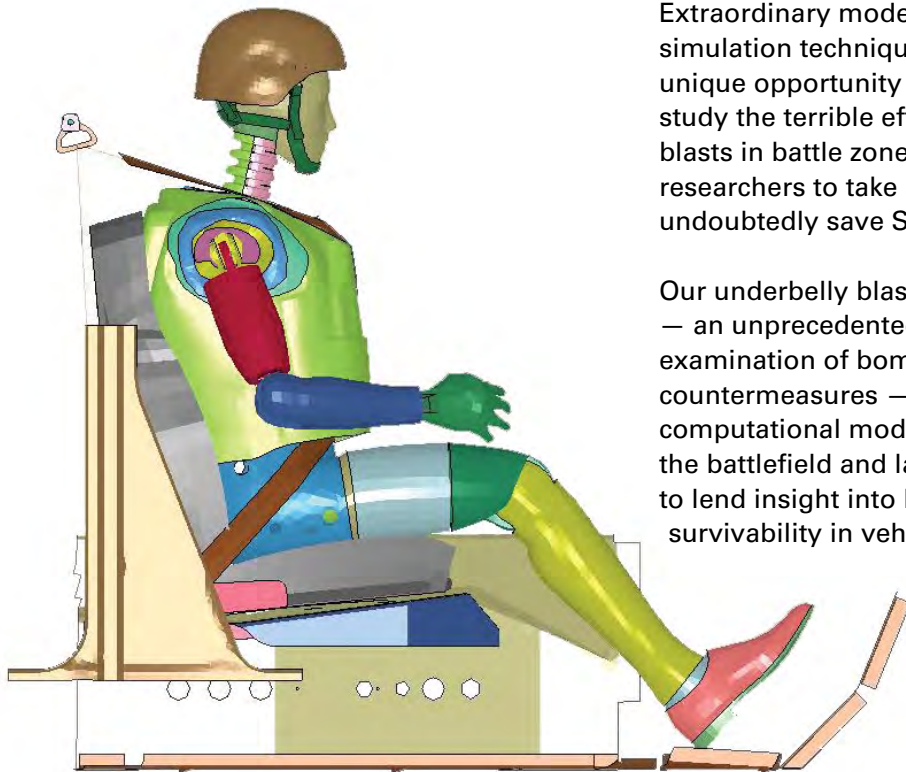
Moving forward, we continue to work with our collaborative partners to pursue advancements in system power, weight and autonomy, leading to developments that continue to protect, unburden and empower our warfighters.



A small UGV undergoes battery testing on a test course in Clinton Township, MI. Advancing these systems' batteries will allow for greater power and enhanced technology to be integrated onto platforms. (U.S. Army TARDEC photo.)

Recognizing the critical support UGVs provide, this year the Army appointed TARDEC's Dr. Jim Overholt as Senior Research Scientist (SRS) in the field of robotics. The SRS will shape the Army's strategic vision for robotics, lead research efforts and provide the DOD with expertise in this ever-developing field. This new position underscores the importance of unmanned systems to our warfighters, as well as TARDEC's position as the focal point for all DOD ground robotics systems.

With more than 25 years experience in military robotics, Overholt is a recognized leader in the field of unmanned systems and artificial intelligence and has been instrumental in efforts to inspire young people to pursue careers in the engineering disciplines.



### GROUND SYSTEMS SURVIVABILITY: KEEPING SOLDIERS SAFE

Extraordinary modeling and simulation techniques provided a unique opportunity for TARDEC to study the terrible effects of bomb blasts in battle zones, allowing our researchers to take action that will undoubtedly save Soldiers' lives.

Our underbelly blast simulation studies — an unprecedented end-to-end examination of bombing events and countermeasures — used advanced computational models, real data from the battlefield and lab demonstrations to lend insight into how to improve survivability in vehicles. Explosions

happen in the blink of an eye. But the 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. 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 in war zones. A better understanding of blast events allows us to design vehicles from the inside out as we devote our energy to maximizing occupant safety. TARDEC also participated in the Tactical Wheeled Vehicle Survivability (TWVS) Program, which studied the aboveground effects of buried mines. We're now focusing on integrating the resulting survivability technologies in combat vehicles.

TARDEC continues to conduct other Soldier-centric studies with a simple question to guide us — how can we better protect our warfighters? Our Nondestructive Testing and Evaluation Laboratory, along with the survivability



and Ballistics Laboratory, allow us to study the properties of armor and gather the information needed to make our vehicles the most survivable in the world.

### **FORCE PROJECTION: KEEPING RESOURCES FLOWING TO FIELD**

Lack of fuel and water can halt a military unit in its tracks. As the DOD's executive agent for fuels and lubricants, and the lead for water supplies, TARDEC maintains a broad role in moving forces across the battlefield. TARDEC conducts research, development and engineering support for route clearance, all ground fuels and lubricants, water purification and handling, military bridging, materiel handling, mechanical countermine and counter-IED equipment.

TARDEC plays a key role in qualifying alternative fuels and lubricants for ground vehicles. Advances include kerosene-based blends of jet propellant 8 (JP-8), which are being tested for future use in Army ground vehicles. TARDEC scientists have also developed "green" grease



An Airman waits to fuel another vehicle at Kirkuk Regional Air Base, Iraq. Petroleum, oil, and lube troops are part of the Force Projection chain, providing support to surrounding forward operating bases as well as Army and Air Force operations. (USAF Photo by SrA Bradley A. Lail.)

— a multipurpose, biodegradable lubricating grease that is less toxic to the environment and meets Army field requirements for performance.

Before Soldiers put a drop of fuel or fluid in their vehicles or burn oil at a base, the Army Petroleum Laboratory

(APL) has tested and approved the material for quality assurance. The APL, which operates under TARDEC supervision, tested more than 7,000 samples last year to validate the fuels, fluids, filters and lubricants used in ground vehicles, along with oils and coal used at facilities.

## VEHICLE ELECTRONICS AND ARCHITECTURE: KEEPING THE ARMY WIRED

Combat units that need to stay mobile and monitor enemy movements use an increasing array of electronic devices to gain an advantage. But the computer infrastructure that enables Soldiers and Marines to communicate with each other on missions, conduct surveillance and gather intelligence also poses challenges in space, weight, power and cooling demands.

Our Vehicle Electronics and Architecture (VEA) team provides new technology solutions for ground vehicle systems, including support structure for in-vehicle electronics, software compatibility and electrical power management.

VEA faces the challenge of inserting the information technology our Soldiers need without compromising vehicle mobility, power and performance. In addition to providing this digital component of warfare, the VEA team focuses on developing a common

standard to integrate data networks, electronics and power requirements across the ground vehicle fleet. Establishing this common approach offers a guide for contractors so we're all building these capabilities using the same basic blueprint.

With the Software Engineering Center's expertise in programming multiple functions to appear on one display screen, the VEA integrates the hardware and software to provide the digital capability to conduct command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) activities. We refer to this common infrastructure approach to accommodate electronic functions as the Digital Backbone of the vehicle.

An example of successful integration is the Mine Resistant Ambush Protected vehicle's (MRAP's) Digital Backbone. Using a gated process with project analysis phased in at key intervals, TARDEC engineers helped design common packaging of

software and architecture for several variations of the MRAP and MRAP All-Terrain Vehicles (M-ATVs).

Over the past year, VEA has spearheaded two other major projects. It helped develop the VICTORY architecture (see item on page 49), which standardizes the approach to in-vehicle electronics and provides an antidote to the "bolt-on" plan. VEA also manages a systems integration laboratory (SIL), which centralizes the Army's method of integrating vehicle electronics for all platforms.

