ARL

U.S. ARMY RESEARCH LABORATORY

Annual Review 2011

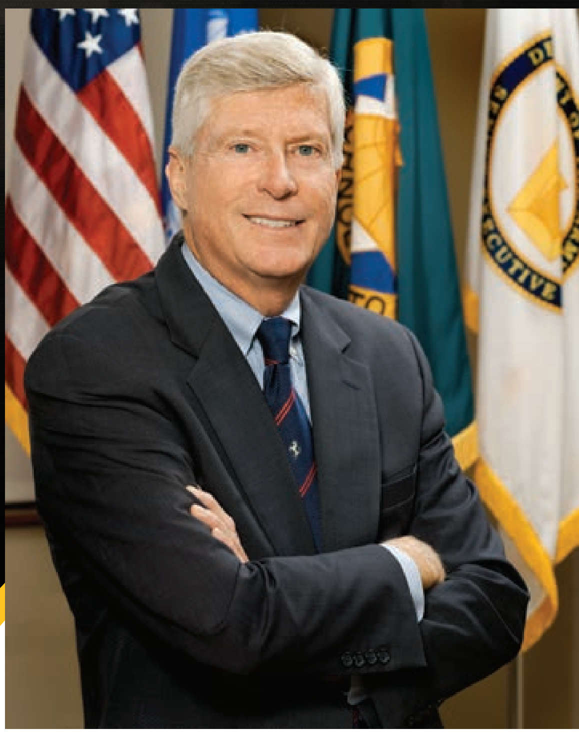
Many Minds, Many Capabilities,

Single Focus on the Soldier

Table of Contents

Welcome to the Fiscal Year 2011 edition of the U.S. Army Research Laboratory (ARL) Annual Review. This publication briefly describes who we are and highlights some of our significant scientific and technical achievements of the last year. The size of this organization – seven distinct directorates and offices with over two thousand military and civilian members – and the scope of research and analysis in which we are involved, limits us to select only a few items to present here as a representative sample of our overall accomplishments. ARL's research continuum stretches from early, long-term, basic research, to evolving new technologies, to supporting current operations. We organize our research and analysis efforts within ten Major Laboratory Programs (MLPs); Extramural Basic Research, Networks, Human Dimension, Lethality, Protection, Mobility, Power and Energy, Sensors, Survivability/Lethality Analysis and Simulation and Training Technology.

This review begins with an introduction that includes our organization, personnel, awards and other recognition earned by ARL and its personnel. The remainder of the publication is structured around the ten MLPs identified above. Again, the accomplishments presented here, while only a small sample of our efforts over the past year, are representative of the skill, dedication and teamwork of our in-house staff and our partners in academia and industry.



John M. Miller
Director, U.S. Army Research Laboratory

The Army Research Laboratory of the U.S. Army Research, Development and Engineering Command (RDECOM) is the Army's corporate laboratory. Its diverse assortment of unique facilities and dedicated workforce of government and private sector partners make up the largest source of world-class integrated research and analysis in the Army.

The mission of ARL is to "Provide the underpinning science, technology and analysis that enable full-spectrum operations." Within ARL we have teams working in partnership with the RDECs, Rapid Equip Force (REF), Joint Improvised Explosive Device Defeat Organization (JIEDDO), and others on the following tasks: current operational technical challenges facing Soldiers in Iraq (OND – Operation New Dawn) and Afghanistan (OEF – Operation Enduring Freedom), maturing and transitioning technologies in the two- to five-year timeframe for existing systems, and generating scientific discoveries that will provide the foundation for Soldier capabilities 15-20 years in the future.

Research, Development and Engineering Command (RDECOM)

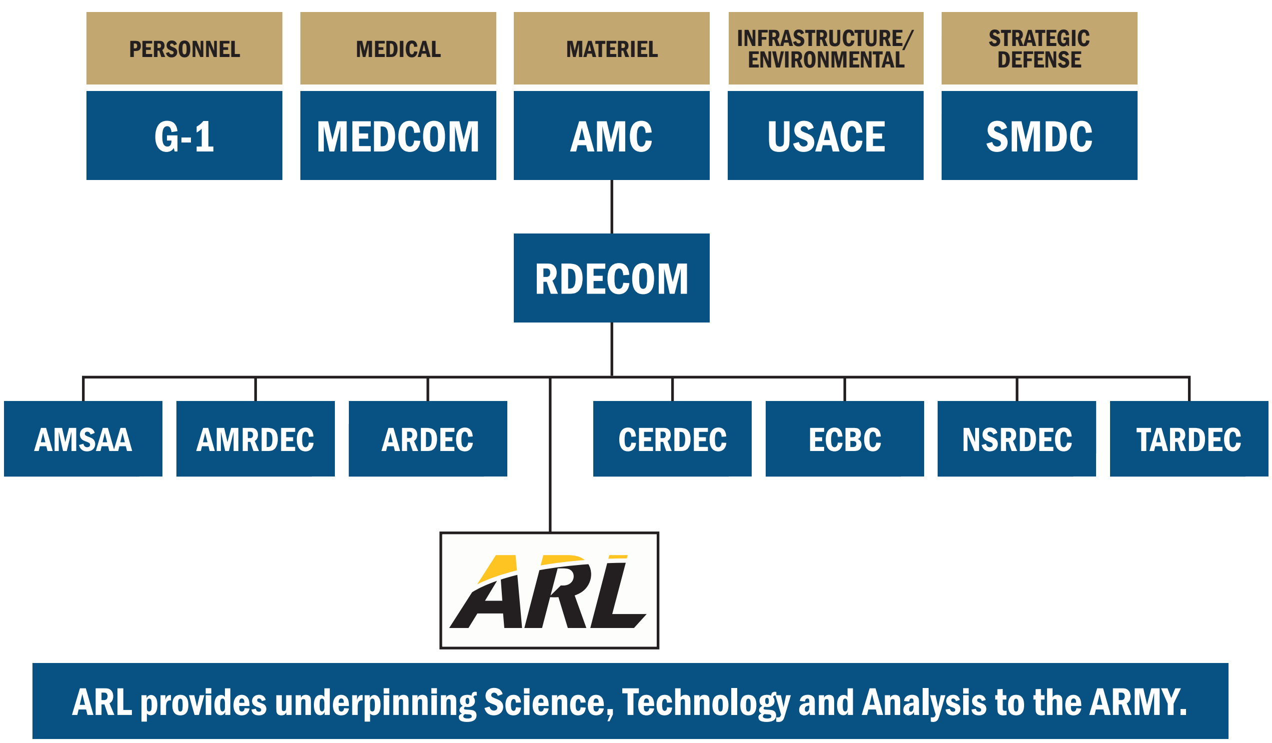
Mission Statement:

Empower, unburden and protect the Warfighter to enable the dominance of the Army.

Vision Statement:

To be the Army's primary source for integrated research, development and engineering capabilities.

Army S&T Performing Organizations

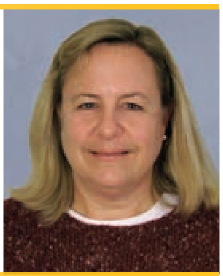


ARL Technical Assessment Board

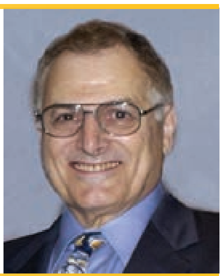
Since 1996, ARL has had a relationship with the National Research Council (NRC) of the National Academy of Sciences. As part of this relationship with the NRC, ARL has in place a Technical Assessment Board (TAB). The charge of this Board is to provide biennial assessments of the scientific and technical quality of ARL. These assessments include the development of findings and recommendations related to the quality of ARL's research, development and analysis programs. We use their input to ensure our work is at the leading edge.

The TAB consists of leading scientists and engineers whose experience collectively spans the major topics within the scope of ARL. Six panels, one for each of ARL's directorates, report to the board. Each board member sits on a panel, six of them as panel chairs (pictured here). The number of members on each panel varies, but their members' expertise is tailored to the technical fields covered by the directorates they review. Approximately 90 subject-matter experts participate across all panels.

DR. MARJORIEANN ERICKSONKIRK
President
Phoenix Engineering Associates, Inc.



DR. LYLE H. SCHWARTZ, NAE
Director (retired)
Air Force Office of Scientific Research



DR. DONALD M. CHIARULLI
Professor of Computer Science and Computer Engineering
Department of Computer Science
University of Pittsburgh

DR. DAVID E. CROW, NAE
Senior Vice President of Engineering (retired)
Pratt and Whitney
Professor Emeritus, Department of Mechanical Engineering
University of Connecticut

DR. DEBASIS MITRA, NAE
Vice President,
Global Research and University Partnerships
Chief Scientist's Office
Bell Labs, Alcatel-Lucent

DR. R. BYRON PIPES, NAE
John Leighton Bray Distinguished Professor of Engineering,
School of Aeronautics and Astronautics,
School of Chemical Engineering,
School of Materials Engineering,
College of Engineering, *Purdue University*

DR. JEREMY M. WOLFE
Professor of Ophthalmology
Visual Attention Laboratory
Harvard Medical School
Brigham and Women's Hospital

The Fellows' mission is to achieve, promote and maintain technical excellence in science and engineering (S&E) at ARL. The Fellows serve as advisors and consultants on technical matters to the ARL Director and the Directorate Directors. The Fellows are carefully chosen from the ARL community, itself a distinguished collection of some of the top scientific minds in our Nation. The selection criteria include an emphasis on nominating those researchers performing the very highest quality ongoing S&E work that also has an extremely high impact on Army needs, the mission and their field of endeavor. There are currently 26 Fellows. Among some of their more important contributions have been evaluations of ARL technical awards, organizing special symposia, and chairing directorate promotion panels. In addition, each year the Fellows review proposals for the Director's Research Initiatives, which is designed to support innovative and high-risk research ideas that have the potential to significantly advance mission needs beyond conventional expectations.

Fellow	Technical Specialty
Dr. Jan W. Andzelm	Multiscale Modeling of Macromolecules and Polymers
Dr. Howard E. Brandt	Theoretical Physics
Dr. Kwong-Kit Choi	Quantum-Well Infrared Technology
Ms. Melanie W. Cole, Co-Chair	Electronic Materials
Dr. Dattatraya P. Dandekar	Shock Wave Interactions and Materials
Dr. Alan S. Edelstein	Magnetic Materials and Devices
Dr. Brad E. Forch	Ballistics and Energetic Materials
Dr. Piotr J. Franaszczuk	Computational Neuroscience and Biomedical Signal Processing
Dr. Kenneth A. Jones	Semiconductor Growth and Microdevice Processing
Dr. T. Richard Jow	Energy Storage
Dr. Shashi P. Karna	Nanomaterials
Dr. Stephen J. Lee	Physical Organic Chemistry
Dr. Tomasz R. Letowski	Auditory Acoustics
Dr. Joseph N. Mait	Electromagnetics and Imaging
Dr. James W. McCauley	Ceramic Engineering
Dr. Nasser M. Nasrabadi	Signal and Image Processing
Dr. Rose A. Pesce-Rodriguez	Analytical Chemistry/Energetic Materials
Dr. Peter J. Reynolds, Co-Chair	Atomic and Molecular Physics
Dr. Betsy M. Rice	Theoretical Chemistry
Dr. Brian M. Sadler	Sensing, Networking and Autonomous Systems
Dr. Paul H. Shen	Semiconductor Optoelectronics
Dr. Ananthram Swami	Signal Processing and Communications
Dr. Don J. Torrieri	Communication Systems and Networks
Dr. Gorden W. Videen	Light Scattering
Dr. Bruce J. West	Mathematics and Statistical Physics
Dr. Michael Wraback	Ultrafast Phenomena in Semiconductor Physics

The ARL Team

ARL accomplishes its mission through the work of a highly educated and trained technical and support staff of 2,013 individuals. Of the 2,013 employees, 1,399 are classified as Scientific and Engineering (S&E), 1002 of whom hold advanced degrees.

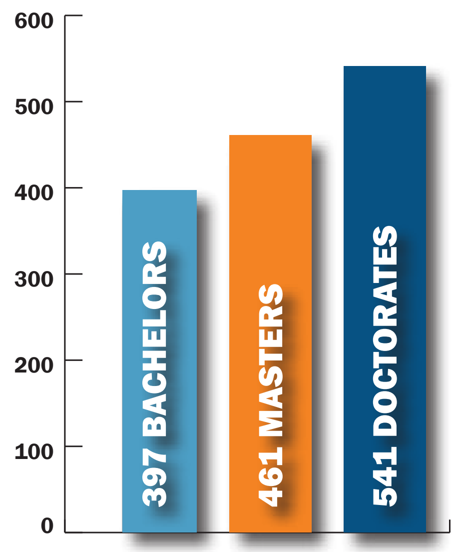
At ARL, we understand that science and technology have been and will remain the engines of economic growth and national security in the United States. In addition, we understand that excellence in discovery and innovation in science and engineering are the direct result of a dedicated, experienced and well-educated workforce.

ARL recruits for and fills positions with the highest caliber applicants. Our interaction with ARL's network of research partners provides the opportunity to interact with graduate students and post-docs with the required expertise from which to recruit and our Personnel Demonstration Project allows starting pay to be negotiated in a competitive range.

1,608 Technical Staff

44	Aerospace Engineers
10	Biologists
4	Biomedical Engineers
95	Chemical Engineers/Chemists
169	Computer Scientists/Engineers
312	Electrical/Electronics Engineers
57	Engineering Psychologists
101	General/Industrial Engineers
81	Materials Engineers
40	Mathematicians/Statisticians
196	Mechanical Engineers
14	Meteorologists
7	Neuroscientists
53	Operations Research Analysts
207	Physicists/Physical Scientists
9	Other S&Es
209	S&E Technicians

1,399 Scientific & Engineering Employees

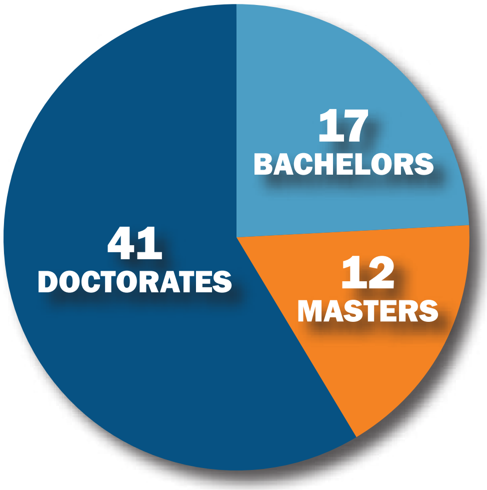


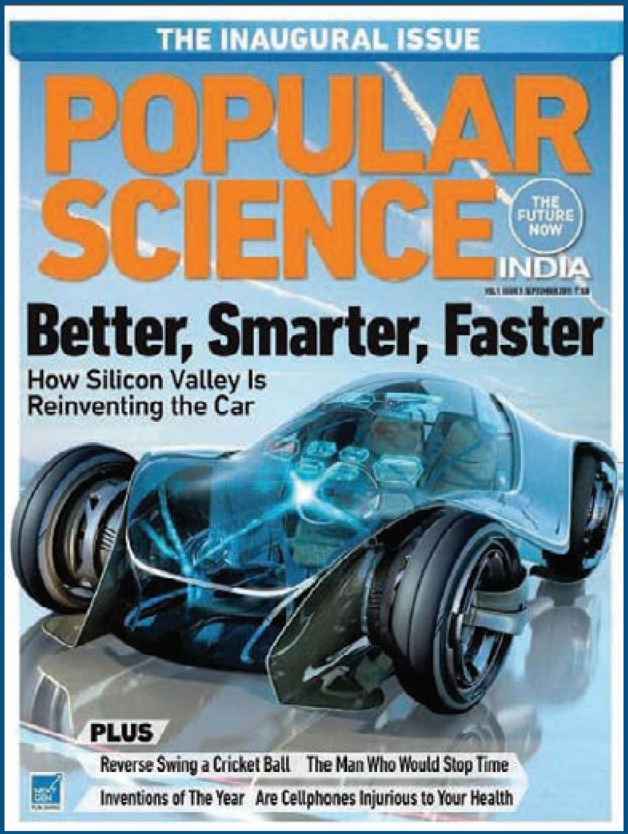
ARL's technical staff must be highly skilled to accomplish our mission and our leadership stresses the importance of advanced technical degrees. In FY11, the ARL scientific and engineering staff was composed of 541 (39 percent) doctorates, 461 (33 percent) Master of Science degrees and 397 (28 percent) Bachelor of Science degrees.

