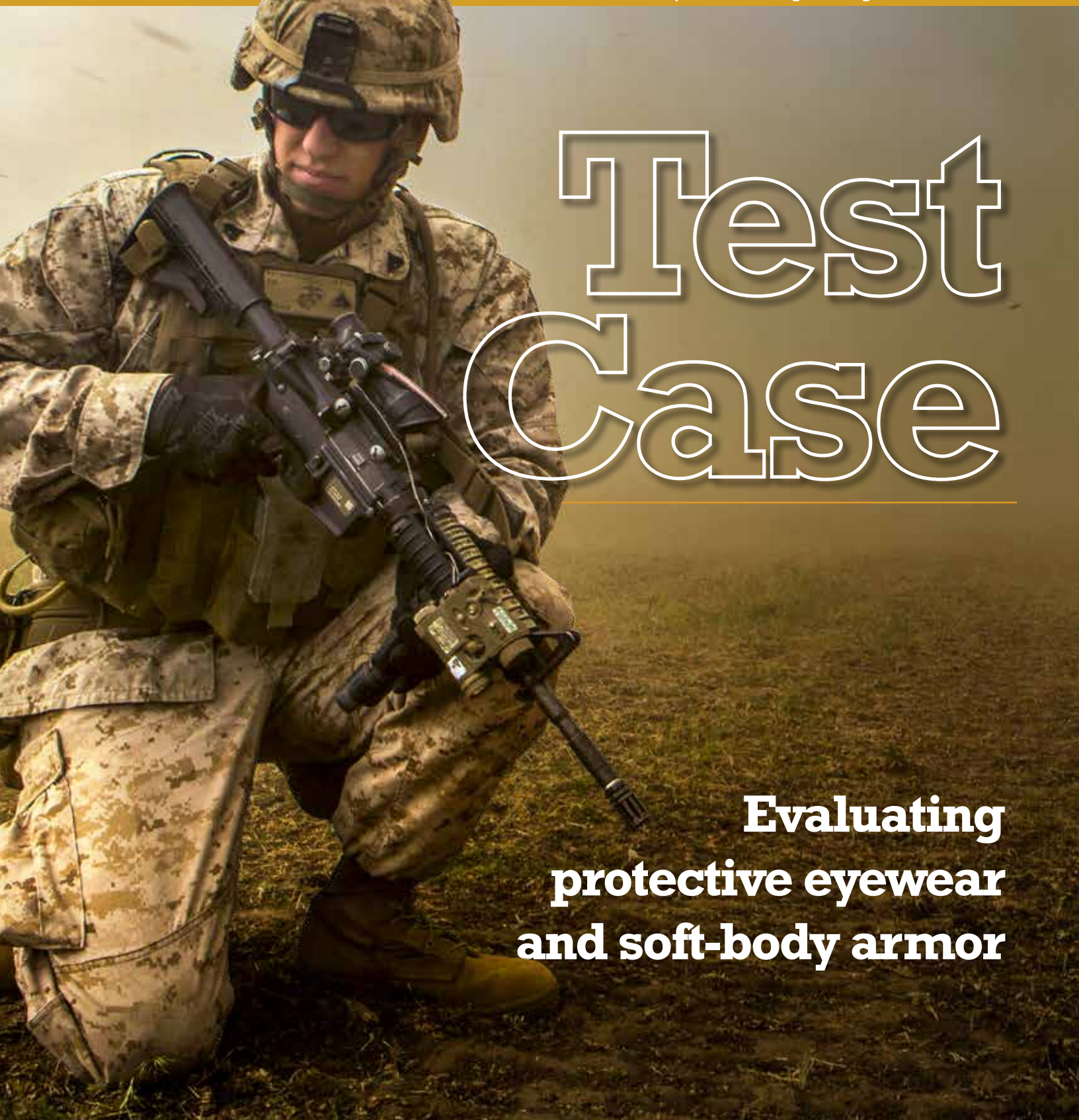
Summer 2015

Soldier Science & Engineering

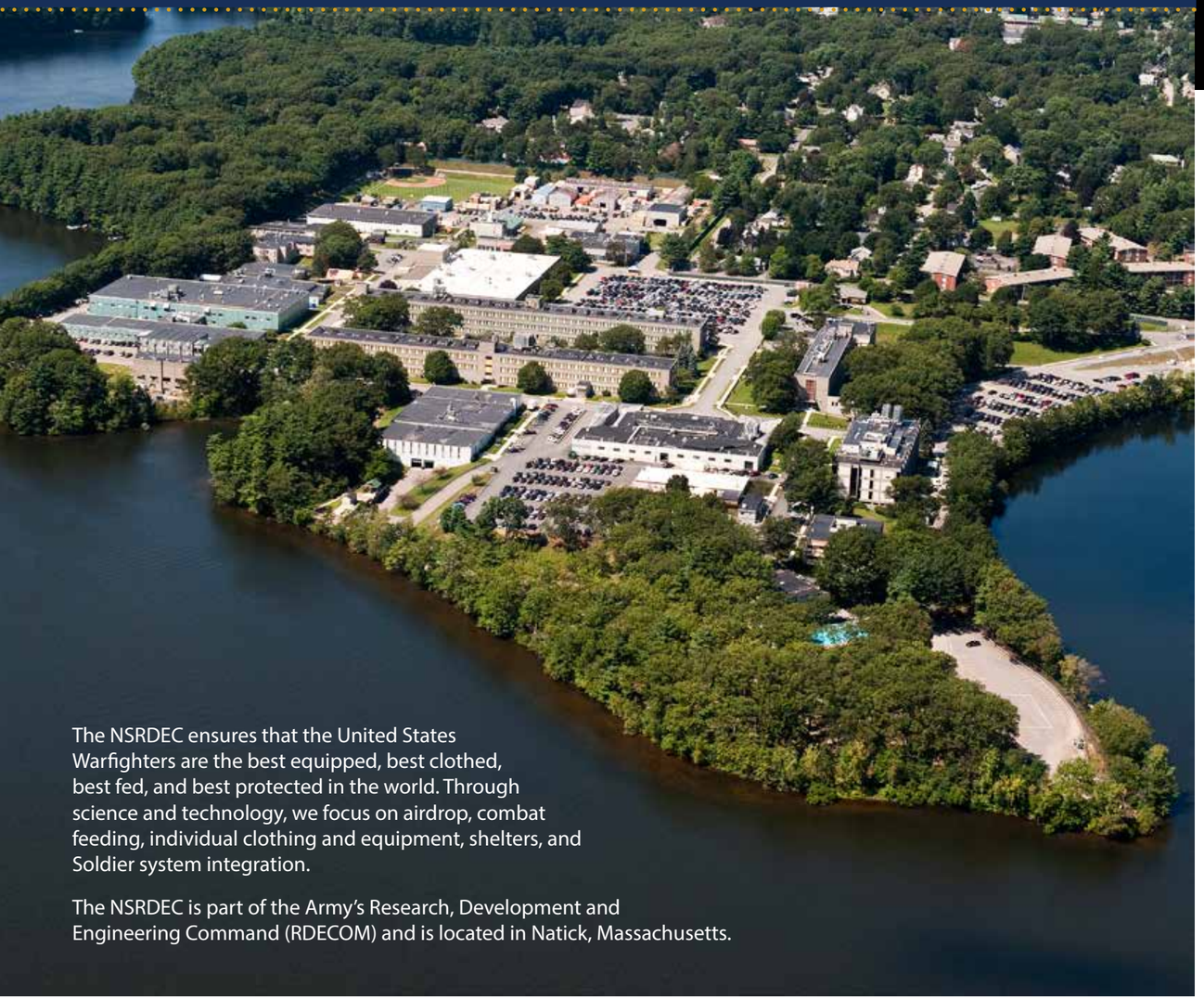
Science and Technolo ck Soldier Research, Development and Engineering Center (NSRDEC)



Test Case

Evaluating protective eyewear and soft-body armor

U.S. Army Natick Soldier Research, Development & Engineering Center (NSRDEC)



The NSRDEC ensures that the United States Warfighters are the best equipped, best clothed, best fed, and best protected in the world. Through science and technology, we focus on airdrop, combat feeding, individual clothing and equipment, shelters, and Soldier system integration.

The NSRDEC is part of the Army's Research, Development and Engineering Command (RDECOM) and is located in Natick, Massachusetts.

OUR MISSION

Research, Development and Engineering (RD&E) to maximize the Warfighter's survivability, sustainability, mobility, combat effectiveness and field quality of life by treating the Warfighter as a system.