VEA also focuses on how to add always-evolving new technologies and thermal management for vehicle modernization programs. The team has become DOD's first choice for technology and engineering expertise to provide vehicle electronics integration, research and application.

# EVENT FOCUS

## **PARTNERSHIPS FORGED AT GROUND VEHICLE SYSTEMS ENGINEERING AND TECHNOLOGY SYMPOSIUM**

When TARDEC works with collaborative partners, it accomplishes more, and usually at a faster rate. When TARDEC strengthens those relationships with an event like the Ground Vehicle Systems Engineering and Technology Symposium (GVSETS), warfighters benefit from the outcome.

The second annual GVSETS brought together about 1,200 members of government, industry and academia to reinforce our collaborative relationships. GVSETS has become a must-attend event for the Ground Systems Enterprise, giving this community a snapshot of the progress we've made in our joint ventures as we develop technology to help the warfighter and prompting an exchange of ideas that leads us to future projects and solutions.

GVSETS consisted of three days of presentations, panel discussions and technical papers. About 300 papers were submitted for the 2010

conference — an 84 percent increase over the previous year's event. A panel of reviewers (a mix of government, industry and academic experts) selected more than 100 papers to formally present at the five mini-symposia.

The presenters spoke to groups in separate mini-symposia in the following subject areas:

- ▶ Modeling and Simulation, Testing and Validation
- ▶ Power and Energy
- ▶ Robotic Systems
- ▶ Systems Engineering and Integration
- ▶ Vehicle Electronics and Architecture.

An astounding 98 percent of GVSETS attendees surveyed said they plan to use the published technical papers for future reference.

TARDEC and TACOM LCMC leaders and staff were among the 400 government employees at the conference. Other Army research and development agencies participated as well, including members of the Communications-Electronics

Research, Development and Engineering Center (CERDEC), Program Executive Office (PEO) Ground Combat Systems, PEO Combat Support and Combat Service Support, PEO Ground Combat Systems, PEO Land Systems (U.S. Marine Corps).

The event also featured more than 80 exhibits, which provided an educational forum for both attendees and exhibitors, and allowed us to explore more potential collaborations.

This type of networking is one of the primary GVSETS objectives, and why we stay engaged with our partners in the event — the National Defense Industrial Association (NDIA) Michigan Chapter and the Engineering Society of Detroit.

Organizers are preparing for the 2011 GVSETS event, which is scheduled for Aug. 9–11 in Dearborn, MI. This event continues to fulfill its objective of bringing together professionals from government, industry and academia for dialogue, discussions and networking to spark collaboration.

# RAPID WARFIGHTER SUPPORT: RESPONDING TO CALLS FROM THE FIELD

Part of the Soldier's Creed is "always place the mission first." In TARDEC's rapid warfighter support areas, we approach our work with the same mentality. This is where projects are not measured in years, but in weeks. Two groups respond to these urgent battlefield situations: the Quick Reaction Cell (QRC) and Center for Ground Vehicle Development and Integration (CGVDI). The Army's Training and Doctrine Command (TRADOC), which integrates capabilities to keep the Army adaptable, supports these rapid response missions.

Combat conditions can change rapidly, and our engineers and technicians have to duly respond and fill technology gaps. When a request based on warfighter feedback comes from the theater of conflict, we act quickly. We have seen firsthand the damage done to attacked vehicles and we know our forces face resourceful enemies and need countermeasures as urgently as possible.

## QUICK REACTION CELL

When Soldiers need an immediate solution to eliminate a recurring threat and potentially save lives, they send requests to the QRC. These requests for technological remedies come directly from the field. The QRC then evaluates the requirements, coordinates resources to deliver mission-enhancing technologies to Soldiers and Marines, and provides a solution that offers the best possible battlefield protection in the quickest amount of time.

Officially, the QRC serves as point of entry for Requests for Information (RFI) from the Area of Operations (AO), tracking Joint Urgent Operational Needs Statements and Operational Needs Statements. In addition to providing technology support to warfighters, the QRC dispenses the latest technical data and information updates to the AO. The QRC receives 20–30 RFIs each month. At any given time, the QRC is actively working on approximately 16 RFIs, completing an average of 128 per year with a completion rate of 84 percent.

The QRC builds strong relationships with the Program Management Offices and other Research, Development and Engineering Centers to align the best integrated solutions.

Some 2010 QRC projects included:

- ▶ Adding a cable or cord that runs from the seat handle to the Stryker's rear that, when pulled, lowers the seat so the driver can be pulled free or moves the seat for egress.
- ▶ Moving the fire extinguisher and compressed air canisters currently situated near passengers' faces on Panther MRAPs and creating a shield in case a can is punctured.
- ▶ Adding a Forward Repair System pre-stocked with a petroleum, oil and lubricants.
- ▶ Developing a way to more rapidly charge the nitrogen bottles under the Stryker's floor that adjust its ride height and suspension. The previous charging process was an all-day effort.
- ▶ Reducing maintenance issues by developing an adequate drainage system from the



center channel of the pneumatic control water valve switch under the RG-33L MRAP's floor.

- ▶ Mounting Vehicle Optics Sensor Systems appliqué on Stryker Infantry Carrier Vehicles for intelligence, surveillance and reconnaissance tasks.

### CENTER FOR GROUND VEHICLE DEVELOPMENT AND INTEGRATION

The CGVDI combines our design and prototyping abilities with exceptional integration expertise — often extending beyond vehicle technologies. The CGVDI provides a litany of RD&E services for the ground vehicle community.

The Center provides a single point of contact for the materiel solution design, fabrication, integration and support of ground vehicle technologies. Using an expedited systems engineering process, the CGVDI's primary role is to integrate the required organizations into a single, coordinate effort to manage cost, schedule, performance and risk.

CGVDI reaches out to various stakeholders, such as the Research,

Development and Engineering Command (RDECOM) laboratories, engineering centers and test community, and other DOD organizations, which dramatically enhances our ability to quickly develop tactical upgrades and deliver them to the battlefield.

Collectively, the CGVDI's developments and improvements sustain top-notch tactical equipment in the field and better ensure warfighters' safety. The team was honored for meeting distinctive rapid requirements to support the Army's mission with the following programs:

- ▶ Add-on-Armor Kit
- ▶ MRAP vehicle Expedient Armor Program Kit
- ▶ MRAP vehicle Gunner Restraint System
- ▶ Adapter brackets for the Self-Protective Adaptive Roller Kit (SPARK)
- ▶ Tip-Over Antenna Mount
- ▶ High Mobility Multipurpose Wheeled Vehicle (HMMWV) Egress Assistance Trainer (HEAT).

## HIGHLIGHTS

### ▶ **Thrown Object Protection System:**

The TOPS Kit uses engineering technology from across DOD to defeat thrown explosives. The kit employs a series of brackets, netting and an extendable, swinging pole to deflect or disrupt thrown explosives and prevent them from exploding where they cause the most damage to a vehicle and its occupants. This year, TARDEC was recognized with an RDA Award for Outstanding Collaboration with Army Research Laboratory (ARL) in development of TOPS.

- ▶ **MRAP Blade:** The MRAP Blade is a small blade that pushes loose dirt back into the crater left from an IED explosion, returning the road to a usable condition for follow-on vehicles. This technology attaches to RG-31 SPARK mounts and allows the spreading of eight yards of debris in a few minutes, reducing the time Soldiers are exposed to potential threats while filling in craters manually.