Key performance indicators for quality of the research staff include metrics reflecting the attitudes and technical opinions of the external research community. For FY11, ARL performed exceptionally in the number of presentations/proceedings (1,403), refereed journal articles (354), technical reports (541), books published (5), chapters of books written (24) and patents awarded (44).

The strength of ARL truly lies in its intellectual diversity. Through focused recruiting efforts, we attract scientists and engineers from a large number of academic institutions worldwide. As a result of these efforts, ARL hired 70 new scientists and engineers in FY11 including 41 with doctorates and 12 with Master of Science degrees, with 41 from Tier 1 schools. ARL strives for diversity of intellectual thought in its new hires and actively recruits from a wide range of schools.

FY11 New Hires

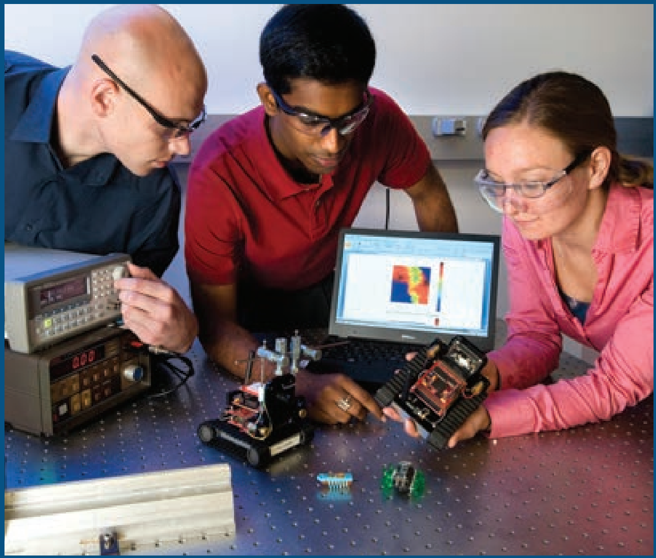




Popular Science Magazine Cover - September 2011

Popular Science - ARL Ranked 13 in Awesome Labs

The Army Research Laboratory was named one of the coolest places in the U.S. to pursue science. *Popular Science* listed the top 25 places to work as a summer intern and ARL was ranked at number 13.



Students Alec Koppel, Vishnu Ganesan and Kesshi Jordan demonstrate the miniature robots they helped develop.

ARL Impresses Participants at Nation's Biggest Science Fair

Nearly 2,000 children and adults visited the Army Research Laboratory exhibit at the inaugural USA Science & Engineering Festival held on the National Mall in October 2010.

ARL joined about 500 exhibitors that supported the nation's largest science, technology, engineering and math (STEM) outreach event.

Highlighting materials research with armor examples and cutting-edge research along with flexible display technology, ARL's exhibit captured the attention of both young and old.

The expo was the culmination of the two-week festival that featured more than 1,500 hands-on science activities and more than 75 performances on four stages on the Mall in Washington.

A grassroots collaboration of the nation's leading science organizations, the festival was hosted by an Honorary Congressional Committee with more than 100 members of Congress supporting the effort.

Sarah Maxwell interacts with visitors to the exhibit.

ARL's Summer Student Symposium a Huge Success

The fifth annual Summer Student Research Symposium was held at Aberdeen Proving Ground in August 2011. A group of 13 finalists presented their summer projects to an audience of peers, ARL staff and a judging panel, which included Director John Miller and the ARL Fellows.

Each year summer student interns conduct research projects and compose technical reports recounting their internship work. The reports are evaluated by directorate judging panels, and the top submissions are selected as symposium finalists. Finalists provide presentations at the symposium, and gold, silver and bronze cash prizes are awarded to the top three presentations in both undergraduate and graduate student categories.

In the undergraduate category, Joshua Martin, University of Delaware, took top honors with his presentation, "Tunable TiO_2 Nanotube Arrays for Flexible Bio-Sensitized Solar Cell." Brian Justusson, University of Michigan, took top honors in the graduate category for his presentation, "Microstructural Investigation and Evaluation of Mechanical Properties in Friction Stir Welded Joints."

ARL Director John Miller and Gary Martin, then executive deputy to the commanding general of RDECOM, pose with the ARL Fellows, mentors and student finalists in the 2011 Summer Student Symposium.

New ARL Agreement with Virginia Tech, 11 STEM Programs Help Spark Student Interest in STEM Careers

Students at all stages of development will now benefit from a ground-breaking, three-year, $17.2 million cooperative agreement to support the management and execution of a consortium of academic and nonprofit institutions that are formed to stimulate science, technology, engineering and mathematics (STEM) education and outreach, and highlight Defense Department career paths.

As part of the Army Educational Outreach Program for the Office of the Assistant Secretary of the Army for Acquisition, Logistics and Technology, ARL's Army Research Office, located in Research Triangle Park, N.C., made the award recently in coordination with the Research, Development and Engineering Command headquarters to 11 existing STEM programs, whose efforts, as part of the consortium, will be led by Virginia Tech.

The focus will be on developing a set of core objectives outlined by the Army to increase the number of STEM graduates by expanding the involvement of students in ongoing Defense Department research and providing STEM education opportunities for students from kindergarten through post-graduate educational levels.

The cooperative agreement is more specifically expected to create synergy among the Army's Educational Outreach programs, increase direct involvement and oversight in these programs, and ultimately influence and improve how these programs are marketed and evaluated.

Army Research Laboratory Supports Braille Writer Technology

Responding to touch, a virtual keyboard appears at the user's fingertips.

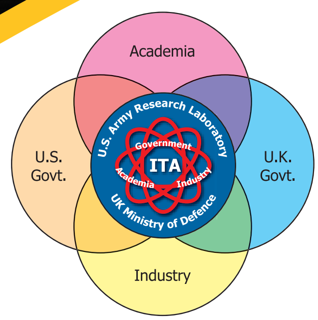
In 2011, as part its outreach efforts, the Army Research Laboratory asked summer institute project directors at Stanford University to explore high performance computing aspects on tablets. At the end of eight-week session, students were challenged to demonstrate their computational sciences research projects on Android tablets Fifteen summer students worked on eight different projects ranging from computational materials science to battle command discrete math applications. One of the projects was a touchscreen Braille writer that, according to the Stanford Report, stands to revolutionize how the blind negotiate an unseen world by replacing devices costing up to 10 times more.

"The purpose of the project was to investigate a software solution that would allow the visually impaired to interact with modern-day tablet computers," said Adam Duran who worked on the project and is an aerospace engineering student at New Mexico State University. The software would transform the Tablet into an accommodation solution that would serve as note taker and electronic communication device. A virtual Braille keyboard would provide the visually impaired with a basic level of functionality not currently available. As a result of this innovation, the University received an invitation to display its touchscreen Braille writer at the 2011 Chairman's Award for Advancement in Accessibility at the Federal Communications Commission in Washington, D.C., in October. Duran, along with mentors Raymond Ryckman, Ramsharan Rangarajan and Adrian Lew, demonstrated the "Braille Input Technology for Android Devices."

PARTNERSHIPS AND COLLABORATIONS

ARL is partnering and collaborating with academia, industry and other government organizations through a variety of continuing and new innovative programs. Our intent is to maximize the use of our limited research dollars by leveraging the resource investments of our partners using a variety of approaches ranging from single investigator grants with individual university faculty, to large centers with groups and consortia, to direct collaborations between university research personnel and ARL in-house scientists, engineers and analysts.

ARL's partnership programs include the Single Investigator Program, Multidisciplinary University Research Initiative Program, Collaborative Technology Alliances, Centers of Excellence, Historically Black Colleges and Universities/Minority Institutions, Army Research Office core grants, Small Business Innovation Research/Small Business Technology Transfer Program, University Affiliated Research Centers, Defense Experimental Program to Stimulate Competitive Research, Short Term Innovative Research and International Technology Alliance.



INTERNATIONAL TECHNOLOGY ALLIANCE

COLLABORATIVE TECHNOLOGY ALLIANCES

- MICRO AUTONOMOUS SYSTEMS & TECHNOLOGY
- ROBOTICS
- COGNITION & NEUROERGONOMICS
- NETWORK SCIENCE

CENTERS OF EXCELLENCE

- HIGH PERFORMANCE COMPUTING
- FLEXIBLE DISPLAYS
- MATERIALS

UNIVERSITY AFFILIATED RESEARCH CENTERS

BIOTECHNOLOGY

ICB: Institute of Collaborative Biotechnologies

Biologically derived:

- Sensors
- Electronics
- Information Processing

NANOTECHNOLOGY

ISN: Institute of Soldier Nanotechnologies

- Protection
- Performance Enhancement
- Injury Intervention and Cure

ELECTROMECHANICS & HYPERVELOCITY PHYSICS

IAT: Institute for Advanced Technology

- Electromagnetic Launch
- Pulsed Power
- Electric Armaments

IMMERSIVE ENVIRONMENTS

ICT: Institute for Creative Technologies

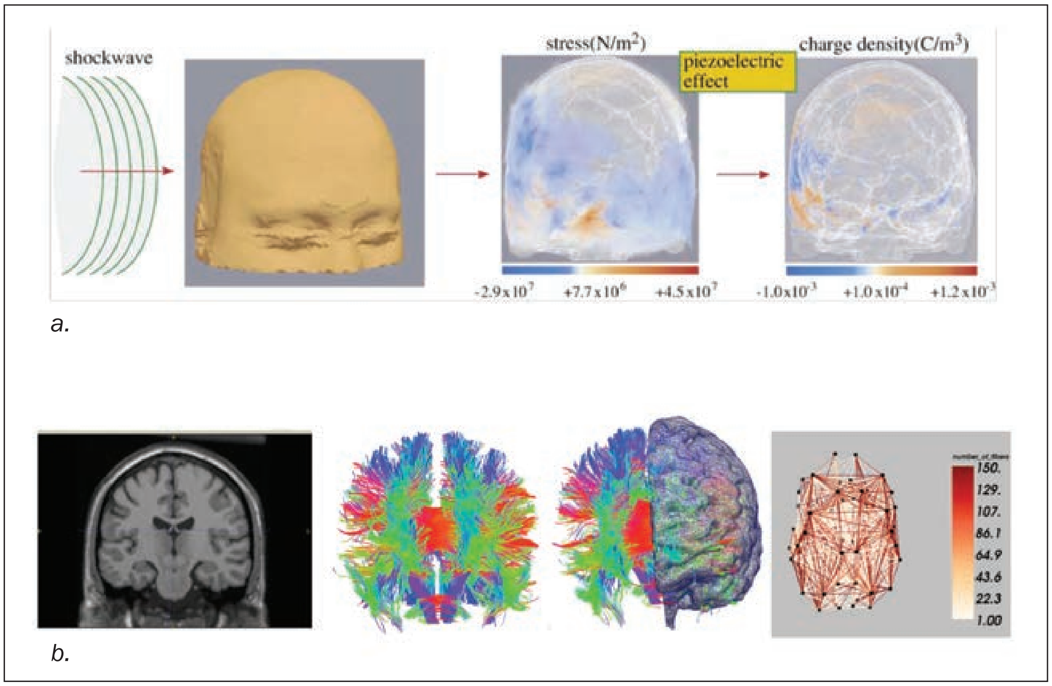
- Full Sensory Immersion
- 3-D Mobility
- Compelling Interactive Stories

Team from MIT's ISN and ARL Tackle the Nation's Top Soldier Protection Challenges

A team of researchers from the Massachusetts Institute of Technology's Institute for Soldier Nanotechnology (ISN) and the Army Research Laboratory are making great progress towards providing Soldier protection solutions built on detailed scientific understanding of the human body in extreme environments. Collaborative efforts have resulted in improved understanding for mitigating traumatic brain injury, the development of methods for neurodiagnostics and predictions for lower extremity injuries.

Under this collaboration, a deeper understanding of multiple potential brain injury mechanisms due to electromagnetic effects in the brain from bone piezoelectricity and axonal deformation damage was gained. An ISN summer student worked with ARL, the Defenses and Veterans Brain Injury Center and the Army's Medical Research and Materiel Command (MRMC), and demonstrated a helmet-based blast sensor suite enabling advanced neurodiagnostics, which included a novel method to evaluate postural stability, an important indicator for neurotrauma, using smartphone-based gyroscopes and accelerometers.

In the area of lower extremity injury prediction, the team has developed new methods to model bone failure at high loading rates, representing the world's most advanced model of bone failure.



The MIT ISN and ARL team have developed unique capabilities to model a number of potential brain injury mechanisms. (a) When an improvised explosive device (IED)-scale blast wave impacts a head, it produces stresses in the skull (here, computed by full-head model mechanical simulations). The piezoelectric response of bone causes the skull to polarize in response to stress, resulting in electric charge concentrations (right) that may produce strong in-brain electric fields. (b) A connectome-based approach uses multiple imaging modalities to inform the finite element model of the brain. This allows explicit representation of axonal damage and provides a framework for investigating brain structure-function relationship deficits.

ELECTROMAGNETIC VULNERABILITY ASSESSMENT FACILITY

This facility addresses the complete electromagnetic threat being encountered in theater and anticipated for the Future Force.

NOVEL ENERGETICS RESEARCH FACILITY

This facility contains a processing complex with energetics processing and manufacturing labs and an explosives casting lab. It also has explosives x-ray capability.