ADDING VALUE THROUGH:

- Basic Science
- Technology Generation, Application, and Transition Enabling Rapid Fielding of the Right Equipment
- Soldier Systems Technology Integration and Transition
- Solving Field Problems Rapidly

OUR VISION

The leader in empowering the world's most capable Soldiers

OUR FOCUS

Deliver world-class research, development and systems engineering and services, with a unique warrior-centric focus.

Soldier Science & Engineering

Summer 2015

Science and Technology News from the Natick Soldier Research, Development and Engineering Center (NSRDEC)

Ready for the challenge

This past April, I was appointed Senior Research Scientist Soldier Nanomaterials, a position new to the Natick Soldier Research, Development and Engineering Center.

In June, the President's Office of Science and Technology Policy issued a call to the scientific community to identify nanotechnology-inspired "Grand Challenges" for the next decade. Some examples included increasing the five-year survival rates by 50 percent for the most difficult to treat cancers; creating computer chips that are 100 times faster yet consume less power; and reducing the cost of turning sea water into drinkable water by a factor of four.

"Grand Challenges" is part of the effort to accelerate the discovery, development and deployment of nanotechnology to address broad national needs. Clearly, this is an exciting time for nanotechnology research, and we have much to anticipate in the decade ahead.

NSRDEC researchers are conducting a wide range of Soldier-centric nanotechnology research. Here are some examples: polymer films with nanoclay for improved food packaging; nanocatalyst-attached textiles for protective clothing against chemical and biological agents; and nanoparticle-coated flexible substrates to convert and store solar energy to provide portable power. NSRDEC researchers are also developing quantum-dot-based materials for new signature systems and are investigating the use of silver nanowires integrated into clothing for thermal comfort in extremely cold environments.

NSRDEC researchers have much to contribute to the "Grand Challenges." I am committed to working with our dedicated researchers to identify and achieve our own nanotechnology-inspired "Grand Challenges" directed at the Soldier in the next decade.

In this issue of Soldier Science & Engineering, you will have the chance to read about just a few of our nanotechnology efforts, including new developments in textiles and food packaging. You will also learn about several other products and innovations that will benefit our nation's warfighters.

R. Nagarajan

Dr. Ramanathan Nagarajan
ST - Senior Research Scientist - Soldier Nanomaterials
Natick Soldier Research, Development and Engineering Center

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Questions regarding NSRDEC Science & Technology?

RDECOM

NSRDEC is part of the U.S. Army Research, Development and Engineering Command, which has the mission to develop technology and engineering solutions for America's Soldiers.

RDECOM is a major subordinate command of the U.S. Army Materiel Command, whose mission is to develop and deliver global readiness solutions to sustain Unified Land Operations, anytime, anywhere.

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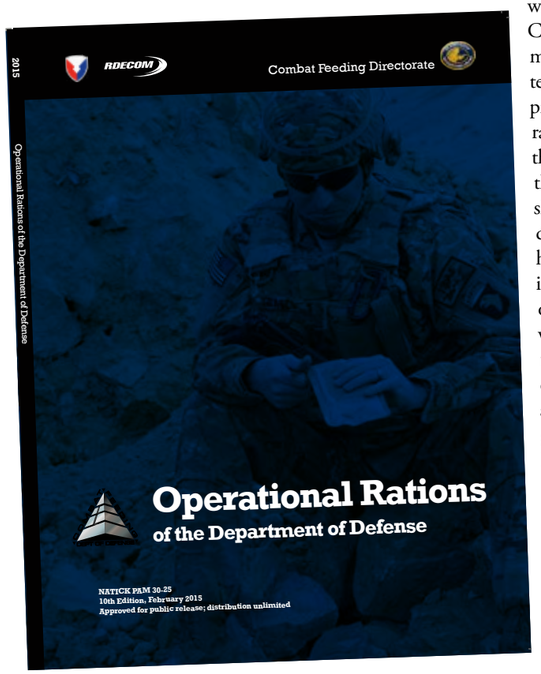


Combat Menu

Natick serves up new ration book

By Bob Reinert, USAG-Natick Public Affairs / NATICK, Mass. (May 12, 2015)

Let's call it the American military's latest combat menu.

That might be easier to swallow than its official name: "Operational Rations of the Department of Defense." Either way, it boils down to the offerings of the DoD Combat Feeding Directorate at the Natick Soldier Research, Development and Engineering Center.