# CONNECTING WITH THE WARFIGHTER

## INTERACTION AT WALTER REED ARMY MEDICAL CENTER DEFINES OUR PURPOSE

The dedication of TARDEC's senior leaders and their commitment to our warfighters has never been in doubt. But even the most vigilant executives can benefit from a reinforcement of purpose. This was our intent when we visited the Walter Reed Army Medical Center (WRAMC) in Washington D.C. What we experienced that day was an appointment with clarity. When you meet a Soldier with an artificial limb or others who suffered combat injuries that changed their lives, their sacrifices are strikingly immediate.

We use terms like "theater" and "fielded" to describe where our people and technology go. But those words cannot convey the reality of the contribution we get from these brave, selfless men and women, who are personally affected by the destruction caused by an IED or RPG. We were witnesses to their sacrifice. And that's the reason for everything we do at TARDEC. That's why we planned this trip — to meet injured warfighters and remind ourselves of the risk involved in performing their duties. This kind of visit has a persistent and galvanizing impact

on our people, sharpening their focus on our purpose throughout the year.

## HEARING IT FIRSTHAND

Face-to-face interaction with warfighters is an invaluable part of our work. In order to develop, improve and deploy technologies and capabilities that keep our Soldiers safe, we must regularly conduct these exchanges.

WRAMC is the DoD's largest military hospital, providing care to more than 150,000 service members and retirees annually. We met with a number of wounded warriors and their families in May 2010. These returning Soldiers suffered their injuries in a variety of incidents, ranging from vehicle-related rollovers and mine blasts to dismounted combat operations. But they all sustained these injuries while protecting our interests in hostile places.

The Soldiers candidly shared how combat and tactical vehicles served them in the field and suggested ways to make these vehicles even more mission-effective. The Soldiers were impressed with the technological improvements in vehicle survivability over the course of their deployments.

## WOUNDED WARRIOR VISITS TARDEC

The exchange didn't end there. We invited SGT Robert Samuel to take a two-day tour through TACOM LCMC and the TARDEC laboratories to speak one-on-one with our researchers, engineers and scientists and view the work they're doing to support the other men and women serving the country. SGT Samuel lost his left leg below the knee, and suffered a shattered right foot and broken left arm in an IED explosion in Afghanistan.

When asked what stood out most during his tour, Samuel cited his time in our Modeling and Simulation lab and his conversations with our survivability team. "The 3-D work that is going on is fascinating," Samuel remarked. "It was interesting also to get a look at the ballistic work being done ... not too many people get to see the things I saw in the labs."

Opportunities like these reinforce our commitment to warfighters and remind us of the responsibility we have each day to keep them safe.



# ***EFFECTIVE COLLABORATION***





## WORKING WITH THE USMC

From a ground systems perspective, the U.S. Army and U.S. Marine Corps (USMC) share many interests and strategic objectives, and coordination of these efforts will inevitably make the smartest use of resources and benefit both services. In FY10, TARDEC continued its efforts to forge a critical partnership with the USMC through Joint projects that strengthen our life-cycle technology planning and management.

Army engineers from TARDEC, PEO Ground Combat Systems (PEO GCS) and PEO Combat Support and Combat Support Systems (PEO CS & CSS) will work closely with the USMC's PEO Land Systems (PEO LS) to develop technology that keeps Soldiers and Marines mobile, lethal and better protected.

The Army and Marines began drafting the Memorandum of Understanding to launch the Joint Center for Ground Vehicles (JCGV), which is

designed to foster better working relationships and outcomes. The JCGV will create efficiencies by consolidating resources and focusing efforts between the services. Each organization will contribute its resources and expertise to improve on the efforts that already exist and avoid duplication. Soldiers and Marines often go to battle side-by-side and they expect their civilian support services to act in the same spirit.

Army and USMC engineers have been working together on at least three prominent joint projects. We helped engineer rapid enhancements for the MRAP All Terrain Vehicle (M-ATV) and continue collaborating on improvements. The services are also combining their strengths to build and test the Joint Light Tactical Vehicle (JLTV).

Also, because we both have a significant stake in how unmanned ground vehicles interact with Soldiers and Marines in combat

zones, we work as a team in the Robotic Systems Joint Project Office (RS JPO), which leads the development, systems engineering, integration, acquisition, testing, fielding and sustainment of robots.

We recognize where we can share skills and facilities, where we can act more effectively together than parallel to each other, and we're dedicated to giving Soldiers and Marines the best technology and capabilities available.

 A convoy of USMC MRAP vehicles drives down a road near Camp Leatherneck, Afghanistan. Joint projects combining Army and USMC engineering teams, such as the MRAP program, has proven beneficial to both services. (USMC photo by Lance Cpl. Samantha H. Arrington.)

# VISITS FROM ARMY LEADERSHIP

## LEADERS SEE TARDEC'S MISSION AS VITAL TO THE ARMY

Under Secretary of the Army Joseph W. Westphal commended TARDEC for "the scope, breadth and comprehensive nature of their work."

Vice Chief of Staff of the Army GEN Peter Chiarelli declared: "The organization's capabilities are impressive, especially at the systems level. Work being done here in southeastern Michigan is bringing forward the assets the U.S. Army needs around the world."

These endorsements are imperative to our ability to combine the people, expertise and laboratory research space to compress development cycles and deliver the most technologically advanced and integrated ground vehicle systems to our Nation's warfighters.

Our mission has always been to give the warfighter a decisive advantage on the ground. But we cannot adequately execute that mission without the trust and complete confidence of the leaders at the top level of Army command.

Visits throughout the year by VIPs such as Dr. Westphal, GEN Chiarelli, GEN Ann E. Dunwoody and MG Nick Justice reaffirm TARDEC's value to the Army and establish the high-level support and advocacy we need to perform at our best.

Everyone at TARDEC was proud that Westphal and these important leaders took the time to personally meet with our talented people, learn about our knowledge base and see the innovation, research and testing capabilities performed here.

During his visit, Dr. Westphal observed: "The work that's being done here is essential to not only the current missions but pretty essential to how we modernize the Army and how best we move this equipping of the Army forward into the future. I didn't realize they were focused on so many aspects of the fleet and looking at everything from energy, to structure and mobility and so forth."

After touring TARDEC, Westphal went behind the scenes with collaborative partners General Motors Corp. and

Ford Motor Co., accompanied by U.S. Senator Carl Levin (D-MI), to assess the dual-use technologies being developed with the auto industry. The trip focused on three key areas that have the highest potential for partnerships and solutions with industry: meeting energy initiatives, cutting costs and helping better protect soldiers.

Chiarelli added that TARDEC's ventures with the auto industry are not only critical to defense, but also to the economy.



TARDEC Associate Director for Survivability Steve Knott (right) describes armor samples to (from left) Sen. Carl Levin and Under Secretary of the Army Joseph Westphal, who are flanked by TARDEC Executive Director for Product Development Thomas Mathes and Executive Director for Research and Technology Integration Jennifer Hitchcock. (U.S. Army TARDEC photo.)

### ARMY SCIENCE BOARD

The Secretary of the Army appoints an Army Science Board (ASB) — a panel of distinguished experts to serve as senior advisors to the highest levels of Army leadership. The ASB visited the Detroit Arsenal last year, and exchanged information and viewpoints with TARDEC executives and subject matter experts.

The ASB gathers input and advises the Secretary of the Army, Army Chief and Staff and other major Army commanders on science and technology matters. The board seeks out the best ideas and helps elevate them, identifies technology niches that otherwise may get overlooked, and targets future investments with a high payoff for effectiveness in the field and for the Nation at large. It also helps TARDEC determine where the research and development here fits into the overall Army policy and plans.