SHOOTING SIMULATOR

This indoor small arms shooting performance simulator with a high-speed weapon tracking system provides real-time continuous weapon aim point data.

ROBOTICS RESEARCH FACILITY

This 13-acre course is used for unmanned vehicles and indirect driving studies. Driving paths include straightaways, slaloms, tight turns, and straight and broad paths in which obstacles such as logs and rocks must be avoided.

LASER OPTICS TESTBED

This laboratory is equipped to support sophisticated investigations in adaptive and nonlinear optics, advanced imaging and image processing, and laser communications for ground-to-ground applications.

ROTORCRAFT SURVIVABILITY ASSESSMENT FACILITY

This state-of-the-art facility provides accurate and timely test and evaluation information that will lead to improvements in aircraft design and reduce injury and death.

PULSE POWER FACILITY

This facility provides a full-scale testbed for development, evaluation and demonstration of pulse power components.

MOBILITY/PORTABILITY RESEARCH FACILITY

This facility sets the Army standard for measuring the effects of various equipment configurations and loads on Soldier mobility and physiological performance.

VERTICAL IMPULSE MEASUREMENT FACILITY

This facility is used for accurately measuring the combined debris and blast impulse produced in landmine detonations. Data are used to validate models and develop technologies for improved survivability of future lightweight tactical and combat vehicles.

TACTICAL ENVIRONMENT SIMULATION FACILITY

This facility is used to study the effect of Soldier equipment on physical and cognitive performance in a completely immersive simulation environment including an Omni Directional Treadmill.

RODMAN MATERIALS RESEARCH LABORATORY

The Rodman has nearly 300,000 sq. ft. of laboratories that enable the pursuit of disruptive and challenging research and characterization in advanced materials technologies for potential applications in Army weapons systems.

TRANSONIC EXPERIMENTAL RESEARCH FACILITY

This facility evaluates aerodynamics and fluid dynamics of projectiles, smart munitions systems and sub-munitions dispense systems.

ZAHL PHYSICAL SCIENCES LABORATORY

The Zahl's cornerstone is its clean room. The lab enables basic and applied research and analysis in nanobiotechnologies; flexible electronics; advanced specialty electronics material growth; nonlinear material research and characterization; and power electronics.

SFC PAUL RAY SMITH SIMULATION AND TRAINING TECHNOLOGY CENTER

This facility provides for advanced simulation technology capabilities, enhancing the Soldier experience in training environments, increasing training system performance and cost effectiveness.

DSRC AND SCIENTIFIC VISUALIZATION FACILITY

This facility features state-of-the-art scalable parallel architectures and large vector-parallel systems supporting missions throughout the DoD's RDT&E community.

AIRBASE EXPERIMENTAL FACILITY

This modern, centralized complex provides analysts, program managers and decision makers with experimental data that addresses the survivability, lethality and vulnerability of air combat systems.

VEHICLE TECHNOLOGY FACILITY

Completed in 2011, this new Aberdeen Proving Ground facility is enhancing air and ground vehicle systems.

ARL HAS FIVE PRIMARY SITES:

Aberdeen Proving Ground, Md.

Adelphi Laboratory Center, Md.

White Sands Missile Range, N.M.

Raleigh-Durham, N.C.

Orlando, Fla.

Unique facilities at our primary sites provide our scientists and engineers access to world-class research centers.

SPIE PRESIDENT AWARD

DR. JOHN PELLEGRINO

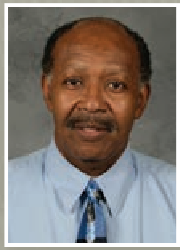
Dr. John Pellegrino, ARL's director of the Computational and Information Sciences Directorate, was presented with the 2011 SPIE President's Award at the Optics and Photonics Symposium in San Diego, Calif. Dr. Pellegrino was chosen for the award due to his service as chairman of the SPIE Symposia Committee, his professionalism, and his dedication to the Society in successfully progressing SPIE Defense, Security and Sensing.

PRESIDENTIAL EARLY CAREER AWARD FOR SCIENTISTS AND ENGINEERS

DR. REUBEN KRAFT

Dr. Reuben Kraft, was honored with the Presidential Early Career Award for Scientists and Engineers for his research in computational mechanics. His work in multiscale modeling techniques applied to armor materials and high-rate injury biomechanics is contributing to the protection of U.S. Soldiers and allies.

DEPT. OF THE ARMY CIVILIAN AWARD FOR HUMANITARIAN SERVICE

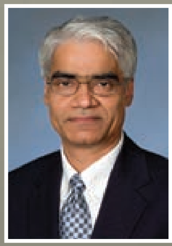


JOSEPH TRAMMEL

Joseph Trammel, team lead and security specialist for the Army Research Laboratory at White Sands Missile Range, N.M., was awarded the Civilian Award for Humanitarian Service for his outstanding efforts associated with saving the life of a fellow ARL employee.

BEST PAPER AWARD - INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS - IEEE NANO 2011 CONFERENCE

DR. MARK GRIEP



DR. SHASHI KARNA

Two ARL scientists were recognized with the Best Paper Award at the IEEE Nano 2011 conference in Portland, Ore. The work that the paper focuses on involves applying the unique capabilities harnessed in engineered Bio-Nano systems to open up a wide array of future-force applications.

ARMY MODELING AND SIMULATION (M&S) AWARD

DIANE MITCHELL

Diane Mitchell was a recipient of the U.S. Army Modeling and Simulation 2010 Award for Individual Analysis and the 2010 National Training Simulation Association Modeling and Simulation Award, Analysis Category. She received the award for outstanding achievement for her analysis and improved performance using the research integration tools. Ms. Mitchell's analyses predict the complex relationship among Soldier cognitive performance, system design and overall mission performance for crews of ground vehicles. She provided vehicle developers with the capability to include Soldier cognitive performance in vehicle crew size requirements.

Research and Development Achievement Awards

Electromagnetic Modeling Research for Sensing-Through-Wall Radar Applications:

- Dr. Traian Dogaru
- Calvin Le

High Voltage Li-Ion Batteries

- Dr. Kang Xu
- Dr. Jan Allen
- Dr. T. Richard Jow

Establishment of Chemical Mechanism for Catalytic Combustion of Butanol in Scalable Multi-purpose Reactors

- Dr. Ivan Lee

Advanced Study of Power and Efficiency Scaling of Eye Safer Fiber Lasers for Directed Energy Applications

- Dr. Mark Dubinskiy
- Dr. Jun Zhang
- Dr. Tigran Sanamyan

Technical Leadership of Multi-Threat Armor Research and Development for U.S. Ground Vehicles

- Dr. Scott Schoenfeld

Reduction of Hazardous Air Pollutants (HAP) and Volatile Organic Compounds (VOC) at Anniston Army Depot - Collaboration Award

- John Kelley

Advanced Passive Armor Technology for the Defeat of Multiple Improvised Explosive Devices (IEDs) and Conventional Weapons - Collaboration Award

- David Kleponis
- Thomas Havel
- Dr. Parimal Patel
- Dr. Brian Scott

2011 Charles L. Hosler Alumni Scholar Medal (Penn State University)

- Dr. James McCauley

National Defense Industrial Association (NDIA) - 2010 Tester of the Year

- Patricia Frounfelker

Secretary of the Army Environmental Awards

- Kes Chesonis
- Dawn Crawford
- Bernard Hart
- William Lum
- Pauline Smith
- Chris Miller

Modern Day Technology Leaders - Black Engineer of the Year Award (BEYA)

- Dr. Thomas Davis

National Defense Industrial Association's William R. Moseley Award

- Dr. James Newill

Command & General Staff College International Sponsor Recognition Award

- Diane Ungvarsky

2010 Army Materiel Command Systems Analysis Award

- David Bromley
- Donald Walker
- Christopher Zella

2010 Stalwart Award - Installation Management

- Col. Pratya Siriwat

JOINT SERVICE ACHIEVEMENT MEDAL

MAJ BRYON MANSFIELD

MERITORIOUS SERVICE MEDAL

COL JOHN SHANKLIN
COL PRATYA SIRIWAT
COL REED YOUNG
LTC KENNETH ROBERTSON
MAJ MICHAEL BAKER
MAJ CHRISTOPHER BYRD
MAJ RYAN HOWELL
MAJ BOYD SHARP
CPT SCOTT SHAFFER
MASTER SGT JEMALL PITTMAN
STAFF SGT TRAVIS PRIVOTT
SGT 1ST CLASS ROBERT HOPKINS
SGT 1ST CLASS GARRY REESE

AMC & RDECOM SOLDIER OF THE YEAR

SGT BERNARD QUACKENBUSH

ARMY COMMENDATION MEDAL

STAFF SGT RANDALL HUFF
STAFF SGT DONALD KNOTT
STAFF SGT SEAN LATHROP
STAFF SGT JAVIER VELAZQUEZ
SGT 1ST CLASS RYAN CALINAGAN
SGT 1ST CLASS JIMMIE SMITH

ARMY ACHIEVEMENT MEDAL

MASTER SGT JEMALL PITTMAN

Strategic Research Initiatives

The U.S. Army has evolved into a high-technology fighting force, relying on cutting-edge research and analysis to maintain its dominance. The research ARL performs to sustain such a force is inherently long-term in nature and may require years before innovative capabilities are delivered to our Warfighters. The seven high-payoff Strategic Research Initiatives (SRIs) depicted below can expand existing competencies or establish new core competencies.

ARL Director's Strategic Initiatives (DSIs) are three-year funded efforts ($500K/yr) for emerging (revolutionary) research areas in support of ARL's Strategic Research Initiatives. These programs have the potential to produce radical, game-changing advances in analysis, technology and warfighting capabilities. DSIs support higher risk research that is collaborative, multidisciplinary and multi-directorate. These initiatives present the opportunity to attract new researchers and develop new infrastructure and have long-term potential to deliver unprecedented capabilities for the Soldier.

MATERIALS & DEVICES IN EXTREME ENVIRONMENTS

- Structural Materials by Design
- Multiscale Multidisciplinary Modeling of Electronic Materials
- Materials in Extreme Dynamic Environments
- Novel Magnetics
- Disruptive Energetics
- System-on-a-Chip (Flexible and Printable Electronics)
- Graphene Nanoelectronics
- Metamaterials & Metastructures
- Heterogeneous Devices

BATTLEFIELD NEUROSCIENCE

- Cognitive Performance & Measurement
- Brain Structure-Function Coupling
- Neuroergonomic System Designs
- Neuro-Cognitive Measurement
- Neurally Inspired Systems
- Multi-Dimensional Modeling of Individual Performance

NETWORK SCIENCES

- Cognitive/Information – Decision Making
- System of Systems Analysis (S4/WEL Integration/Interoperation)
- Cyber Systems Architectures (Behaviors & Defenses) (INVA/DE – Interrogator Experiments)
- Battlefield Actionable Intelligence (Sentient Intelligence & Information Systems)
- Graduated Computational Representations of Human Decision Making in Networked Domains

HIERARCHICAL COMPUTING

- Commodity Computing
- Nonlinear HPC/ Scalable Algorithms
- Reduced Order Models

EXTREME ENERGY SCIENCE

- Networked Energy
- Energy Harvesting & Scavenging
- Novel Energy Storage
- Hydrogen Production of Water
- Pulsed Power

AUTONOMOUS SYSTEMS TECHNOLOGY

- Autonomous Tactical Navigation & Manipulation
- Cognitive Robotics
- Scalable Autonomy
- Intelligent Behavior & Systems

EMERGING SCIENCES

- Quantum Information (Computing, comms, Sensing, Imaging & Simulation)
- Bio-inspired Systems
- Simulation, Training & Immersive Technologies
- Human Response Modeling – Physics-Based Mechanical to Bio-Functional Coupling
- Predicting Social, Cultural & Behavioral Small & Large Scale Dynamics

DSIs highlighted in yellow

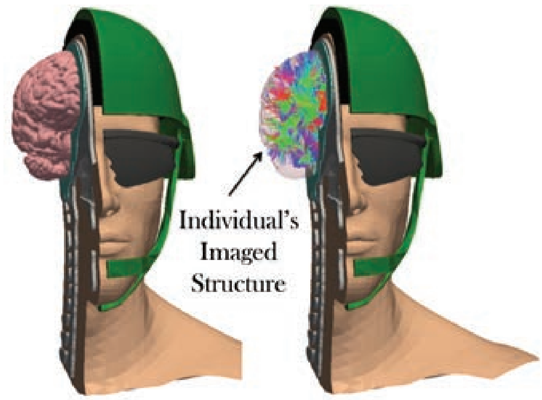
In FY11, ARL funded twelve DSIs in the areas of Cognitive/Information - Decision Making; Materials in Extreme Dynamic Environments; Graphene Nanoelectronics; Multiscale Multidisciplinary Modeling of Electronic Materials; Heterogeneous Devices; Hydrogen Production from Water; Brain Structure-Function Coupling; Novel Energy Storage; System of Systems Analysis; Structural Materials by Design; Quantum Information and Cyber Systems Architectures.

The success of the ARL DSIs will help ensure decisive warfighting superiority for our Soldiers.

Researchers Examining the Brain to Help Enhance Soldier Protection

A collaborative team of ARL researchers began a new Director's Strategic Initiative to examine the brain. It is aimed at developing a multidisciplinary, multiscale understanding of the relationship between the brain's physical structure and its dynamic electrochemical functioning. One goal in this initiative is to understand the set of circumstances under which individual differences in brain structure can be leveraged to account, predict or enhance the measurement of brain function at varying time scales.

The initiative has four main research areas. Two areas focus on large-scale structural and functional analysis of empirical datasets aimed at developing novel metrics that would support individual-specific neurotechnologies. In this first year, a time-evolving functional measure was implemented and tested on several datasets. Third, the biomechanical research area develops models of structural changes at the level of brain tissue response to enhance Soldier protection technologies, and during year one, the team designed and implemented a constitutive model that includes white matter fiber tract imaging data thereby enabling a physics-based approach to modeling brain damage. Finally, the fourth research area ties together the previous three areas by developing models that simulate how differences in structure link with changes in functional patterns of brain activity in order to augment the design of both neurotechnologies and Soldier protection. The first-year effort delivers network-level simulations, where neural mass model regions are coupled together to create small-scale models of structural networks.

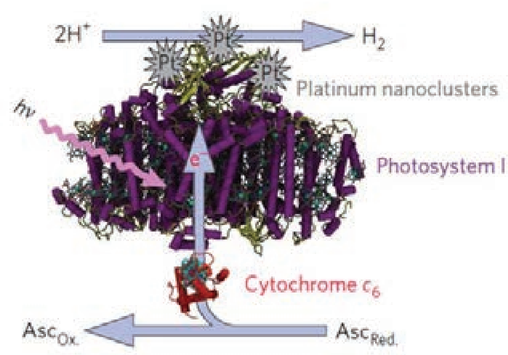


Brain structure collected on a brain imaging scanner is incorporated into a finite element model used to model simulated tissue damage.