In its generous serving of 72 pages, the 10th edition of Combat Feeding's ration book dishes out a history of combat rations and their present state. Maybe they are not four-star restaurant quality, but Combat Feeding's 24-menu options include everything from the familiar Meals, Ready-to-Eat, or MREs, to such special purpose rations as religious meals and those used in humanitarian situations.

"We want the warfighter to know what is out there and what's going to be coming their way," said Michael Stepien, Combat Feeding program marketing analyst. "Our team works very hard to provide a wide variety of rations to accommodate the diverse members of the military. This book showcases the amount of dedication our directorate has to constantly upgrading the variety and quality of rations available to the warfighter. We can also use the book for different outreach events to tell the story of the amazing work going on within Combat Feeding."

If, as Napoleon Bonaparte famously observed, an Army marches on its stomach, the ration book is a road map to the destination of satisfying a voracious organization that has been eating military rations since the American Revolutionary War. The book debuted in 1950 and was last published in 2012.

"Moving forward, the goal is to publish it annually as the menus change," said Stepien, pointing out that the 2015 version is currently available online.

The current ration book has compelling imagery and feature stories about Combat Feeding to accompany the usual information about available items. Philip Fujawa of NSRDEC Strategic Communications, who provided art direction for the publication, designed it to be easily digested.

"It ties in the work that goes on and how it applies to the menus," Stepien said. "There's an enormous amount of work that goes on behind the scenes here that most people aren't aware of. Our project officers deserve a great deal of credit for constantly focusing on innovative methods to improve our rations and increase the quality of life for our warfighters. Featuring highlights of their work helps tell the story of what it takes to build a combat ration."

Combat Feeding strives to give warfighters a taste of home in some of the most inhospitable places on Earth.

"Soldiers work in such harsh and extreme environments, and they require the right nutrition," Stepien said. "We wanted to make sure that this book discusses the nutrition aspect and we're able to convey through the imagery the challenges that our Soldiers face throughout their deployments and how we, as Combat Feeding, work to supply them with the rations they need to ensure they're able to continue to fight."

Toward that end, each new ration book contains new items craved by warfighters, and omits others that proved unpopular with them. Among notable additions to the Combat Feeding inventory are creamy spinach fettuccine and pasta and tomato sauce.

Eliminated items include spicy penne pasta and ratatouille.

The hope is to offer something for every palate. The best way to accomplish that is to regularly survey warfighters in the field to obtain their preferences.

"The feedback from Soldiers certainly demonstrates that our continuous product improvement program has been effective," Stepien said. "It's very rare that you find a Soldier saying anything really negative about the rations.

"We have been able to identify entrees that warfighters aren't particularly fond of, and we've been able to remove them and replace them with rations that have received high ratings from field tests."

As Stepien pointed out, Combat Feeding's job extends beyond the taste buds to nutritional value.

"The taste of the MREs is very good," Stepien said. "It's important to us now to build upon that flavor of the MRE and incorporate more things into it … to make the Soldier perform more effectively on the battlefield, whatever we can do to ensure that the Soldier has a decisive advantage."

Flexible photovoltaic panels used to capture the energy of the sun to charge batteries and provide electricity to expeditionary base camps are shown.

Army base camp team to demonstrate science, technology innovations

By NSRDEC Public Affairs / NATICK, Mass. (April 22, 2015)

The U.S. Army Natick Soldier Research, Development and Engineering Center, or NSRDEC, along with the U.S. Army Maneuver Support Center of Excellence, will host a demonstration of base camp technologies at Fort Leonard Wood this week.

NSRDEC's Sustainability Logistics Basing, Science and Technology Objective - Demonstration, or SLD-STO-D, team will present nine integrated technology and non-materiel solution sets in a collaborative effort to reduce fuel resupply by 25 percent, reduce water resupply by 75 percent, and decrease waste generation for back haul by 50 percent at 50 to 1,000 personnel expeditionary base camps while maintaining current quality of life.

"This demonstration and assessment of new base camp technologies are very important for the Army and the joint warfighter. These nine technologies are critical to the objectives of reducing the fuel, water and waste water removal requirements of expeditionary base camps, which will reduce the need for re-supply and reduce the risk to our warfighters conducting re-supply operations," said Maj. Gen. John F. Wharton, U.S. Army Research, Development and Engineering Command commanding general.

The collaborative effort is funded by the office of the assistant secretary of the Army for acquisition, logistics and technology and managed by RDECOM, with participation by other RDECOM organizations including the Tank Automotive Research, Development and Engineering Center and the Communications-Electronics Research, Development and Engineering Center.