During their visit with TARDEC associates, ASB members inquired about researchers' progress on hybrid

technology, fuel efficiency, weight efficiency, alternative fuels and water purification. They discussed the issues of potential commercial off-the-shelf solutions for tactical needs, and how to coordinate efforts with TRADOC. Also, TARDEC addressed the challenges in modifying engine and transmission systems for military applications in an economical and competitive way, and how to incentivize private industry.

Initially chartered by the Department of the Army in 1977 under the Federal Advisory Committee Act, the ASB includes top-level advisors from the private sector, academia, non-DOD government agencies and former senior military officers.

## GENERAL APPROVAL



AMC Commanding General GEN Ann E. Dunwoody toured TARDEC facilities with RDECOM's Commanding General MG Nick Justice to meet face-to-face with our engineers, researchers and scientists early in 2010. Dunwoody stressed the importance of TARDEC's role in developing requirements for the Ground Combat Vehicle and in rapid acquisition — the Army's effort to shorten the concept-to-deployment timeline for new technology. High-level visits like this one show that Army leadership is supportive and engaged in our mission here. (U.S. Army TARDEC photo.)



## PARTNERSHIP WITH INDUSTRY



Former TARDEC Military Deputy COL Paul Lepine speaks with GM Executive Director of R&D Alan Taub during a visit to GM's Warren, MI, campus. Our engineers, scientists and technicians work closely with their industry counterparts to deliver relevant technology solutions for combat and tactical vehicle fleets. (Photo by Chuck Cloud, courtesy of GM.)

Partnerships with the private sector are an important part of our success and ability to provide Soldiers with the very latest technology advancements. Many technologies have been developed through collaboration with industry, and we are always in search of new partnership opportunities.

TARDEC's location in Southeast Michigan means many of those partnerships are with the automotive industry. We are often able to take advantage of the extensive automotive knowledge that surrounds us and leverage it to help develop dual-use technologies that are beneficial for both the auto industry and the military. These partnerships allow government and industry to share information, technology and capabilities to generate new developments that make vehicles lighter, safer and more energy-efficient.

Additionally, many TARDEC associates are members of professional, fraternal and alumni associations. These associations provide important

opportunities to exchange ideas and develop partnerships, leading to a stronger industrial and manufacturing base and giving government engineers a broader range of quality resources. Most importantly, technologies created through these partnerships contribute to the overall goal of empowering and unburdening our Soldiers.

#### **EVENT FOCUS: NORTH AMERICAN INTERNATIONAL AUTO SHOW AND SOCIETY OF AUTOMOTIVE ENGINEERS 2010 WORLD CONGRESS**

TARDEC participated in two premiere international automotive events in FY10: the North American International Auto Show (NAIAS) and the Society of Automotive Engineers (SAE) World Congress, both held in Detroit, MI. Each event draws thousands of visitors annually, showcasing the newest automotive trends and providing opportunities for dialogue. During these events, we displayed the Army's latest advancements in alternative energy technologies and highlighted the R&D work we're doing to improve fuel

efficiency and integrate renewable and alternative energy technologies onto ground vehicle platforms. At the SAE World Congress, our associates spoke on panels, presented technical papers and were engaged with working groups. This yearly event allows engineers to come together and exchange ideas.

Most importantly, these events allow us to form new partnerships and continue our collaboration with the automotive industry.



Rep. Nancy Pelosi (D-CA) (left) and TARDEC Director Dr. Grace Bochenek (center) listen as NAC Director Paul Skalny explains TARDEC's mission and commitment to warfighters during the 2010 NAIAS in Detroit, MI. (U.S. Army TARDEC photo.)

## **PARTNERING FOR INNOVATIVE SOLUTIONS**

In April 2010, TARDEC's Director, RDECOM's Deputy Commanding General (CG) and TRADOC's CG visited non-traditional automotive businesses in Southeast Michigan known for their innovative business practices. Each company had a performance racing background and was known for providing rapid solutions. This visit allowed us to speak with industry experts about their processes for efficiently and effectively overcoming challenges and identify several business approaches we could adopt to increase effectiveness.

Understanding both the differences and similarities between government and industry not only leads to better collaboration, but can also inspire a change in processes that speeds development cycles and creates efficiencies — which are two key Army objectives.

### **NATIONAL AUTOMOTIVE CENTER: CONNECTING TO INNOVATION**

As the catalyst linking industry, academia and government agencies, the National Automotive Center (NAC) serves as the Army's focal point for technology projects that benefit both commercial markets and the military.

Chartered by the Secretary of the Army in 1993, the NAC aligns resources to create joint efforts with the automotive industry and several other endeavors too. For instance, NAC members are working with the Navy, Air Force and private industry to develop and qualify (approve for military use) kerosene-based blends of synthetic and renewable alternative jet propellant 8 (JP-8) fuels for ground vehicles.

One of its most effective programs is the Hybrid Truck Users Forum (HTUF), which has encouraged the major commercial truck manufacturers to develop fuel-saving hybrid-electric and hybrid-

hydraulic systems for fleet vehicles. The Army plans to apply this proven technology to non-tactical work trucks on installations (see HTUF sidebar, next page).

The NAC also works closely with business groups, government organizations and laboratories to address technology gaps in areas such as advanced energy storage capabilities and advanced materials. In FY10, this collaborative drive resulted in an agreement among the NAC, Michigan Economic Development Corporation, Department of Energy and Oak Ridge National Laboratory. The partners formed a research group focusing on advanced materials development, energy conversion and storage technology, and bio-energy.

NAC researchers and an industry partner are also pursuing vehicle-to-grid technology, using a microgrid called the Electronic Power Control and Conditioning module to relay clean, consistent

electric power from a vehicle to a forward operating base in the field.

On the new ideas front, the NAC manages TARDEC's Small Business Innovation Research program, which solicits technology to help warfighters and increase small business participation in research and development.

The NAC also invites new ideas through its online Ground Vehicle Gateway, which allows small companies, inventors, university sources or even other government agencies to submit suggestions for possible joint projects with the Army (For more information see Appendix B).

The Maneuver Sustainment Vehicle leads the world's largest convoy of HE commercial trucks during the 2010 HTUF in Dearborn, MI. Lessons learned from commercial hybrid truck use will help integrate these vehicles into the Army's non-tactical fleets. (U.S. Army TARDEC photo.)





# EVENT FOCUS

## HYBRID TRUCK USERS FORUM SEPT. 28-30, 2010

The NAC initially launched HTUF to demonstrate hybrid truck efficiency and durability to the military by proving the technology in day-to-day, real-world conditions in the commercial market.

This year, at its 10th National Conference, HTUF celebrated its impressive

accomplishments and set new goals to keep the momentum rolling on hybrid technology adoption. The NAC and its nonprofit partner CALSTART, working under contract to the Army, estimate that HTUF has accelerated the acceptance of hybrid trucks by 18-24 months.

During this annual conference, HTUF Working Groups met to set key

performance parameters that guide manufacturers as they develop hybrid-electric and hybrid-hydraulic drive systems. The commercial truck market demonstrates the efficiency and durability of the technology in their daily rounds, and the Army will use that knowledge to place hybrid vehicles in non-tactical fleets on military bases.



# ACADEMIC PARTNERSHIPS: FINDING SOLUTIONS ON CAMPUS

The academic world and TARDEC have much to learn from each other. Our associates often engage directly with university researchers when working on specific technologies, such as automotive capabilities, materials and software development. The benefits of these collaborations are two-fold: they help us with problem-solving and allow us to inspire the next generation of engineers and scientists. Our work with colleges and universities raises awareness of rewarding high-tech careers for Army civilians.