Understanding Photosystem I as a Biomolecular Reactor for Energy Conversion

Future warfare presents unprecedented challenges to the Army's capability of supplying power and energy to deployed military units where access to power grids is not feasible. Reliance on fuel transported via traditional means not only imposes a heavy burden to the Army's logistic chain, but it also creates vulnerabilities that endanger Soldiers' lives and mission objectives. Developing an onsite ability to generate power/fuel using resources available from remote battlefield environments is of critical interest to the Army's long-term power and energy strategy.

A multidisciplinary research group at ARL initiated this new Director's Strategic Initiative project to leverage a ground-breaking discovery of their academic partners at the University of Tennessee-Knoxville (UTK). It was determined that the Photosystem I (PSI) protein, isolated from cyanobacteria or spinach, can be used as a bio-molecular catalyst for hydrogen production in aqueous solutions. This collaborative effort is exploring the possibility of harnessing solar energy through this photosynthetic mechanism, which is followed by either converting the energy directly or storing it as an energy-dense fuel.



IJ Iwuchukwu, M Vaughn, N Myers, H O'Neill, P Frymier, BD Bruce. Nature Nano (2009) 5, 73-79

Preliminary achievements have been made with densely packed PSI assembled on Au electrodes with various surface linkers; detection of photo-current from PSI immobilized on electrodes; and parameterization and dynamics simulations of PSI and oligomeric cytochrome c6 and a proposed model of the docked PSI/cytochrome c6 complex.

Advanced En-Route Planning Capability for Airborne Mission

ARL engineers working with a Soldier while installing the system on an aircraft.

The Army Research Laboratory teamed with the Program Manager WIN-T and the 82nd Airborne Division, located at Fort Bragg, N.C., to provide an En-Route Command-and-Control/Mission-Planning system that provides the command group with a common operational picture and situational awareness while in flight.

The 82nd Airborne Division has long used a variety of disparate components and systems to help communicate and provide assault/target information to commanders while in flight. ARL teamed with the 82nd Airborne Division to integrate existing capabilities with new network enabling technologies to provide an integrated system that offered both voice and data to the Soldier while on an aircraft. The system provided an extension of the tactical Secret Internet Protocol Router Network (SIPRNET) to the aircraft and through Voice-Over-Internet Protocol (VOIP) services provided voice communications over tactical radios. The system also provided two wideband data pipes for network connectivity; one was for home base communications and the other was for inter-plane communications. The systems were flight tested during a joint forces exercise (JFX) at Fort Bragg. ARL and 82nd personnel participated in the JFX and successfully demonstrated the system.

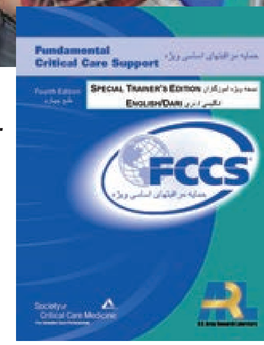
Soldiers preparing for airfield assault during the joint forces exercise.

En-Route Command-and-Control/ Mission-Planning system.

Statistical Machine Translation Provides Advanced Medical Instruction to Afghanistan

Afghan physicians train in critical care medicine with support from U.S. Medical Embedded Training Teams.

To meet pressing operational Soldier requirements, ARL developed new technologies to tailor automatic language translation to tactical applications. One particularly urgent translation requirement for security and humanitarian assistance in Afghanistan is medical training materials for native Dari speakers. ARL met this challenge using a knowledge management approach that captures the work of bilingual (English-Dari) medical experts in the form of parallel text aligned at the sentence level. The parallel text is fed as training data to machine learning algorithms that produce new Statistical Machine Translation (SMT) software specialized for the medical domain. In FY11, ARL used this method to complete all chapters and appendices of the Special Trainer's Edition (Bilingual English-Dari), Fundamental Critical Care Support, and printed 500 copies. This 800-page manual allows U.S. medical trainers to provide full access to the latest information on intensive care medicine for the first time to Afghan doctors in their native language.



Inset photo: ARL's bilingual English-Dari medical training manual.

Highly parallel format of bilingual trainer's manual facilitates cross-lingual technical communications.

Mitigating Loss of Persistent Surveillance Systems Due to Weather

Persistent Surveillance System (PSS) performance has declined with numerous weather-related crashes in Afghanistan, impacting mission and payload loss. The Army Research Laboratory determined a major factor was complex terrain induced weather and turbulence. An initial ARL analysis report to the U.S. Central Command (CENTCOM) identified atmospheric hazards to PSS operations for two sites. ARL mitigated losses through more timely hazard warnings from a first of its kind diagnostic wind and turbulence 3-D Wind Field (3DWF) model. The model was delivered to the Air Force Weather Agency in August 2011, capturing complex terrain effects at 50-meter resolution. ARL delivered an enhanced My Weather Impacts Decision Aid (MyWIDA) to CENTCOM identifying specific hazardous weather thresholds for aerostat risk analysis. Completing the sensing and diagnostics package, an ARL Doppler Light Detection and Ranging (LIDAR) system was demonstrated at PSS training sites at Yuma Proving Ground, Ariz., to remotely sense in real time the weather features that impact PSS operations.

Primary test facility for PTDS at Yuma Proving Grounds, Ariz. (Inset photo: ARL Doppler LIDAR System installed and demonstrated at Yuma Proving Grounds, Ariz.).

Aerostat lost due to weather-related events.

Armor Technology for Future Vehicles Transitions for Current Fight

The Army Research Laboratory state-of-the-art armor technologies have been modified for the future fight and transitioned for use in the current fight. During the Operation Iraqi Freedom (OIF)/Operation Enduring Freedom (OEF) timeframe, ARL researchers designed multiple advanced armor approaches for defeating emerging and projected threats. Requirements for these technologies were driven by lessons learned during OIF/OEF and other recent operations. In fiscal year 2011, ARL transitioned newly developed passive and reactive ground combat vehicle (GCV) appliqué armor technologies to the Tank Automotive Research, Development and Engineering Center for application and evaluation on multiple platforms. The development of these armor technologies relied heavily on the unique facilities and expertise available at ARL and leveraged previous ballistics and materials research, design, and maturation performed under ARL core and supplemental efforts. The transition of these armor technologies will provide unprecedented armor performance for current ground combat vehicles, as well as other future combat vehicles and heavy trucks.

Army armored fighting vehicles.

ARL Trains Battle-Damage Assessors

To increase the effectiveness of in-theater battle-damage assessments (BDA) and subsequent analyses performed by subject-matter experts in the continental United States, ARL provided training for members of the National Ground Intelligence Center (NGIC), the office of the Program Manager for the Mine-Resistant Ambush-Protected vehicles (PM MRAP), and the 20th Support Command (Chemical, Biological, Radiological, Nuclear and High-Yield Explosives (CBRNE)).

This training consisted of classroom sessions as well as hands-on experience with vehicles damaged during live-fire testing at Aberdeen Proving Ground.

MRAP live-fire test event.

These sessions included three-day training for NGIC personnel deploying in early January 2011 to bolster BDA teams already in theater, and a one-day course for the explosive ordnance disposal team assigned to the 20th Support Command (CBRNE) in June 2011. The training enhanced the damage assessors' effectiveness for conducting in-theater battle-damage assessments. It covered design attributes and vulnerabilities of the main vehicle platforms being used in Operation Enduring Freedom, ways to infer threat properties from observed vehicle damage, and techniques for properly documenting and reporting observations.

Once these teams reached theater, ARL maintained contact addressing their questions. ARL synthesized incident and damage reports from theater with medical data obtained through the joint trauma analysis and prevention of injury in combat partnership for analyses leading to improvements to fielded systems and changes to operational tactics, techniques and procedures that enhance occupant safety.

25mm High Explosive Air Burst (HEAB) Technology (XM25)

XM25 Counter Defilade Target Engagement System.

The Army Research Laboratory is the technical lead for Program Manager Soldier Weapons on the development of the XM25 25 mm individual air burst weapon system. The system is designed to enhance the capability of individual Soldiers to defeat targets in defilade, a critical user identified capability gap for lethality. A forward operational assessment of the XM25 is currently underway in Afghanistan with support from ARL personnel involved in training Soldiers, enabling and evaluating XM25 combat tactical integration, and collecting data for the Engineering and Manufacturing Development phase of the contract. Recent advancements to the XM25 design include hardware modifications to improve reliability and reduce weight and an improved fire control laser optimized to improve ranging performance against targets of varying reflectivity out to 2,000 meters. Additional modifications addressed weapon ergonomics including butt-plate configuration, rear bolt buffer housing and recoil optimization. Based on extremely positive preliminary Soldier feedback, an additional 24 weapons and several thousand rounds were requested to support a second in-theater forward operational assessment.

Airburst technology against counter defilade targets.

ARL Survivability Analyses Yield Recommendations for Improving Stryker Infantry Carrier Vehicles

Soldiers in Afghanistan are now riding in new Strykers with a double-V hull (DVH), a variant of the Infantry Carrier Vehicle (ICV), designed to protect them from improvised explosive devices and roadside mines.

To assist the Office of the Director, Operational Test and Evaluation with their assessment of the merits of the new Stryker DVH variant, ARL provided recommendations for reducing the vulnerability of the baseline Stryker ICV to underbody blast threats. By analyzing the results of live-fire tests and outcomes of comparable attack events from Operation Enduring Freedom, ARL was able to develop and validate recommendations for improving materiel and tactics, techniques and procedures.

These recommendations were included in the first evaluation report of the Stryker DVH, which was circulated among senior leaders in the Department of Defense and Congress.

Stryker ICV variant went from conception to production in less than a year.

Soldiers in-theater are using the new Stryker ICVs.

The remainder of this review is structured around our ten major laboratory program areas of Extramural Basic Research, Networks, Human Dimension, Simulation and Training Technology, Lethality, Mobility, Power and Energy, Sensors, Protection, and Survivability/Lethality Analysis.

The accomplishments presented here, while only a small sample of our efforts over the past year, are representative of the skill, dedication and teamwork of our in-house staff and our partners in academia and industry.

Extramural Basic Research

- Electrochemical Models Leading to Improved Fuel Cell Performance
- Integrating Semiconductors with Biology to Harness Microbes
- First Functional Atomic Circuit Will Enable Revolutionary Sensors

Networks

- High Performance Computing for Robust Mobile Networks
- Optimizing Battlefield Cyber Attack Detection
- Coalition Sensor Interoperability and Data/Information Sharing via the ITA Sensor Fabric and Policy Management Toolkit

Human Dimension

- Reducing Visual Demands of Army Aviators
- Classification of Task-Related Brain Activity in Complex Environments
- Enhancing Soldier Cognitive Performance for Mission Command Collaboration and Decision Making

Simulation and Training Technology

- Multiple Amputation Trauma Trainer Prepares Approximately 120,000 Soldiers Deploying in 2011
- Virtual Human Agent Technology Development Accelerated
- Enhanced Dynamic Geo-Social Environment is the First Simulation Built to Allow Training Anywhere and at Anytime

Lethality

- Multiscale Computational Tools for Enabling “Game Changing” Energetics
- Weapon Systems Research for Improved Individual Soldier Lethality
- Modeling to Enable Next Generation Missile Propulsion Capability

Mobility

- Advanced Intelligence for Small Military Robots in Urban and Complex Environments
- Planetary Fault Detection Can Lead to Improved Helicopter Transmissions
- Enhancing Human-Robot Team Performance

Power and Energy

- SiC for New Compact High Voltage Capabilities
- Catalytic Combustion for Scalable Compact Power
- High Voltage Batteries for Extended Mission Duration

Sensors

- Demonstration of Cue-to-Slew Capability
- Low Defect TCA Process for Ubiquitous IR Imaging
- Sensing-Through-Wall Radar Research

Protection

- Injury Biomechanics for Enabling New Concepts for Soldier Protection
- Aluminum Alloy Research Leading to Superior Underbody Protection
- 3-D Through-Thickness Reinforcement (3D-TTR) Concept Enables Unprecedented Multi-Hit Armor Performance

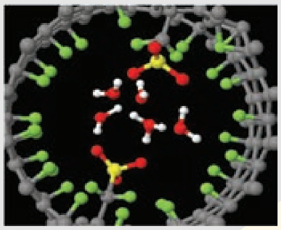
Survivability/Lethality Analysis

- ARL Conducts Apache Block III Live-Fire Testing
- ARL Completed the Development of the QRC-335 (400) Series of Airborne Electronic Attack (EA) System
- ARL Develops Experimental Technique to Assess Helmet Protection

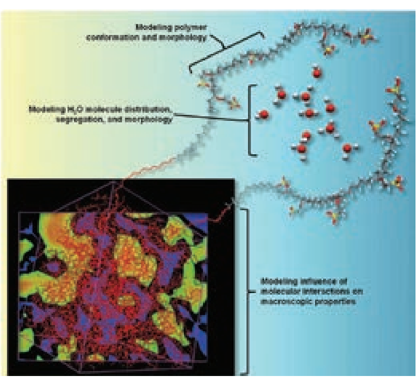

PINEDA

Electrochemical Models Leading to Improved Fuel Cell Performance

The Army Research Laboratory funded researchers at the University of Tennessee developed a new multiscale modeling approach that is providing innovative guidelines for the next generation of fuel cells. Current fuel cells require less expensive components while functioning over a range of conditions. One such component is the polymer electrolyte membrane (PEM), which allows protons to permeate from one side of the cell to the other, thereby generating current. The researchers mimicked the molecular environment of a PEM using carbon nanotubes. This novel approach revealed unexpected atomic-scale interactions that influence how protons move through the membrane, thus contributing to the PEM's effectiveness. Using these fundamental insights, the researchers successfully predicted the morphological properties and water distribution in common PEM types. These discoveries may ultimately enable reductions in a Soldier's required battery weight by up to 60 percent, relative to current solutions.



Model systems comprising carbon nanotubes (CNTs) decorated with PEM functional groups were used to obtain critical and unanticipated insights into the effects of hydration, confinement and hydrophobicity on proton interaction and transport.

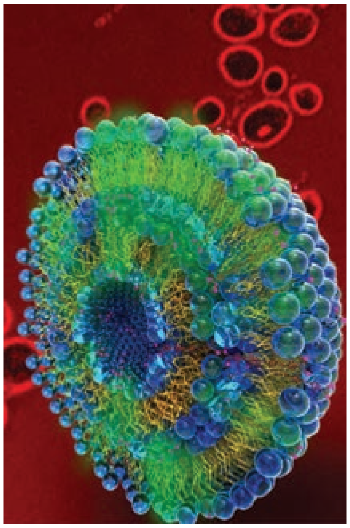


Using the outcome of the Army Research Laboratory funded CNT-based model, scientists were able to use large-scale molecular dynamics simulations to successfully predict the phase segregation, morphology and distribution of water molecules for different PEM chemistries. Understanding these properties is critical in understanding how molecular interactions influence the performance of the PEM.