Other key partners are the Maneuver Support Center of Excellence, the Army Corps of Engineers, and other members of the capability development community including Program Executive Office Combat Support and Combat Service Support.

"The collaboration between RDECOM's NSRDEC Sustainability/Logistics-Basing Science and Technology Objective-Demonstration team, the Army Corps of Engineers, and the Maneuver Support Center of Excellence Contingency Basing Integration Technology Evaluation Center is the key to the integration and success of future expeditionary basing. It's a great example of how RDECOM is working with TRADOC and other partners to understand the requirements and use our expertise and partnerships to deliver the best capability to the Soldier, Joint Warfighter and Nation," Wharton said.

The event will be held at Fort Leonard Wood's Contingency Basing Integration and Technology Evaluation Center, or CBITEC, and will also include a demonstration and ration sampling by NSRDEC's Department of Defense Combat Feeding Directorate.

This is the second operationally relevant demonstration event that SLD-STO-D will conduct to showcase nine integrated fuel and water waste technologies in a 1,000-person base camp setting at CBITEC.

"We are utilizing a model-based systems engineering approached to show how the selected technologies within the Army's S&T [science and technology] portfolio can contribute to a 25 percent reduction in fuel, 75 percent reduction in water resupply and a 50 percent reduction in waste backhaul at base camps compared to an established operationally relevant baseline," said Gregg Gildea, team leader for NSRDEC's Sustainability Logistics Basing, Science and Technology Objective - Demonstration team.

The demonstration will be held in conjunction with CBITEC's Leadership Demonstration Day will provide an overview of the SLB-STO-D effort and a detailed walk-through of the demonstration venue and each of the nine technologies to leverage all available resources at a single time.

The key purpose in the demonstration is to collect empirical data on selected candidate technologies, in an operationally relevant environment, to be used to calibrate models, conduct simulations and perform trade-off analysis part of the systems engineering process to show how we will meet our objectives.

Outcomes will be used to inform Army leadership on future S&T investments for enhanced technology transition while identifying future operational gaps and allow for efficient contingency base planning.

Photo: Michael Stepien, NSRDEC Combat Feeding Directorate

Test Kitchen

Fort Leonard Wood assesses new mobile unit

By Tiffany D. Wood, Fort Leonard Wood / FORT LEONARD WOOD, Mo. (April 7, 2015)

The U.S. Army's mobile kitchen was put to the test on Fort Leonard Wood during a demonstration that will assess new energy-efficient appliances used to feed about 1,000 Soldiers, April 21.

Eight cooks, with the 4th Maneuver Enhancement Brigade, or MEB, were the first to use the appliances to prepare and serve 350 pounds of steak, 350 pounds of fries and 252 pounds of green beans in the new Modular Appliances for Configurable Kitchens also referred to as the Containerized Kitchen - Improved.

Staff Sgt. Joshua Phillips, 4th MEB cook, said the Soldiers were excited to use the new appliances, which include a combination of griddles, servers, Hawkmoor burners, convection ovens, French-plates and tilt skillets. The Soldiers were also eager to have a say in what may be the Army's future mobile kitchens, he said.

"The biggest thing the Soldiers, preparing the food, are looking forward to is that we will have a chance to provide feedback on the equipment and hopefully be able to help get equipment that is more user friendly once it actually gets fielded," Phillips said.

Researchers and developers with the Maneuver Support Center of Excellence Capability Development and Integration Directorate and the U.S. Army Natick Soldier Research Development and Engineering Center in Natick, Massachusetts, led the demonstration at the fort's Contingency Basing Integration Technology Evaluation Center, or CBITEC - a training base camp that is used as a lab to assess capabilities and evaluate new technologies for the Army.

Mark Ferguson, who heads up the CBITEC, said the demonstration, which will be the first for the lab, allows researchers the opportunity to evaluate the efficiency and operability of the kitchen and appliances.

"The new kitchen and appliances were designed to address specific capability gaps found with the existing appliances in the areas of function and design," Ferguson said.

Specifically, he said, the existing appliances are inefficient and noisy, require a generator, cannot be removed from the kitchen, and dump all their heat and exhaust into the cooking area. "The new appliances address all those issues, will use far less fuel, and can be operated on solar power," Ferguson said.