In FY10, TARDEC had partnerships or agreements with universities from across the country, combining our skills on more than 200 projects (also see ARC sidebar, next page). These partnerships also have the power to lead to joint industry-university programs that achieve fundamental solutions to technological challenges.

Here are examples of important academic partnerships that, over the past fiscal year, have

allowed us to advance technology that supports the warfighter:

- ▶ Mississippi State University's Simulation Based Reliability and Safety (SimBRS) Consortium helps the Army examine its ground vehicles' toughest challenges. For example, an enhanced M&S code developed to monitor damage accumulation in vehicle tracks has led to a spinoff program for solving track problems.
- ▶ Our partnership with the University of Louisville's Vehicle Architecture Research Laboratory has produced the Concept & Modeling Tool Suite (CMTS). CMTS software may eventually show how effectively a new approach or idea satisfies the project requirements without having to build costly demonstrators or engage in lengthy, expensive tests.
- ▶ Lawrence Technological University's Center for Innovative Materials Research (CIMR) greatly expands TARDEC's ability to understand how elements affect Army vehicles in any

climate. Lawrence Tech offers a two-semester course in this specialty through a partnership with industry, TACOM LCMC and TARDEC.

- ▶ TARDEC's long-standing partnership with Virginia Tech's Center for Vehicle Systems and Safety has improved our understanding of terramechanics, which is the study of off-road vehicle capabilities. This research may prevent vehicle rollovers, for instance, which may save Soldiers' lives.

These academic partnerships allow us to leverage experts in academia to bring the brightest minds together across organizational borders to solve specific challenges.

The central surface combustion chamber at Lawrence Tech's CIMR can determine whether component parts or vehicle systems can withstand heat up to more than 2,000 degrees Fahrenheit and various amounts of force. This research is crucial in preparing vehicles for missions in extreme environments. (Photo courtesy of Lawrence Tech.)







## ***PARTNERSHIP WITH THE AUTOMOTIVE RESEARCH CENTER***

TARDEC also partners through the University of Michigan with the Automotive Research Center (ARC), which consists of a combination of academic researchers and government scientists. This university-based Army center of excellence allows TARDEC to advance the technology of high-fidelity M&S of military and civilian ground vehicles. The ARC's post-graduate students and ground systems engineers have achieved developments in vehicle dynamics and control; human centered M&S; high performance structures and materials; advanced and hybrid powertrains; vehicle system integration, optimization and robustness; and energy-efficient propulsion systems. This vital partnership provides us with M&S expertise, allowing us to better design vehicles and understand complex situations inside, outside and around our ground vehicle platforms.



# RESULTS OF SUCCESSFUL COLLABORATION

## TACTICAL WHEELED VEHICLE SURVIVABILITY

Underbody blasts, IEDs, rocket-propelled grenades, and direct — or even indirect — artillery fire all pose threats to military trucks and their crews. In the past, the Army often integrated survivability technologies on vehicles in an ad hoc manner, creating burdensome power demands, decreased mobility and maneuverability, and increased need for thermal management, among other challenges.

Government collaboration developed a truck survivability approach that could adapt to changing missions, threats and technologies and increase survivability on the underprotected tactical wheeled vehicles. The Tactical Wheeled Vehicle Survivability (TWVS) Army Technology Objective (ATO) demonstrated holistic survivability through the integration of cutting-edge technology solutions on a versatile demonstrator truck with plug-and-play capabilities. The program took the Army's survivability layer methodology and expanded it to include encounter avoidance.

To allow all new and existing technologies to communicate with one another, the program leveraged the vehicular integration for command, control, communications, computers, intelligence, surveillance and reconnaissance/electronic warfare (C4ISR/EW) interoperability (VICTORY) architecture, which streamlines and prioritizes data, allowing the driver and commander to share access to the information through common displays.

The TWVS ATO also advanced various technologies, found new ways to centralize vehicle power for the truck's subsystems, expanded the second-generation VICTORY architecture and yielded Technology Readiness Level 6 armors. TARDEC and ARL were recognized with an RDA Award for their collaboration on the TWVS ATO.



## VICTORY

Electronics are vital to vehicle effectiveness, maneuverability and survivability. The VICTORY program takes a strategic approach toward an integrated, network-centric method of managing electronic assets in a combat vehicle.

Comprised of PEO Command Control Communications-Tactical, the U.S. Army Communications-Electronics Research, Development

and Engineering Center and PEO CS&CSS, VICTORY is focused on designing an open, flexible and adaptable electronic architecture that eliminates redundancies, reducing space, weight, power and cooling demands and cost. This network-based system can be exported into other vehicle platforms, following a systems integration approach. TARDEC's role is to assess the best way to apply the VICTORY architecture to future tactical wheeled vehicles and subsystems.

The effort also demonstrates the Army's ability to activate partnerships among agencies to work toward the same goal. The VICTORY team is working with PEO Ground Combat Systems (GCS) and the Stryker Brigade Combat Team to provide a demonstrator platform for the new system.

▶ The Integrated Survivability Demonstrator (ISD) was the result of four years of partnership and cooperation between government and industry. The ISD has 50 survivability technologies integrated onto it and will play an important role in protecting our warfighters. (U.S. Army TARDEC photo.)

A Soldier executes pre-combat checks on one of his vehicle's communications systems. ▶ Minimizing redundancies and maximizing space claims with vehicle electronics are key to helping Soldiers use their available technologies to the fullest. The VICTORY architecture is one of the many ways TARDEC and its partners have improved these capabilities for Soldiers. (U.S. Army photo by SPC Shannon Black.)



### JOINT LIGHT TACTICAL VEHICLE

The JLTV is the future ground vehicle for the U.S. Army and USMC. Led by PEO CS&CSS's Product Manager JLTV with support from manufacturers, as well as TARDEC, the vehicle features advanced technology and capabilities that will benefit deployed Soldiers and Marines. JLTV offers the maneuverability of an HMMWV with protection similar to an MRAP and new technology integrated to enhance vehicle capabilities. The

JLTV's joint protection requirements are designed to meet warfighters' current and future survivability needs in a mobile, transportable and expeditionary vehicle solution.

In addition to technological advances, JLTV is an example of successful collaboration between government and industry partners, with all program phases demonstrating transparency and open communication.

### FUEL EFFICIENT GROUND VEHICLE DEMONSTRATOR

FED is a bold new approach designed to address the Army's energy challenge and improve vehicle fuel efficiency. TARDEC and its industry partners designed two demonstrator vehicles — FED Alpha and FED Bravo — using two different engineering approaches, with the common objective of validating fuel-efficient systems and components that can be transferred to existing ground vehicle



◀ Pictured here is a JLTV at Aberdeen Proving Ground's Churchville Test Area in Churchville, MD. The JLTV features cutting-edge export power, power generation and electrical capabilities. (U.S. Army photo.)

The FED Alpha, put through the paces during testing in Chelsea, MI, will play a key role in improving fuel efficiency for Army ground vehicles. (U.S. Army TARDEC photo.) ▶



platforms. With a combined potential to boost the Army's fuel economy by approximately 70 percent, the vehicles will play a pivotal role in managing overall energy costs.

FED Alpha followed a traditional, top-down systems engineering approach, while FED Bravo was conceived in a more open-ended "Monster Garage" approach that borrowed the former cable TV show's brainstorming method. FED Alpha was constructed and unveiled in late 2010, and FED Bravo is scheduled to be built and tested in 2011.