This portable power system was developed from a previous ARL funded project. The recent ARL- developed electrochemical models may enable improved PEMs for fuel cells, ultimately enhancing the performance of portable battery-charging systems, such as the example shown here.

Integrating Semiconductors with Biology to Harness Microbes

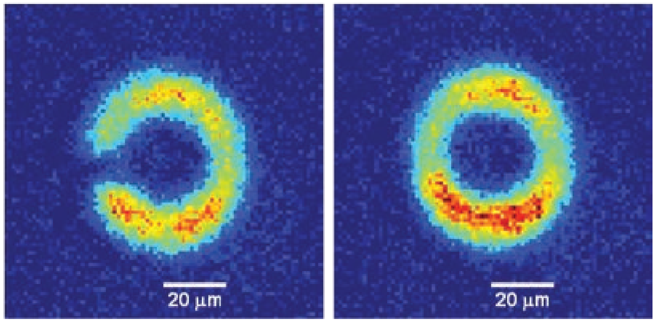
The Army Research Laboratory funded researchers at the University of California - Santa Barbara are the first to successfully incorporate synthetic semiconducting molecules into the membranes of living cells to directly harness the energy from cellular respiration. These researchers, part of the Institute for Collaborative Biotechnologies, discovered a specialized class of water-soluble, semiconducting molecules that can be inserted into the membranes of living microorganisms allowing for the direct transfer of electrons arising from cellular respiration to electrodes outside the cell. This achievement provides a new approach for mediating electron transfer in microorganisms. In collaboration with ARL scientists, these researchers found that incorporating these molecules into yeast-based microbial fuel cells (MFCs) significantly improved performance relative to traditional MFCs. This discovery may enable the conversion of waste biomass to electricity and lead to future applications for the Soldier, such as renewable bio-energy production and bioremediation of wastewater.



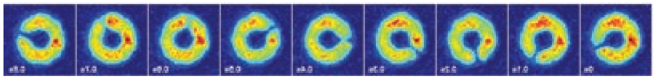
(Foreground) The cross section of a vesicle, a non-biological model of a microorganism, reveals several lipid bilayer membranes with the new membrane-incorporated molecules. Blue spheres represent the polar, water-soluble, heads of the lipids, which have yellow non-polar hydrocarbon tails attached. The new membrane-incorporated molecules are colored in pink. (Background) Fluorescence of the yeast cells demonstrated that the molecules were successfully incorporated into the cell membranes.

First Functional Atomic Circuit Will Enable Revolutionary Sensors

The Army Research Laboratory funded physicists at the University of Maryland, the Joint Quantum Institute, in collaboration with ARL scientists, have created the first ever functional atom-based circuit. The research team created the circuit by crossing laser beams to trap ultracold atoms into a ring, with adjustable barriers to control the atomic rate of flow in the circuit, similar to a control switch in an electrical circuit. The researchers added two types of circuit elements: a stationary barrier to study the stability of the atom current, and a tunable barrier that can be rotated. Just as the ability to control electrons led to the electronics revolution, this atom-based circuit is a key step for a future "atomtronics" revolution. This device may ultimately enable powerful applications for the Soldier, such as ultra-accurate gyroscopes for GPS-independent navigation, and quantum-based encryption for ultra-secure communication.



The researchers created a functional atomic circuit with stationary barrier. This "atom circuit" is composed of ultra-cold sodium gas, as shown in these false-color images. A focused laser beam creates the circuit element, which is a barrier across one side of the ring and constitutes a tunable "weak link" that can turn off the current around the loop. A laser-based barrier can stop the flow of atoms around the circuit (left), while the atoms can circulate around the ring in the absence of the barrier (right).



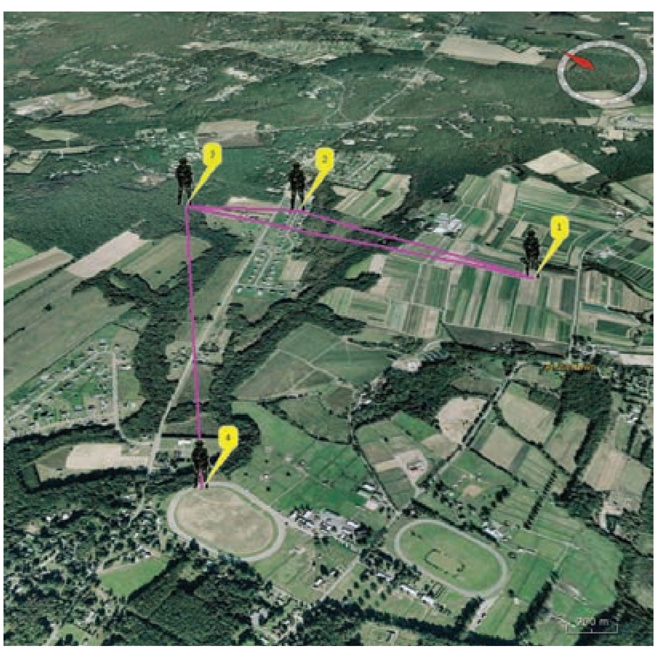
In this type of atomic circuit, the researchers have implemented a control switch that is tunable and can be rotated, as shown in this series of time-lapse images. This barrier can be rotated by the investigators at the speed desired.

High Performance Computing for Robust Mobile Networks

ARL researchers have developed unprecedented large-scale network simulation capabilities made possible through the use of High Performance Computing (HPC). Complex interactions of deployed digital devices (radios, sensors, UAVs, etc.) can now be analyzed and optimized both before and during mission execution. This key enabling technology is providing networks with sufficient speed, fidelity and security to achieve success while avoiding pitfalls that can occur in dynamic and mobile networks (such as connection difficulties due to limited battery power or range).

These capabilities were showcased in 2011 during the Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) Network Modernization (NM) event at Fort Dix, N.J. Supercomputers at ARL-APG delivered simulated data in real time to the tactical network where command and control systems deployed in the exercises were able to interact with simulated HPC-generated entities. Simulations were recently completed representing simulated network nodes involving one of the largest Mobile Ad Hoc Network (MANET) simulations ever completed.

Plans for FY2012 include more robust, realistic network optimization by scaling to brigade and larger networks.



The 3-D interactive interface allows researchers to observe and control MANET simulations, emulations and experiments in real time during C4ISR-OTM (on-the-move) exercise.

HPC Simulation integrated into FBCB2 to provide visualization of live and simulated events during C4ISR-OTM. HPC-driven simulations help test the scalability of MANET command and control devices in the C4ISR-NM exercise.

Jerry Clarke, Computer Scientist, observes MANET exercises using real and virtual entities generated by HPC resources at ARL-APG.

ARL maintains a robust emulation facility that enables exploration of attack and detection concepts. Computer scientist Rommie Hardy discusses emulated environment with Maj. Bryon Mansfield.

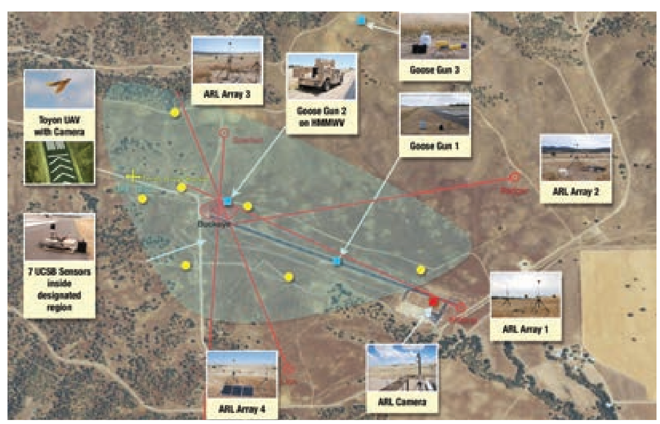
Optimizing Battlefield Cyber Attack Detection

Current tactical networks are rapidly evolving—in complexity, capacity and importance to the success of our Soldiers. Resilient tactical systems, capable of detecting and responding to attacks and abnormalities in battlefield traffic, ensure accurate delivery of vital information to win battles and save lives. The Army Research Laboratory is collaborating with the Communications-Electronics Research, Development and Engineering Center in a multi-year initiative to address the intractable problem of intrusion detection in the mobile ad hoc environment by extending the ARL Interrogator intrusion detection framework, currently collecting data from over 300 sensors throughout the global information grid, into the tactical arena. In fiscal year 2011, ARL research focused on aggregation and compression of relevant host data, enhancing host-based intrusion detection capabilities, minimizing resource drain and exploiting sampling techniques, while demonstrating adequate detection performance in a testbed environment. These foundational concepts lay the groundwork for actionable attack awareness, ensuring reliable network-enabled battlefield operations.

In fiscal year 2012 the test bed will move to the ARL Wireless Emulation Laboratory, where additional capabilities will be incorporated to allow generation of attack scenarios, host behavior monitoring, and evaluation of Interrogator in a tactical forward operating base scenario.

Coalition Sensor Interoperability and Data/ Information Sharing via the ITA Sensor Fabric and Policy Management Toolkit

This unprecedented technology enables coalition sensor assets to be integrated and networked, and data/information to be shared and disseminated under distributed policy-control to support dynamic coalition operations. ARL is collaborating with the United Kingdom Ministry of Defence to develop this unique coalition capability for Network Enabled Operations with distributed intelligence, surveillance and reconnaissance (ISR) assets and users at the edge of the network. The collaborative effort leverages two key technology components developed within the U.S.-U.K. International Technology Alliance program, Sensor Fabric and Policy Management Toolkit. The fabric is a flexible middleware infrastructure for sensor discovery, access and control, and data consumability. The policy tools perform a variety of distributed management functions within the fabric infrastructure such as sensor/platform command and control, data access control, and filtering of data/information. In June 2011, this coalition technology was successfully demonstrated with disparate ground sensors and aerial platforms in an operational environment at Camp Roberts, Calif. In 2012, the ITA team will integrate and demonstrate the technology as part of a U.K. Persistent Wide Area Surveillance (PWAS) capability concept demonstration. The technology development effort is funded by the Office of the Secretary of Defense Coalition Warfare Program.



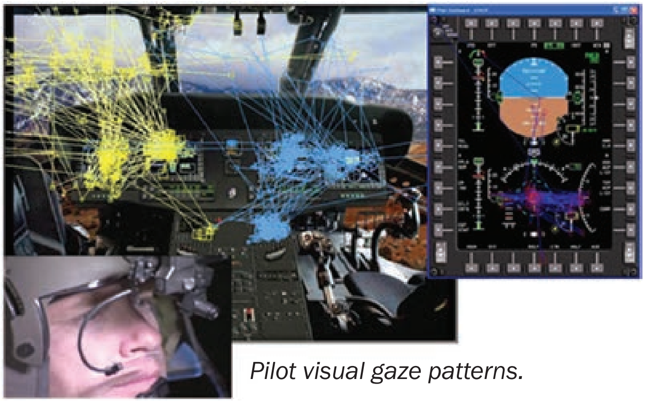
Persistent ISR scenario with networking and interoperability of two coalition networks: one sensor network with four acoustic arrays plus one fixed mounted camera and a second sensor network with seven low-cost unattended ground sensor (UGS) plus one unmanned aerial sensor (UAS) with visual camera onboard plus one UAS data harvester.

ARL researcher fitting an Army aviator with an eye tracker.

Reducing Visual Demands of Army Aviators

Army Research Laboratory researchers have achieved significant advances in quantifying the visual demands placed on pilots during simulated flight, and those advances are being used to refine and improve system design. The innovative use of eye tracking technology to record point of gaze, coupled with performance data, is helping system designers understand which display elements exhaust visual resources. Given frequent and unexpected spikes in pilot workload, it is important to characterize the exact point in which workload is elevated, as well diagnose the driver of the increase. Is the complexity of the information increasing mental workload or is the effort required to obtain visual information serving as a bottleneck for decision making? Combined behavioral and eye tracking metrics are allowing researchers to approach system design with a scalpel rather than a hatchet. This has resulted in significant cost savings throughout the development cycles, increased pilot efficiency and reduced the potential for mid-air collisions by ensuring that pilots keep their heads up and their eyes focused.

Human-figure modeling for Army aviation systems.



Pilot visual gaze patterns.

Classification of Task-Related Brain Activity in Complex Environments

Emerging neuroscience-based technologies will harness signals taken directly from the brain, providing completely new and more effective human-system interactions. While many current efforts focus on clinical applications, a team of Army Research Laboratory-led scientists and engineers are providing pioneering solutions to make Soldier neurotechnologies a reality. In recently completed Warfighter experimentation, the team, and their Tank Automotive Research Development and Engineering Center (TARDEC) and contractor partners, implemented new experimental designs to induce behaviors and brain responses that resemble what might occur in the operational environment – a critical issue given the strong task and context dependence of human brain function – and demonstrated the ability of computational algorithms to reliably identify unique, task-relevant patterns in the observed electrical activity recorded from participants' scalps. The team's results were consistent with previous research findings under much more controlled conditions, paving the way for the development of future neurotechnologies that can be deployed in operationally relevant environments to make Soldier-system interactions more effective.

The Ride Motion Simulator (RMS) at TARDEC's Ground Vehicle Simulation Laboratory provided the ARL-led research team with unique capabilities to enhance the realism and increase the impact of research on neurotechnology development.

Enhancing Soldier Cognitive Performance for Mission Command Collaboration and Decision Making

The Army Research Laboratory measured the human dimension of the Joint Forcible Entry Warfighter and Combined Arms Maneuver/Wide Area Security experiments at Mission Command Battle Lab (MCBL), Fort Leavenworth, Kan. The experiments embodied the concepts, organizations and doctrine that the Training and Doctrine Command envisions for future mission command.

ARL's focus under the Tactical Human Integration of Networked Knowledge (THINK) Army Technology Objective was how to enhance Soldier cognitive performance in this distributed collaboration and decision-making environment. Information flow was quantified via network metrics that capture not only message traffic, but how individuals and teams shared and acted on information and how those patterns contributed to overall mission effectiveness. This in-depth examination of the mission command work domain will be used to inform data repositories, information products, applications and services that support the Soldier's workflow.

The fiscal year 2011 experimentation highlighted more than a decade of collaboration between ARL and the MCBL for Soldier-focused experimentation, which continues to provide mission command and human dimension insights for the Army.

Multiple Amputation Trauma Trainer Prepares Approximately 120,000 Soldiers Deploying in 2011

The Army Research Laboratory completed prototyping the Multiple Amputation Trauma Trainer, which is the Army's first ever medical training simulator that incorporates patient movement while training Soldiers to treat severe lower torso injuries. The simulator uses state-of-the-art special effects to portray multiple types of blast wounds. It combines two lower amputations with animatronics technology that generates movement in the limbs. It also incorporates lifelike reusable synthetic tissue technology for trauma training with enhanced realism and durability. The device is attachable to the fielded mannequin-type patient simulators and to human role players to enhance training realism. The simulator trains tourniquet application/adjustment, splinting broken bones and airway management. The simulator won the 2011 Department of The Army Best Simulation in Acquisition. The simulator also won the 2011 National Training Simulation Association Award for Excellence and the Interservice/Industry Training, Simulation and Education Conference Governor's Award.