The U.S. Army's mobile kitchen will be put to the test on Fort Leonard Wood during a demonstration that assessed new energy-efficient appliances used to feed about 1,000 Soldiers, April 21, 2015.

One area the cooks assessed was the kitchen's temperature, said Phillips, who is looking forward to a "cooler, more comfortable piece of equipment to cook in."

"The kitchens we have now are extremely loud and, during summer, extremely hot to the point that a cell phone will turn off. My cell phone actually said, 'Due to hot temps, the cell phone is powering off.' I've never seen a cell phone do that before," Phillips said.

After the demonstration, the data collected will be used to determine the levels of savings the Army would see if the new kitchen and appliances were used to feed Soldiers at base camps around the world.

Project Presentation Day highlights NSRDEC and USMA collaboration

By Jane Benson, NSRDEC Public Affairs / NATICK, Mass. (May 7, 2015)

Collaboration and ingenuity reigned at the United States Military Academy's and Natick Soldier Research, Development and Engineering Center's Project Presentation Day.

The NSRDEC-hosted event featured presentations by USMA West Point cadets, demonstrating accomplishments and lessons learned during the 2014 Academic Year Research Collaboration with NSRDEC. The event was part of a larger collaboration effort between NSRDEC and USMA, which have a shared interest in researching innovative technologies for the Soldier.

NSRDEC's Henry Girolamo developed and implemented the collaboration and continues to manage the effort. Girolamo and USMA's Lt. Col. Michael Benson are the key points of contact under a Memorandum of Understanding, or MOU. The MOU involves joint research projects and the sharing of training sites, research staff, historical data, field equipment and facilities. Several NSRDEC technologies will also be deployed with cadets during USMA Cadet Leadership Development Training.

"The research being conducted at USMA is viewed as complementary to NSRDEC research and may promote beneficial and innovative improvements to NSRDEC products," said Girolamo, lead — Emerging Concepts & Technologies, Warfighter Directorate at NSRDEC.

"The partnership between NSRDEC and USMA has allowed our faculty and cadets to engage in real-world problems," said USMA advisor and assistant professor, Becky Avrin Zifchock, Ph.D. "From a faculty perspective, this ongoing relationship has allowed me to assist in the maturation of some initiatives, while advancing others that are still in early stages of development. The fresh thinking of the cadets brings a new and innovative perspective on both types of projects."

During the NSRDEC-hosted Project Presentation Day, cadet teams discussed design enhancements to modular extendable rigid wall structures; a torso-load redistribution device to improve Soldier comfort, mobility and usability; a female head shape and helmet fit study related to female hairstyles; micro-climate cooling technology for the individual Soldier; a device that may help improve Soldier performance at the ankle joint; and the Cadet Leadership Development Training field exercise. Research presented was conducted through year-long programs in multiple departments.

"The collaboration between USMA and NSRDEC provides great mutual benefit for both organizations," said Benson, Ph.D., director, Center for Innovation and Engineering, Department of Civil & Mechanical Engineering, USMA. "Cadets have an opportunity to learn about and partner with NSRDEC on relevant challenges that they may soon see firsthand as junior officers. NSRDEC benefits from the innovation and passion of these motivated cadets and faculty with their unique blend of Army experiences and the strong academic program, as well as the long-term investment of increasing awareness across the ranks as to the mission and capabilities of NSRDEC. Strengthened with summer internships, USMA and NSRDEC both have great potential to continue to reinforce a successful partnership in service to the nation."

"Overall, it was an amazing experience from both a mechanical engineering student and future U.S. Army officer prospective," said West Point cadet Angela Bapp, who worked on the torso-load redistribution project. "It was inspiring to work so closely with Ms. (Karen) Gregorczyk and her engineering team to see what resources and facilities are available at such a large engineering center. The direct impact these technologies have on the future Soldiers I will soon lead also left me awestruck. I am extremely grateful for the experience of working with the teams at Natick and challenging myself and my team to solve a real-world, complex Soldier design problem. The opportunity to brief Brig. Gen. (William E.) Cole, Brig. Gen. (Timothy) Trainor, Command Sgt. Maj. (James P.) Snyder and other senior leaders at the Natick facilities was also a phenomenal experience."

In the future, the collaboration may be expanded to include additional areas of research.

Photo: Sgt. Duncan Brennan, U.S. Army

Medical supplies, such as IV solution bags, will be kept cool on the way to treat heat injuries by the Heat Ailment Recovery Pack, or HARP, developed by the Natick Soldier Research, Development and Engineering Center.