Both vehicles represent a new threshold in collaboration, as industry partners and universities worked with TARDEC engineers to contribute the strongest ideas and most efficient parts and design elements to the final product. The new systems engineering and systems integration techniques developed through this program can be applied to other TARDEC projects to foster innovation and best practices.



## JOINT CENTER FOR GROUND VEHICLES

Creating a single voice for ground vehicle research, development and integration leads to better information sharing, which, in turn, leads to better decision-making at all levels. To that end, members of the TACOM LCMC developed a structure that allows them to institutionalize systems integration excellence and collaborative enterprise-level planning and portfolio alignment to achieve the best value in ground systems acquisition programs for the warfighter.

JCGV was established collaboratively by organizations within the TACOM LCMC, including PEO GCS, PEO CS&CSS and TARDEC in conjunction with PEO LS and Marine Corps Systems Command, under the 2005 Base Realignment and Closure report's authority, which mandated the formation of a joint Army and USMC ground vehicle center. It provides the centralized governance needed to collaboratively manage the enterprise



portfolio, synchronize technology development, establish common goals and principles, drive efficiencies and foster open communication.

The JCGV will help strengthen the ties among the TACOM LCMC partners, and it will function and serve as the means by which we achieve much of the Materiel Enterprise concept.

▲ A Landing Craft Air Cushion vehicle and a Light Armored Vehicle (LAV) come ashore during a training exercise. The LAV is one of the first vehicles that TARDEC and the USMC have collaborated on to improve Marines' capabilities. Continued partnerships will help support the Joint Force and demonstrate TARDEC's role as a leader in ground vehicles. (U.S. Army photo by SSG Helen Searcy.)

► An MRAP is fitted with the OWM kit, which preserves both infrastructure and technology integrated onto the vehicle and serves as an example of how engineering collaboration can lead to rapid solutions. (U.S. Army photo.)



### OVERHEAD WIRE MITIGATION KIT

Designed for MRAP vehicles, the Overhead Wire Mitigation (OWM) kit provides electrocution protection and helps preserve local infrastructure. Previously, the vehicle's height caused its antennae to catch and pull down high-voltage wires, telephone wires and laundry lines while patrolling in the urban areas of Iraq. This resulted in Soldiers being exposed to electrocution threats from low-hanging wires, along with inconveniences to the local population. To alleviate this problem, the kit directs the wires up and over the MRAP, protecting both the infrastructure and the Soldiers.

The OWM kit is made from nonconductive and radio-frequency-transparent materials that prevent interference with other MRAP capabilities. It can be adapted to future technologies and accommodates the Remote Weapon Station and Boomerang sniper detection system. The newest kit, the Generation 3 Reversible, enables MRAPs to travel under low-hanging obstacles in reverse.





The kits use pre-existing hard points on the vehicle with no drilling required to mount them. Many pieces are commercial off-the-shelf items that are stored in bulk in theater. Installing the entire system requires only a ratchet set, hacksaw and a drill. In November 2010, the OWM Kit was recognized with a 2009 Army's Greatest Inventions Award.

### TANGLEFOOT PAYLOAD

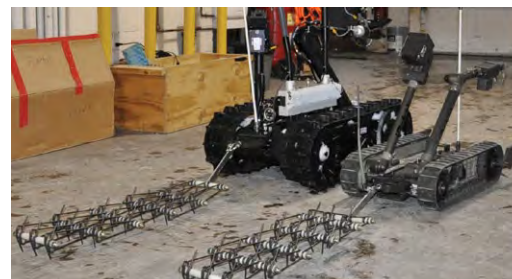
As part of our ongoing effort to better equip and protect Soldiers, our GVR team joined with the Robotic Systems Joint Project Office (RS JPO) and industry partners to develop, test and produce the Tanglefoot payload, which provides robotic systems with enhanced capabilities for recognizing and defeating threats. GVR and RS JPO designed a payload system to accommodate small UGVs — a three-month effort that included systems engineering, testing, logistics and training.

Tanglefoot incorporates a payload interface kit, wire rake and mast and serves as a simple, universal

and low-cost method to assist with route clearance and dismounted maneuver support elements. The Tanglefoot attachment can be implemented on all robotic platforms being used in the field.

Field units have been pegged to receive individual payloads to assist Soldier operations. GVR and RS JPO continue to monitor the technology's performance, incident reports and recommendations for improvement or change requests. Further research is planned for advancing the solution for high speed, performance and other operational utilities.

The project underscores the importance of collaboration, as GVR rapidly developed and tested the device and transferred it to RS JPO for fielding, allowing our warfighters to receive the equipment they need. As the Tanglefoot payload's research continues, we intend to work cooperatively with other government partners to produce unmanned systems that detect and defeat threats.



The Tanglefoot attachment can detect and destroy IED threats, preventing risk to warfighters. Here, the technology is attached to medium and small UGVs — just two robotic platforms on which the technology may be deployed. (U.S. Army TARDEC photo.)

## ABOVE AND BEYOND

In addition to supporting our warfighters, TARDEC associates act as Army ambassadors and serve as role models for their colleagues and the community at large. Our associates demonstrate Army and TARDEC values at educational events, tradeshow, open houses, professional forums, in their charitable works and by showing good stewardship of our natural resources.

For instance, TARDEC associates actively support the Combined Federal Campaign, the world's largest annual workplace charity campaign. Our associates donate to eligible nonprofit groups that provide health and human services throughout the Nation and the world.

We also take great pride in our commitment to the environment, maintaining programs to make the Arsenal even more energy independent, increase on-base recycling and reduce waste. Our efforts have been recognized by an International Organization

for Standardization (ISO) 14001 Environmental Management System Surveillance Audit. ISO 14001:2004 is an internationally accepted standard devised to address the delicate balance between maintaining a thriving business and reducing environmental impact.

TARDEC also tries to do its part for the Michigan economy. We work with the regional authorities to help diversify the economy by attracting defense industry leaders to the Detroit area. Helping to develop a defense corridor here not only takes advantage of the area's considerable engineering expertise, but also helps generate jobs.

The defense and automotive industries share many technological interests, which is why this has been TARDEC's home for so long. Our people believe more strongly than ever that TARDEC is in the right place to accomplish its goals, and that this economy provides an exciting opportunity to grow.



TARDEC's Environmental Management System Communication Subgroup passed the ISO 14001:2004 EMS Surveillance Audit with zero findings of nonconformance. This is just one example of the way in which our associates strive for excellence and continue to be good stewards of environmental resources. Picture: (from left) Donna Leung, Darin Kennedy, Greg Rusch and Janis Caliguri. (U.S. Army TARDEC photo.)



***SUPPORTING THE  
FUTURE FORCE***





# DEVELOPING FUTURE SCIENTISTS

**As technology evolves, new threats arise and our warfighters conduct missions in challenging and unpredictable environments, we must be prepared to meet the needs of both the Current and Future Forces. The next generation of scientists and engineers must be prepared to meet the challenges that will face tomorrow's Soldiers.**

We maintain a firm commitment to work with academia at all levels, partnering with schools and districts to involve students from an early age in science and engineering related activities. We work with educators throughout Michigan to enhance the National Defense Education Program's Science, Technology, Engineering and Mathematics (STEM) efforts sponsored by the Office of the Secretary of Defense. These efforts encourage students to commit themselves to STEM education at a time when competition from other nations in this area is fierce. Our associates engage students through exhibits, demonstrations, competitions, career fairs and special

events, creating awareness of the diverse array of available Army S&T careers and advising them on educational paths that will help them reach their goals. Summer hire programs and internships provide high school and college students with firsthand career experience, involving them in projects that provide important support to our warfighters.