Improvements in medical training simulations will lead to better trained medical personnel and improved Soldier survivability.

Virtual Human Agent Technology Development Accelerated

Under the direction of the Army Research Laboratory, the Institute for Creative Technologies commenced development in 2011 of holodeck-like simulations that allow Soldiers to be immersed in training environments and interact with life-size virtual human agents. The virtual humans are a blend of Army first ever, near-term, futuristic technologies in artificial intelligence, graphics and animation. Virtual human technology not only improves stimulation of kinetic battlefield tasks but also non-kinetic battlefield decision making, which has been nearly impossible to replicate, since the creation of synthetic environments, without live role players. ARL developed the Army's first ever prototype simulation that uses virtual humans to assists company grade officers and non-commissioned officers develop and practice leadership skills that normally are only learned during early career assignments through on-the-job training resulting from trial and error methods. The two prototype simulations were delivered to the Army Maneuver Center of Excellence and the Navy Officer Training Command located in R.I.

Soldiers can now train with life-size virtual humans in holodeck-like simulations.

Enhanced Dynamic Geo-Social Environment is the First Simulation Built to Allow Training Anywhere and at Anytime

The Enhanced Dynamic Geo-Social Environment is the first Army owned massively multiplayer online simulation that is designed to train Soldiers anywhere, anytime, on any multiple, seamlessly changing geo-specific battlefield terrain. The first ever technical achievement is the software integration of the Army's One Semi-Automated Forces with

ARL's work on the enhanced dynamic geo-social environment allows Soldiers to train anywhere.

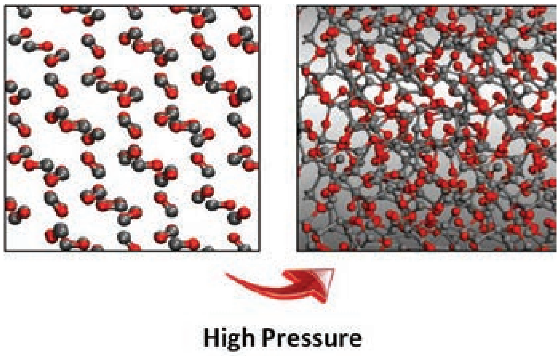
massively multiplayer online technology that provides a scalable simulation from single battlefield entities such as Soldiers to massive formations such as Brigade Combat Teams persistently replicated in near real time without latency in interoperability, communications or visualizations. The prototype promotes the conduct of individual training, collective training and mission rehearsals in a full spectrum of battlefield operations that closely replicate the contemporary, multiple warfighting environments. The simulation supports counter-insurgency, cultural, sustainment and traditional kinetic training tasks in combat units and the leader development classes of the Infantry and Armor schools. The Army's Training and Doctrine Command is the collaborating sponsor.

Multiscale Computational Tools for Enabling “Game Changing” Energetics

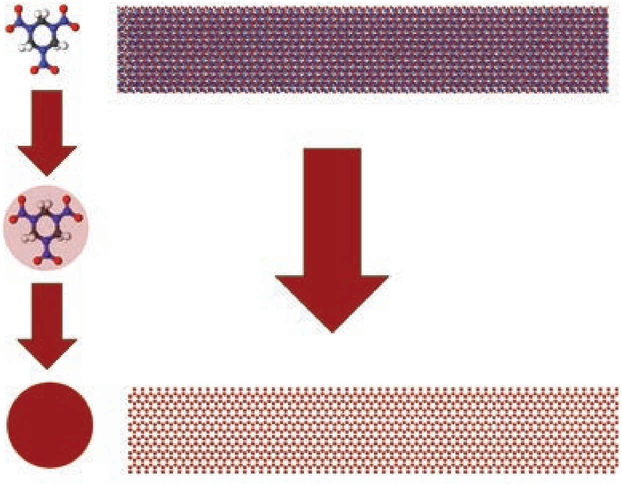
ARL is aggressively engaged in computational research to enable new game-changing classes of energetics with the goal of affordable lethality at reduced size. A multiscale computational framework approach has shown the feasibility of predicting the structure/property relationship for simple and complex energetics required when exploring new mechanisms for storing and releasing unprecedented amounts of energy and power.

These computational tools have demonstrated remarkable accuracy in predicting energetic material behavior and have been implemented to explore the creation of new families of energetic materials containing stored structural energy stabilized with additives and recovered from extreme pressure fabrication.

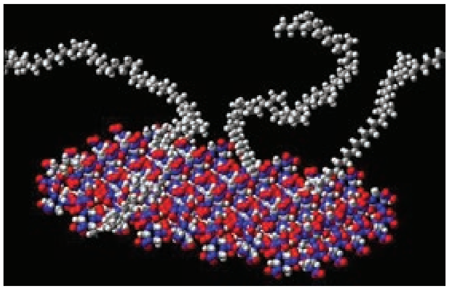
Design and fabrication of new forms of energetic materials can now go beyond the constraints of conventional chemical synthesis. Continued research in the multiscale computational framework will reveal new insights into energetic material behavior and provide a pathway for achieving significant improvements in energetic performance and new opportunities for weapon technologies providing overwhelming firepower to the individual Soldier.

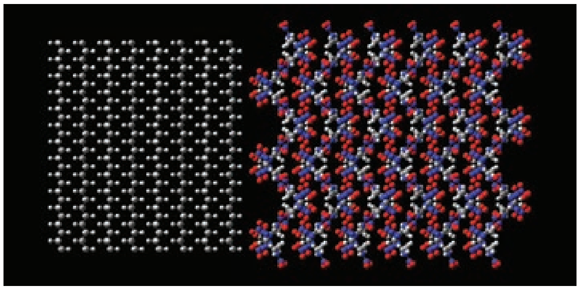


Computational modeling of structural energy compounds explores the properties of non-traditional compounds to guide efforts in synthesis.



ARL-developed mesoscale Dissipative Particle Dynamics (DPD) in conjunction with ARL-developed coarse-grained mesoparticle force fields have been used to study large-scale shock events (shown on right). Coarse-grained forced fields allow for the replacement of molecules, from single molecules up to hundreds of molecules, with a single mesoparticle (as seen on the left). The addition of DPD produces the correct thermodynamic properties and responses for mesoparticle simulations.





ARL-developed force fields allow the computation of energetic material -polymeric binder interfaces. Calculations using these force fields are used in fitting and validation of novel multiscale particle-based mesoscale models.

Weapon Systems Research for Improved Individual Soldier Lethality

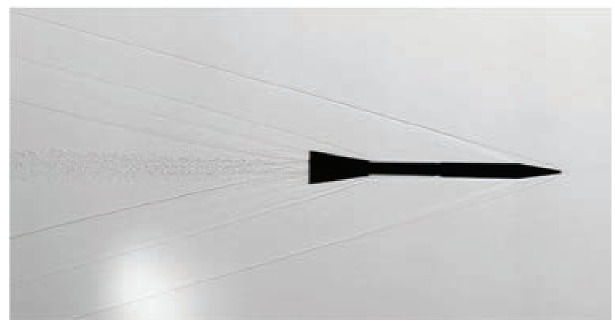
Individual Soldier weapon systems have become increasingly important on the battlefield and continued enhancements to these systems will provide the Warfighter with a broadened tactical advantage and greater effectiveness in urban settings and other diverse environments. ARL has conducted fundamental research into small arms systems resulting in improved accuracy, penetration and lethality, and continues to transition these technologies to ARDEC, PM-Soldier Weapons (PM-SW), PM-Maneuver Ammunition Systems (PM-MAS) and TRADOC (MCOE).

Enhancements in accuracy have been demonstrated through advancements in long-range precision in which the probability of hit was quadrupled at ranges greater than one kilometer. Current breakthroughs in the penetration mechanics of hard and soft targets have yielded a 50 percent reduction of target penetration energy when compared to other state-of-the-art technologies.

Additional advancements in small arms technologies such as advanced armor-piercing, efficient propulsion, low observable tracers, and consistent lethal effects, have been achieved by ARL. These technologies provide substantial improvement in the precision engagement capabilities of individual Soldiers. This research addresses the Maneuver Center of Excellence number one priority and capability gaps identified in the Small Arms Capabilities Based Assessment.

0.50 caliber saboted flechett.

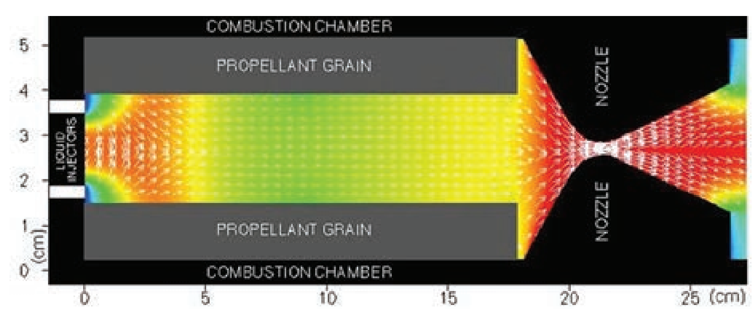
0.50 caliber smooth bore weapon.



180 grain long rod.

Modeling to Enable Next Generation Missile Propulsion Capability

Ongoing Army solid propellant rocket development programs are investigating minimum smoke and accelerated burn rate formulations for tactical missile rocket engines. In support of these programs, the Army Research Laboratory has developed a time-accurate, multi-phase, reacting-flow, physics-based computational fluid dynamics (CFD) code, which includes explicit models for solid phase, high-temperature thermodynamics and finite-rate chemical kinetics. With this approach, multidimensional reactive flow dynamics can be studied in complex geometries. The CFD code has been successfully used in simulations performed to elucidate the dynamics underlying the ignition and combustion of propellant formulations with enhanced burn rates via embedded mechanical structures. Incorporation of this CFD code into ongoing research efforts will assist the enhancement of battlefield range and terminal lethality of Army missiles, such as Hellfire and JAGM. The ARL CFD code is also being used in a collaborative effort with the Aviation and Missile Research, Development and Engineering Center to develop propellants for existing and next generation tactical missiles.



CFD modeling of a hybrid (HTPB-IRFNA) engine.

Advanced Intelligence for Small Military Robots in Urban and Complex Environments

The Army Research Laboratory is developing intelligent behaviors for man-portable robots that will automate reconnaissance and surveillance tasks for the Soldier, thus reducing his workload and improving his situational awareness. In fiscal year 2011, ARL researchers developed an innovative technique that enables robot localization to within 1 meter in a global positioning system denied urban environment using vision-based localization in urban environments. Accurate localization is critical to providing situational awareness. ARL researchers have also developed a state-of-the-art algorithm for adaptive vehicle planning that considers real-world constraints, such as communications and power limitations, while autonomously navigating the complex urban environment in which Soldiers must operate using multi-robot vehicle routing and planning. This groundbreaking algorithm that is a successful application of recent advances in combinatorial optimization for logistics problems will enable robots that have short endurance to perform missions over extended periods of time by working as a team to get the information that the Soldiers need. In fiscal year 2012 the research will be focused on speed and scale: making ground navigation faster through a combination of more robust mapping and motion planning that more accurately reflects the robot dynamics and environmental disturbances, and making the multi-robot task planner able to cope with larger teams and longer horizons by exploring sensible solution heuristics.

ARL engineers work with Soldiers at Ft. Benning, Ga., to test ARL-developed autonomous behaviors.

ARL has developed algorithms that can localize the robot in an urban environment to within 1 meter without a global positioning system (GPS) and without visiting the site in advance.

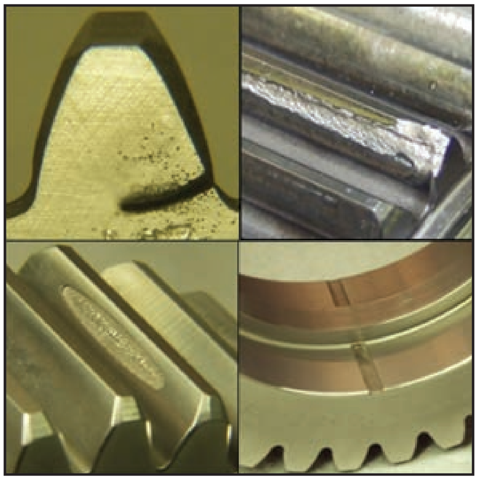
ARL engineers prepare the robots for collaborative behavior experimentation at the Ft. Benning, Ga., military operations on urban terrain (MOUT) site.

Planetary Fault Detection Can Lead to Improved Helicopter Transmissions

OH58 Kiowa Warrior.

Undetected damage in helicopter transmissions can lead to catastrophic failure of the propulsion system and loss of lift. To better diagnose the condition of helicopter transmissions, ARL teamed with NASA engineers to develop techniques to detect such faults before failure, focusing on the planetary gearsets which exist in many helicopter transmissions. This is challenging because planet gears revolve around the center-axis of the transmission, making detection of a faulty gear mesh problematic, when using a stationary sensor.

Using the method of "vibration separation," engineers were able to optimize the extraction of vibration signals from passing planets and generate a virtual signal for each gear in the planetary system. The results were transitioned to the Army Aviation Applied Technology Directorate and Bell Helicopter in 2010. Further research in this area includes determining the amount of data required to make an accurate picture of transmission health and methods for better detecting sun gear tooth cracks.



Planet and sun gears used in research experiments containing both seeded and naturally grown faults.

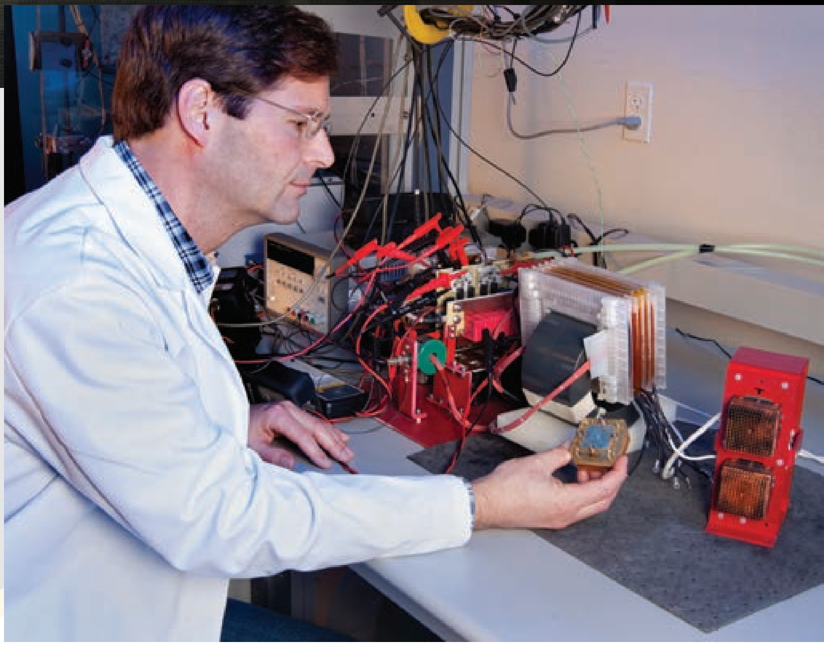
Enhancing Human-Robot Team Performance

To optimize human-robot teaming, the Army Research Laboratory is putting human factors first to ensure that the advantages of autonomy can be employed for maximum mission effectiveness. Human-robot interaction research for dismounted Soldiers has demonstrated both the value of using robotic assets and the increased payoff of highly intuitive, multimodal communication interfaces to those robots. In the field at Fort Benning, Ga., ARL showed that Soldiers were able to complete building-mapping missions significantly faster with advanced interfaces compared with more labor-intensive traditional teleoperation methods. For the mounted Soldier, research investigated the utility of RoboLeader, an intelligent agent, as a single interface between the Soldier operator and a team of robots and the results tell us that RoboLeader can help Soldiers control multiple robots. Consequently, Soldiers can focus on other attention-demanding tasks that are critical on the battlefield--maintaining situational awareness and effective communications with fellow crewmembers. Future ARL efforts will investigate the uses of handheld devices and intelligent technologies to enhance Soldier-Robot teaming.