Whatever field these students find themselves in, developing a passion for STEM is crucial to our Nation's success. These skills will also equip our future workforce with the innovation and intelligence to address the challenges our Soldiers will face in the future.

## STUDENT PROGRAMS

Our Summer Hire Program plays a key role each year in developing the Army's future scientists, researchers and engineers. This program exposes high school and college students to the multiple engineering and technological applications that are critical to improving warfighter effectiveness. Summer hires are

actively involved in processes and projects, working closely with TARDEC associates and getting a hands-on learning experience.

This year, more than 800 students applied to the program and 77 were accepted. These students worked closely with associates throughout our focus areas in robotics, mobility, M&S and other disciplines. Of those 77 students, 25 were converted to Student Career positions when the program finished.

Our Student Temporary Employment Program (STEP) and Student Career Experience Program (SCEP) opportunities allow university students to work alongside our researchers, scientists, engineers and administrative personnel as they pursue their education. Throughout the year, approximately 50 STEP and SCEP participants are embedded in our teams, developing their skills and applying academic theories to meaningful, real-world programs, challenges and projects.

Bachelor of Science graduates can join our rigorous internship program. Tailored specifically to each participant's career path, this rotational program allows individuals to better understand the scope of TARDEC's work, acclimate to the workforce and prepare for possible career opportunities.

These programs offer real-world training and experience, enrich students' education and equip them to provide the capabilities that will support Soldiers now and in the future.

Elizabeth Barrios, a TARDEC STEP associate, monitors a distillation unit in the Fuels and Lubricants Physical and Chemical Properties Laboratory. Our Force Projection team ensures that the fuels, greases and lubricants used on Army ground vehicles keep our warfighters mobile. (U.S. Army RDECOM photo.)







**TARDEC's 2010 summer hires. Seventy-seven high school and college students worked alongside the organization's researchers, scientists and engineers on a number of important projects throughout our technology focus areas. The TARDEC Summer Hire Program is highly competitive, providing students with real-world experience and an opportunity to support our warfighters. (U.S. Army TARDEC photo.)**



## **WORKING WITH DETROIT PUBLIC SCHOOLS**

TARDEC has been involved in teaching, coaching and mentoring hundreds of Detroit Public Schools (DPS) students since our partnership began in 2002. Additionally, DPS students have received more than \$60,000 in awards from the U.S. Army eCYBERMISSION Science Contest. TARDEC also founded the USA/Canada K-12 Math/Science Teacher/Student Exchange Program, which allows educators and students to participate in an exchange to experience the other country's educational system and bring back lessons to improve their schools.

Within the DPS, we retain a strong partnership with Noble Elementary School. In 2009, the school asked us to begin a collaborative program for its students. The program was a joint effort between DPS, TARDEC and the TACOM LCMC that gives students insight into Army life and demonstrates how STEM topics can benefit students in their future careers.

Our continued partnership with DPS and other Michigan schools will help us prepare the next generation of engineers to serve our future Soldiers.

## **ROBOTICS EVENTS**

We understand the importance of cultivating inquisitive minds and encouraging students to pursue growing scientific fields, such as robotics. This year, TARDEC reinforced efforts to recruit and develop the next wave of scientists by sponsoring or co-sponsoring four student robotics events.

FIRST (For Inspiration and Recognition of Science and Technology) invites high school students to take on a new robotics challenge each year. In 2010, the teams had six weeks to prepare robots for a game called Breakaway — a soccer-like contest that required robots to climb obstacles to score goals. TARDEC is Michigan's largest supporter of FIRST.

Robotics, Engineering and Technology (RET) Week, held at Macomb

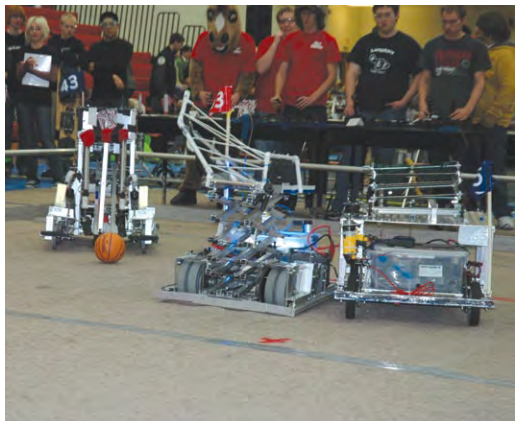
Community College in Warren, MI, invites students to learn about careers in robotics and engineering and see exhibits showing semiautonomous robotics. Many students participated in a robot-building challenge and viewed a FIRST demonstration.

Middle school students competed in a robotics competition at Maker Faire Detroit in Dearborn, MI, where do-it-yourself inventors displayed their creations. TARDEC was part of the RDECOM Strong Zone exhibition tent at the event, which sponsored the robotics competition.

College students faced off in the annual Intelligent Ground Vehicle Competition at Oakland University in Rochester Hills, MI, last summer. In this event, 58 teams from 47 different universities, representing five countries, guided robots through obstacle courses and scored points based on how many waypoints they reached in a six-minute time limit.



Fans of all ages enjoy the TARDEC Robotics Exhibit at the 2010 Maker Faire Festival. Guests used remote controls to maneuver robots in the RDECOM Strong Zone. These events introduce students to potential S&T careers. (U.S. Army TARDEC photo.)



▲ RET Week allowed our associates to provide local students with hands-on knowledge about robotics careers. Here, TARDEC Engineer Matt Skalny assists students at RET Week's Robofest Lego Robotics station. Robofest is a program designed for Middle School students to teach them about robotics technology. (U.S. Army TARDEC photo.)

▲ Teams compete during the Oakland County Competitive Robotics Association Championships Robotics in Holly, MI. TARDEC showcased several robotics ground systems and provided attendees with an overview of the capabilities that UGVs bring to the warfighter. (U.S. Army TARDEC photo.)



# ***CONCLUSION***





President Harry S. Truman once said: “America was built on courage, on imagination and an unbeatable determination to do the job at hand.”

Our Soldiers and Marines are still on the battlefield displaying courage every day. While our scientists, researchers and engineers have accomplished many notable objectives to help warfighters, as we have presented in this report, we know the struggle continues. And that’s why we must continue to show imagination and determination to complete the current job at hand and keep us strong in the future.


We won’t rest on our laurels. Our Nation’s Soldiers and Marines count on us to keep the momentum rolling on technological innovation and

improvements to ground systems deployed to war zones. As we look to the future, we know our work will become more important than ever. Alternative energy has become a priority. Fuel efficiency is essential to our energy security goals. Maintaining equal or better power and performance in our vehicles will continue to be a challenge — and we’re determined to meet it.

The renewed focus on systems engineering to streamline processes and work quickly but with superior quality compels us to show leadership in those skills. We also recognize the power of working with partners, and are consistently proving the validity of the concept that the sum is greater than any individual part. We align our technology portfolio with our

TACOM LCMC partners so that we are making the best decisions with financial resources in an era of doing more with the same allocation of resources. We will also continue to develop autonomous and unmanned ground vehicles, which can take on certain battlefield tasks to keep our warfighters out of harm’s way.

We invite these challenges — among others — and have not wavered in our commitment to provide the very best ground vehicles possible to the men and women in the fight. In fact, knowing that our work makes a difference to our Soldiers and Marines reinvigorates our sense of purpose each and every day.



A route clearance patrol vehicle with the 510th Clearance Company, 20th Engineer Battalion, pushes through a tight section of road next to a qalat wall near Kandahar City, Afghanistan. The vehicle uses the TARDEC-designed SPARK to protect against IEDs. (Photo by PO2 Ernesto Hernandez courtesy of the U.S. Army 20th Engineer Battalion.)

# APPENDIX A – TARDEC LABORATORIES, FACILITIES AND TEST EQUIPMENT

Advanced Collaborative Environments  
Laboratory/Immersive Virtual  
Environment Laboratory

Advanced Concepts Laboratory

Air Flow/Coolant System Component  
Evaluation Laboratory

Battery Technology Evaluation Laboratory

Cave Automatic Virtual Environment (CAVE)/  
Immersive Virtual Environment Laboratory

Center Guide Wear Research

Computer-Based Applications/Ground  
Vehicle Simulation Laboratory (GVSL)

Countermine Testing Complex Facility

Crew Station/Turret Motion  
Base Simulator/GVSL

Design and Digital Mock-Up Laboratory

Dynamic Structural Load  
Simulator Laboratory

Electric Components Evaluation Laboratory

Electronics and Prototyping Laboratory

Embedded Simulation Laboratory

Environmental Heat Management  
Chamber and Laboratory

Flexible Steady-State/Transient Vehicle  
Evaluation Test Cell and Laboratory

Laser Protection Materials  
Development Laboratory

Fuel Equipment Test Laboratory

Fuels and Lubricants Research  
Facility and Laboratory

Fuels and Lubricants Vehicle  
Filter Test Equipment

Fuels and Powertrain Lubricants Laboratory

Hydraulic Bushing Machine

Grease and Fluid Laboratory

GVSL Synthetic Environment

GVR Vehicle High Bay

Intelligent Mobility/Robotics Laboratory

Intelligent Systems System  
Integration Laboratory (SIL)

Lightweight Materials Test, Analysis  
and Prototype Fabrication Center

M1A2 SIL

Pervasive Computing Laboratory

Petroleum and Water Business Area  
Water Treatment Test Facility (Selfridge  
Air National Guard Base)

Physical Prototyping Laboratory

Pintle Motion Base Simulator/GVSL

Power & Energy SIL

PowerWall/Immersive Virtual  
Environment Laboratory

Propulsion System Component  
Test Cells and Laboratories

Reconfigurable Automatic Virtual  
Environment/Immersive Virtual  
Environment Laboratory

Reconfigurable N-Post Simulator/GVSL

Ride Motion Simulator/GVSL

Robotics SIL and Vehicle Bay

Signature Management Field  
Testing Equipment

Signature Management Virtual Design  
and Fabrication Laboratories

Single-Cylinder Engine Research  
Test Cell and Laboratory

Steady-State Vehicle Evaluation  
Test Cell and Laboratory

Steady/Transient State HE Propulsion  
Evaluation Test Cell and Lab

Surrogate Instrumented Mine Capability

T-130 Track Bushing Research

TARDEC High Performance Computing Center

Vehicle Inertia Properties Evaluation Rig/GVSL

Visual Perception Laboratory

Water Quality and Water Test Cell Laboratories

## 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

<b>AGI</b>	Army's Greatest Inventions	<b>FED</b>	Fuel Efficient ground vehicle Demonstrator
<b>AMC</b>	U.S. Army Materiel Command	<b>FIRST</b>	For Inspiration and Recognition of Science and Technology
<b>AO</b>	Area of Operations	<b>FY</b>	Fiscal Year
<b>ARC</b>	Automotive Research Center	<b>GCS</b>	Ground Combat Systems
<b>ARL</b>	Army Research Laboratory	<b>GVPM</b>	Ground Vehicle Power and Mobility
<b>ASB</b>	Army Science Board	<b>GVR</b>	Ground Vehicle Robotics
<b>ATO</b>	Army Technology Objective	<b>GVSETS</b>	Ground Vehicle Systems Engineering and Technology Symposium
<b>C4ISR/EW</b>	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance/Electronic Warfare	<b>HMMWV</b>	High Mobility Multipurpose Wheeled Vehicle
<b>CASSI</b>	Concepts, Analysis, Systems Simulation and Integration	<b>HTUF</b>	Hybrid Truck Users Forum
<b>CAVE</b>	Cave Automatic Virtual Environment	<b>IED</b>	Improvised explosive device
<b>CG</b>	Commanding General	<b>ILSC</b>	Integrated Logistics Support Center
<b>CGVDI</b>	Center for Ground Vehicle Development and Integration	<b>ISO</b>	International Organization for Standardization
<b>CMTS</b>	Concept and Modeling Tool Suite	<b>JCGV</b>	Joint Center for Ground Vehicles
<b>COTS</b>	Commercial off-the-shelf	<b>JLTV</b>	Joint Light Tactical Vehicle
<b>CRADA</b>	Cooperative Research and Development Agreement	<b>JP-8</b>	Jet propellant 8
<b>CS&amp;CSS</b>	Combat Support and Combat Service Support	<b>LCMC</b>	Life Cycle Management Command
<b>DOD</b>	Department of Defense	<b>Li-ion</b>	Lithium-ion
<b>DOE</b>	Department of Energy	<b>M&amp;S</b>	Modeling and Simulation
<b>DPS</b>	Detroit Public Schools	<b>M-ATV</b>	MRAP All-Terrain Vehicle
<b>EMS</b>	Environmental Management System	<b>MRAP</b>	Mine Resistant Ambush Protected vehicle
		<b>NAC</b>	National Automotive Center

<b>NAIAS</b>	North American International Auto Show	<b>STEP</b>	Student Temporary Employment Program
<b>OWM</b>	Overhead Wire Mitigation	<b>SWaP-C</b>	Size, weight, power and cooling
<b>PEO</b>	Program Executive Office	<b>TARDEC</b>	U.S. Army Tank Automotive Research, Development and Engineering Center
<b>PM</b>	Program Manager	<b>TARGET</b>	TARDEC Gated Evaluation Track
<b>QRC</b>	Quick Reaction Cell	<b>TOPS</b>	Thrown Object Protection System
<b>R&amp;D</b>	Research and Development	<b>TRADOC</b>	U.S. Army Training and Doctrine Command
<b>RDA</b>	Research and Development Achievement	<b>TWVS</b>	Tactical Wheeled Vehicle Survivability
<b>RD&amp;E</b>	Research, development and engineering	<b>UGV</b>	Unmanned Ground Vehicle
<b>RDEC</b>	Research, Development and Engineering Center	<b>USMC</b>	U.S. Marine Corps
<b>RDECOM</b>	U.S. Army Research, Development and Engineering Command	<b>VEA</b>	Vehicle Electronics and Architecture
<b>RERS</b>	Renewable Energy Rodeo and Symposium	<b>VICTORY</b>	Vehicular Integration for C4ISR/EW interoperability
<b>RFI</b>	Request for Information	<b>WRAMC</b>	Walter Reed Army Medical Center
<b>RS JPO</b>	Robotic Systems Joint Project Office	<b>WSARA</b>	Weapon Systems Acquisition Reform Act
<b>S&amp;T</b>	Science and Technology		
<b>SAE</b>	Society of Automotive Engineers		
<b>SBIR</b>	Small Business Innovation Research		
<b>SCEP</b>	Student Career Experience Program		
<b>SIL</b>	Systems Integration Laboratory		
<b>SME</b>	Subject matter expert		
<b>SPARK</b>	Self Protective Adaptive Roller Kit		
<b>STE</b>	Senior Technical Expert		
<b>STEM</b>	Science, Technology, Engineering and Mathematics		





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