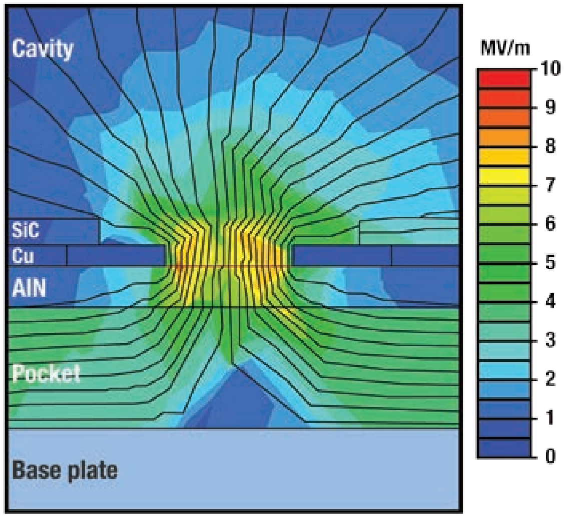
Soldiers assist ARL researchers routinely to ensure optimum human-robot interaction.

SiC for New Compact High Voltage Capabilities

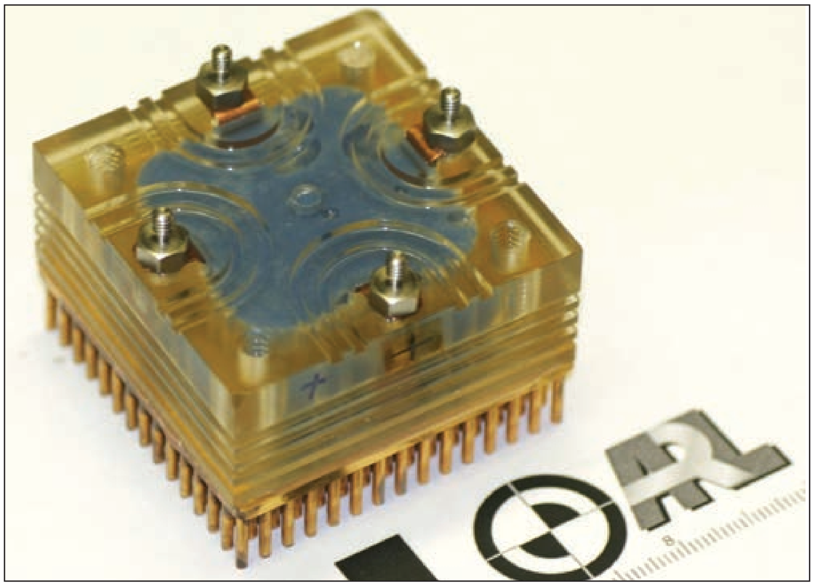
The Army Research Laboratory has developed and demonstrated a 15-kV, semiconductor rectifier module based on a CREE, Inc. silicon carbide (SiC) junction-barrier Schottky diode having the highest reverse blocking voltage ever fabricated. Current 15-kV, 3-A full-bridge rectifiers require 20 silicon diodes and dissipate approximately 170 W in heat. In comparison, ARL's SiC rectifier module requires four diodes and dissipates just 20 W. The SiC diodes allow for both an 80 percent volume reduction and eight-fold increase of efficiency – an achievement attributed to the Army's commitment to maturing wide band gap semiconductor technologies. ARL performed extensive electrostatic simulations on package geometries to reduce electric field intensities within the dielectric materials, mitigating localized degradation centered at volume defects. A novel packaging approach (U.S. patent application 13/186,021) fabricated by ARL minimized component footprint by 30 percent and increased heat rejection by a factor of four relative to conventional technologies. These advancements are building blocks for next-generation, compact, high power conversion systems, bringing a new wave of electric power solutions to the Soldier.



Dr. Wesley Tipton installs one of four SiC rectifier modules in an ARL-developed high voltage technology demonstrator, 40-kV DC-DC converter.



Electrostatic field simulation used to identify high electric field regions (>7 MV/m) that could produce partial discharge and dielectric.

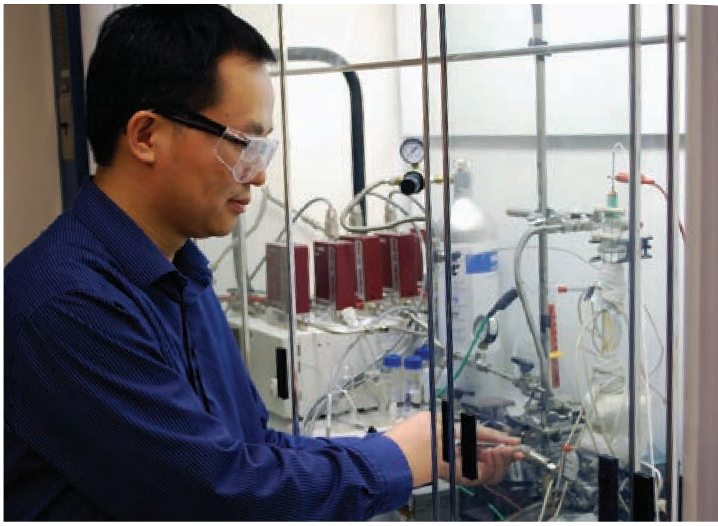


ARL-developed, full-bridge rectifier module incorporating 15-kV SiC diodes.

Catalytic Combustion for Scalable Compact Power

Meeting current and future Army power requirements remains a tremendous challenge, particularly given the ever increasing power demands of the Soldier. Alternate fuels such as butanol, a bio-renewable fuel with high energy content approaching jet propellant (JP)-8/diesel fuel, are a means to address these demands. The Army Research Laboratory has established a unique method of specific chemical steps for catalytically combusting or reforming bio-fuel butanol using a catalytic reactor and leveraging our chemical analysis capabilities and expertise. Energy efficiency and fuel flexibility are two critical aspects of converting energy to provide reliable electrical and mechanical power to the Soldier. ARL's research addresses these issues by establishing the fundamental mechanism by which butanol is combusted or reformed in a catalytic reactor; developing a scalable reactor operating across combustion, hydrogen (H_2) production, or olefin generating regimes; and demonstrating electrical power generation via an integrated high temperature lead telluride (PbTe)-based thermoelectric generator device. The chemistry knowledge gained is facilitating new thermophotovoltaic (TPV) burner designs for power sources for extended mission time.

Adam Gamson measuring the biofuel combustion products using gas chromatography analysis.



Dr. Ivan Lee withdrawing butanol combustion products from a reactor for reformation experiments.

High Voltage Batteries for Extended Mission Duration

The need to reduce batteries used for extended missions is a well recognized Army requirement. A typical 72-hour mission in Afghanistan requires a Soldier to carry, on average, seven types of batteries — 70 individual batteries in all — weighing from 16 – 30 pounds (nearly one fifth of total equipment weight). The Army Research Laboratory has achieved a breakthrough in Lithium (Li)-ion battery technology by designing components that can operate at 5 volt (V) - a game changing increase in energy density, up to 30 percent, over current state of the art Li-ion technology. Such densities allow smaller form factor sources or more energy for all battery applications. ARL was the first to develop a combination of electrolyte additives and cathode material at high cell voltage (5V) that operate for hundreds of cycles without cell degradation. Moreover, it is essentially a drop-in technology that can be easily adopted by battery manufacturers. This technology can reduce the amount of battery weight a Soldier carries for the average 72-hour mission by approximately 20 percent. ARL sponsored a Battery Technology Industry day in mid February at SAIC in McLean, Va. Unburdening the Soldier was a key driver for the research and development effort and industrial interest was obvious by requests for samples and license applications.

Dr. Kang Xu assembling a test cell that uses a high voltage electrode and electrolyte.

Demonstration of Cue-to-Slew Capability

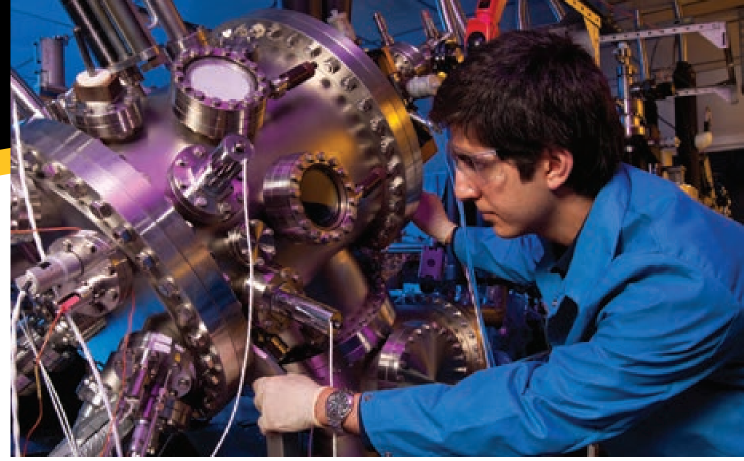
A new multimodal personnel and vehicle detection capability has been demonstrated by ARL and integrated into the Persistent Ground Surveillance System (PGSS). This capability uses a network of non-imaging ground sensors (e.g., acoustic, seismic, electromagnetic) communicating in real time to vector an imaging system on the PGSS aerostat to view an actionable scene. An initial capability, requested by the Army Deputy Chief of Staff for Intelligence (G-2), was demonstrated for the Intelligence and Security Command in early fiscal year (FY) 2011. A second demonstration requested by Army G-2 exposed the 504th Battlefield Surveillance Brigade to using this sensor cueing capability with the iScout system during their FY11 certification exercise. This new capability has enhanced the Soldier's ability to obtain real-time information about ground targets and has eliminated the need for the PGSS aerostat operator to constantly scan in all directions in hopes of finding a moving target.

iScout is a compact, rugged, multi-modal sensor developed under a Small Business Innovation Research contract.

Imager gondola on the Persistent Ground Surveillance System aerostat.

Inside the Persistent Ground Surveillance System ground station.

Low Defect TCA Process for Ubiquitous IR Imaging



Sina Simingalam operates a molecular beam epitaxy (MBE) chamber for the growth of MCT on a large area Si substrate.

The Army Research Laboratory has pioneered a defect reduction process using thermal cycle annealing (TCA) for improving mercury cadmium telluride (MCT) grown on scalable silicon (Si) substrates. Currently, the use of MCT -- a mainstay material for Army infrared (IR) systems -- is limited due to high levels of dislocations when grown on scalable substrates such as Si (an inexpensive substrate material). These dislocations increase pixel noise and limit IR focal plane array (FPA) operation. ARL's new TCA process has decreased dislocation levels by a factor of ten, allowing for large format IR FPAs for enhanced persistent surveillance and 360-degree situational awareness capabilities. Additionally, this achievement will lead to wafer-scale processing, and hence significant FPA cost reductions, yielding ubiquitous availability of high performance IR detectors. In FY11, the Night Vision and Electronic Sensors Directorate (NVESD) of the Communications and Electronics Research Development and Engineering Command (CERDEC) asked ARL to begin transitioning this technology to Raytheon Vision Systems and Teledyne Infrared Sensors, industrial partners under a manufacturing program managed by NVESD.

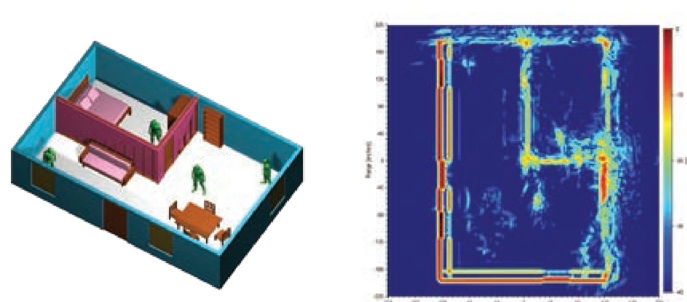
Dr. Priyalal Wijewarnasuriya inspects a TCA annealed 3-inch wafer from a large area annealing furnace.

Sensing-Through-Wall Radar Research

Developing actionable intelligence on activities within enclosed structures remains one of the most difficult challenges facing the Army. ARL, in cooperation with the Intelligence and Information Warfare Directorate (I2WD) of CERDEC, is investigating the use of ultra-wideband radar technology because it provides the ability to simultaneously penetrate many materials while still maintaining relatively high resolution. ARL scientists, using high performance computing resources, have developed sophisticated computational electromagnetic models of complex building structures and human signatures to build a fundamental understanding of the capabilities and limitations of sensing through wall-radar-technology.

Sense-through-the-wall radar.

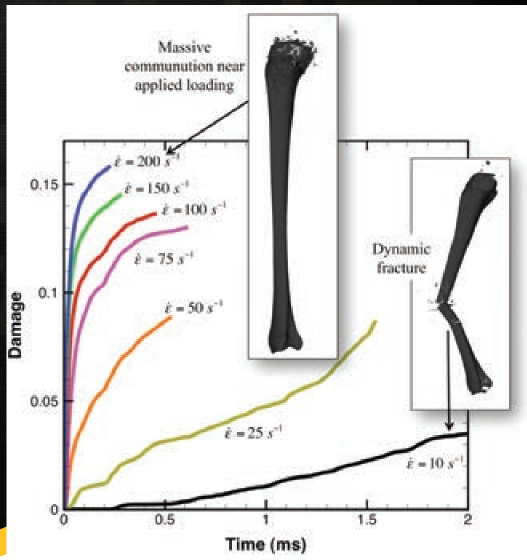
The technology will provide Soldiers with the capability to detect, locate and sense personnel with concealed weapons or explosives behind obstructions from a stand-off distance. This work culminated in a book chapter authored by ARL scientists that appeared in the first book ever written on "*Through-The-Wall Radar Imaging*."



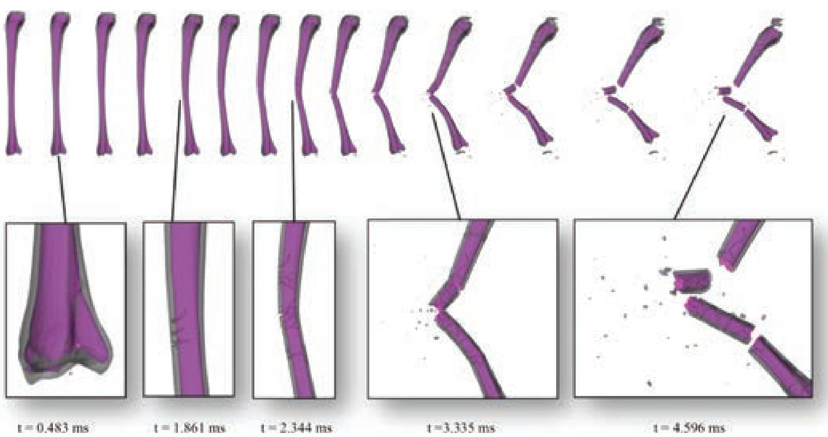
CAD model of complex room and resulting radar image generated using electromagnetic model data.

Injury Biomechanics for Enabling New Concepts for Soldier Protection

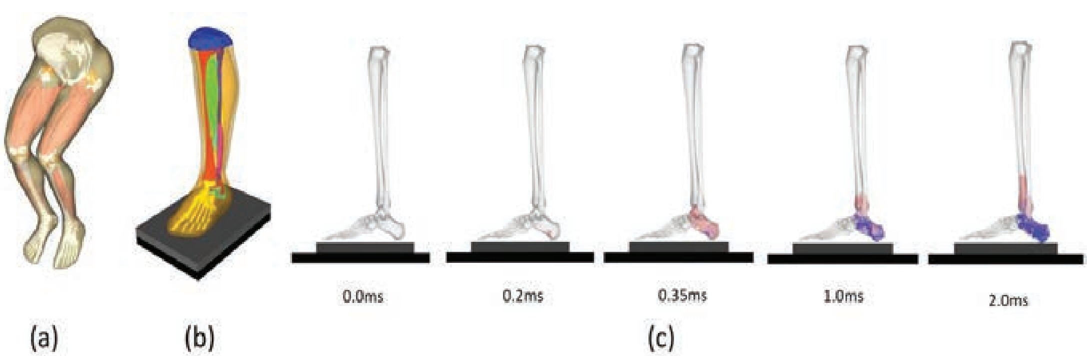
ARL is merging research in ballistics and biomechanics to develop a pathway to leap ahead in Soldier protection technologies. The human body is subjected to a wide range of loading conditions within the military operational environment. To develop the best protection for the Warfighter, the relationships between armor interactions with the body, human injury and human performance must be understood. ARL is conducting strategic research in computational injury biomechanics, high-rate soft tissue physics and materials and manufacturing to address the technical challenges of Soldiers in extreme military environments.



Damage plotted as a function of time during a compressive high strain rate simulation. A change in failure mechanism is observed as the rate of loading is increased from a transverse dynamic fracture to massive comminution near the proximal end of the tibia.



Computational modeling showing bone fracture explicitly from high strain rate loading. Both the cortical and trabecular bone is represented.



(a) A high-resolution anatomical model of the lower extremities enables specific injury mechanisms to be explored. (b) A hierarchical approach with models and submodels is used. Here a submodel of the knee and below with a representative vehicle floor plate is shown – the same setup for which cadaveric experimental tests exist. (c) Failure and damage fronts captured in the lower leg submodel (red represents trabecular bone and blue represents cortical bone). Note the massive comminution in the calcaneal and distal tibia regions. These simulations enhance our understanding of injury mechanisms and enable ARL to design novel protection strategies.

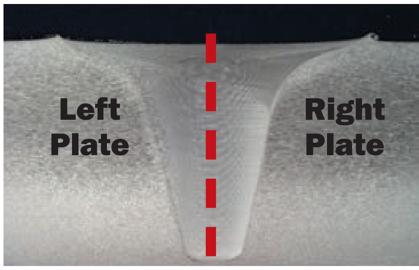
Aluminum Alloy Research Leading to Superior Underbody Protection

Typical friction stir welding tool used for aluminum alloy plates.

The MAK after the blast test event. The MAK had a permanent deformation of less than 1 inch.

ARL research in advanced aluminum alloys is leading to critical advances in vehicle underbody protection. Incorporation of these technologies will provide ground combat vehicles with significant enhancements to ballistic shock and mine blast resistance at less weight.

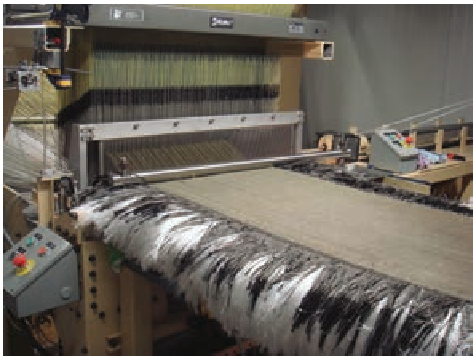
When joined together by conventional means, aluminum alloy plates typically result in ballistically weak structures. ARL, in collaboration with Edison Welding Institute and General Dynamics Land Systems (GDLS), has developed an advanced welding process called friction stir welding (FSW), which is used to join high strength aluminum alloy plates, resulting in a structure that has a ballistic shock resistance equal to the base material. ARL also developed new ultrasonic modeling techniques used to evaluate FSW joints. Upon validation, the FSW technology was transitioned to GDLS for application to current and future aluminum hull ground vehicles. ARL is currently advancing the FSW technology to extend to aluminum plates up to 3 inches in thickness and beyond.



Cross section of an aluminum friction stir weld.

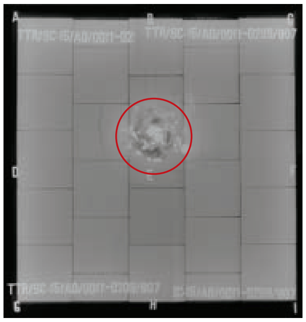
ARL, as part of the JPO MRAP Underbody Working Group, and in collaboration with Alloy Technology Innovations and Corvid Technologies, has also developed the monocoque aluminum kit (MAK), which avoids the mechanical weaknesses of joints through the manufacture of a contoured underbody plate formed from a single monolithic plate of aluminum. Demonstration of the MAK was the first ever instance of a thick plate (>2.0 inches) aluminum armor alloy formed in a single piece for an armored vehicle hull application. The MAK technology has been transitioned to JPO MRAP and vehicle manufacturer Osh Kosh, and is under consideration for fielding by SOCOM.

3-D Through-Thickness Reinforcement (3D-TTR) Concept Enables Unprecedented Multi-Hit Armor Performance



A Jacquard loom weaving a 3-D reinforced glass, carbon, and aramid fiber hybrid architecture.

In Fiscal Year 2011, a 3D-TTR armor concept underwent successful proof-of-concept experimentation, marking a major milestone in a multiyear effort by ARL, U.S. Army Mantech, Textile Engineering and Manufacturing, Inc (TEAM), and university partners to develop an innovative, lightweight, multi-hit composite armor technology. Historically, composites and ceramics enable lightweight armors, but not with a multi-hit capability. To enable multi-hit performance, a high degree of damage localization is required. For this concept, hybrid composite architecture designs of glass, carbon, and aramid fibers were enabled by ARL developed 3-D textile fabrication modeling and simulation codes. These hybrid architectures were fabricated using a textile weaving process that incorporates state-of-the-art computer-driven Jacquard looms used extensively in the production of 3-D reinforced damage tolerant composites. Here, for the first time, Jacquard loom technology enabled a ground combat vehicle armor design, resulting in an affordable, lightweight, multi-hit armor for highly efficient protection applications. Future efforts will focus on the utilization on high-performance computing models of 3D-TTR architectures to reduce armor weight, space claim, and cost while maintaining multi-hit capability.



X-ray of confined bullet debris indicating localized damage.

ARL Conducts Apache Block III Live-Fire Testing

The Army's Apache Block III (AB3) program is a major update to the AH-64D Apache Longbow. It will provide Army aviators with an aircraft that has both the advanced capabilities of the Apache Longbow and the agility and performance of the original Apache.

The Army Research Laboratory conducted live-fire testing on the AB3 at ARL's Rotorcraft Survivability Assessment Facility. These efforts included dynamic ballistic testing of the Composite Main Rotor Blade (CMRB) and Improved Drive System (IDS) while operating at flight-representative power levels on a restrained AH-64D and static testing of various components, such as drive shafts, gears and bearings.

ARL's live-fire test results and vulnerability analysis are the basis for the survivability evaluations prepared by the Army Test and Evaluation Command and the Office of the Director, Operational Test and Evaluation. These test results and analysis will also be used to feed the AB3 full-rate production decision in 2012.

Apache Block III Improved Drive System test setup, gun view.

Apache Block III on ARL's Rotorcraft Survivability Assessment Facility pad.

Restrained Apache Block III operating at a flight representative power level on ARL's Rotorcraft Survivability Assessment Facility pad.

ARL Completed the Development of the QRC-335 (400) Series of Airborne Electronic Attack (EA) System

As technology proliferates rapidly throughout the world, electronics that can adversely impact U.S. operations are more readily available and more advanced than ever. In order to operate successfully, Army air and missile defense (AMD) systems need to be survivable against asymmetric advanced electronic attack (EA) threats that employ technology sometimes more advanced than that in U.S. systems.

To evaluate and demonstrate the survivability of AMD systems in an EA environment, ARL developed and fabricated the QRC-335 (400), the latest in ARL's QRC-335 family of airborne EA pods for use on full-scale, high-performance aircraft. The QRC-335 (400) is the Army's first digital radio frequency memory (DRFM)-based airborne EA system in the inventory.

The QRC-335 (400) was flown in experiments during Patriot developmental test events to simulate an EA environment. The data from these systems allowed the Lower Tier Project Office to determine the performance of Patriot in an advanced EA environment.

QRC-335 (400) pod is the Army's first DRFM-based airborne EA system in inventory.

QRC-335 (400) pod attached to an Air Force F-16.

ARL Develops Experimental Technique to Assess Helmet Protection

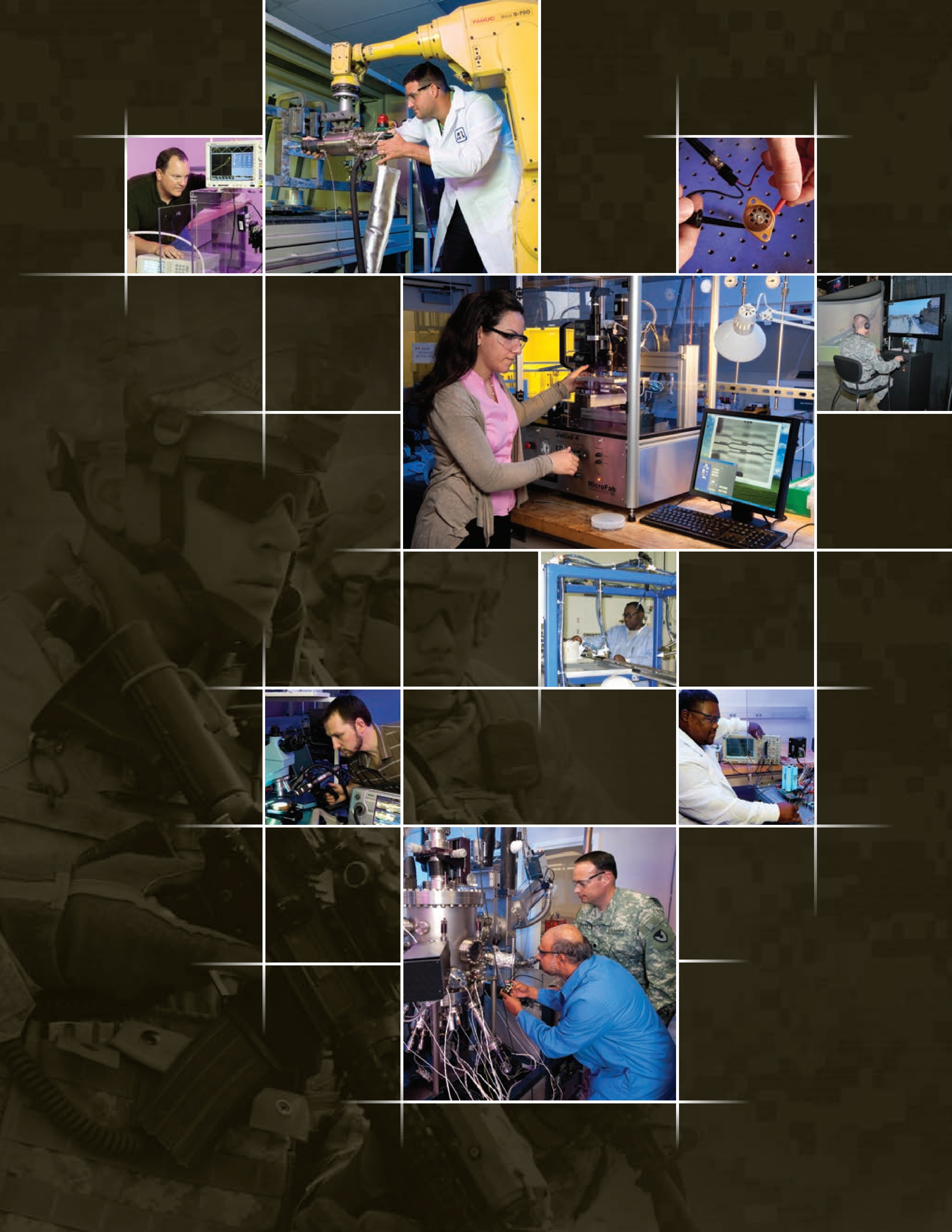
When a Soldier's helmet is struck by a bullet, the impact produces a bulge inside the helmet that can impact the Soldier's head and cause an injury. To measure and assess this phenomenon, ARL has developed an experimental technique using digital image correlation (DIC) to collect detailed dynamic physical response data on the deformation of a helmet's inside face.

DIC uses high-speed cameras to record the deformation as it happens, and measures how fast the deformation occurs.

The ARL team is paying particular attention to how the velocity of the expansion of the bulge changes as it grows and eventually comes into contact with the Soldier's head. These measurements can then be correlated with the potential for head injury.

This experimental technique is already proving its utility for optimizing helmet designs by allowing helmet developers to assess and validate the performance of helmet prototypes.

Dr. Dixie Hisley and James Gurganus brief Maj. Gen. Nick Justice on ARL's new experimental technique using DIC during the 2010 Army Science Conference.


FANUC
MicroFab

U.S. Army Research Laboratory
2800 Powder Mill Road • Adelphi, MD 20783-1197

U.S. ARMY RDECOM