'Cool effort'

NSRDEC helps warfighters with heat injuries

By Bob Reinert, USAG Natick Public Affairs / NATICK, Mass. (June 26, 2015)

In hopes of bringing medical treatment to Soldiers on remote battlefields in warm climates, the folks at Natick Soldier Research, Development and Engineering Center, or NSRDEC, recently put forth a "cool effort."

The Heat Ailment Recovery Pack, or HARP, is being developed by the Joint Foodservice Engineering Team, or JFET, of the Combat Feeding Directorate at NSRDEC. It will help personnel maintain medical supplies at the proper temperatures and keep potable water cool until medical attention can be administered to Soldiers with heat-related injuries.

"They don't have this capability at all," said Ben Williams, a mechanical engineer with JFET. "It's never been done before. It's a brand-new concept."

Williams was approached about a year ago by deployed Joint Special Operations Command U.S. Africa Command, or JSOC AFRICOM, personnel about developing something to cool water and medical supplies to treat individuals, who are suffering from heat-induced medical conditions. Together, they approached the Rapid Equipping Force, which approved the funds to produce four of the bags for testing and evaluation.

"I love working directly with people in the field because it makes your job easier," Williams said. "You're not trying to develop products in a vacuum, and you're not making products that people don't want. It makes your life easy."

Williams had already helped Soldiers in the field cool water with the Beverage Cooling Unit and maintain water temperature with the Insulated Container for Bottled water. JSOC AFRICOM wanted Williams to combine the two concepts, providing a means to not only maintain the temperature of medical supplies and bottled water, but to cool them on demand, when necessary.

"Being able to provide Soldiers on the ground with medical supplies and water at the proper temperature after an extended, or even an indefinite, period of time in remote locations is a major challenge," Williams said. "The state-of-the-art technology before the HARP for this application was just your standard portable, plug-in refrigerator. The HARP is a completely new concept, which can either maintain the contents' temperature or drop it to acceptable levels within minutes, depending on what the user requires."

Williams and Brian Grady, an equipment specialist with the NSRDEC Aerial Delivery Design and Fabrication Team, got to work making the concept a reality.

"We have to actually make this from scratch," Grady said. "We're not production; we're prototype. But to build four of these? It's a production process, and we tackle it and get it done.

"Obviously, it's not a parachute, but its fabric. We have a lot of these items that we take in, too. Who else will build this?"

The result was a 23-inch-wide, by 26-inch-long, by 20-inch-high pack, which weighs up to 60 pounds when fully loaded with medical supplies and water. Its micro-refrigeration unit is powered by a BB-2590 lithium-ion battery, which can be run continuously for three hours in 120-degree temperatures.

"You can drag an IV bag or medical supplies down to 50 degrees off of one battery from 120 degrees, if you just let it run," Williams said.

An integrated flexible solar panel can also be used to recharge batteries and extend the HARP's runtime while acting as a solar shade for the system.

"It needs to be a self-sufficient system, capable of running indefinitely," said Williams in explaining the solar panel.

The HARP, coated with a newly developed infrared-reflecting material, can cool its contents down from 120 degrees to a usable temperature of 98 degrees in a mere 15 minutes. Using its remote control and monitoring system, the HARP can keep an IV fluid bag constantly usable (below 98.6 degrees) for 100 hours in 120-degree temperatures, all while being monitored and controlled from a distance of up to 100 feet.

"Remote monitoring and control is an absolute necessity, especially when the system is stored on the outside of the vehicle or in a cargo area," Williams said.

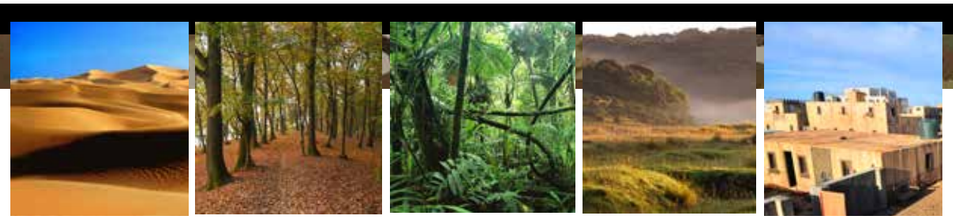
The HARP is also capable of being broken down and configured for man-transportable use within minutes, while still maintaining its cooling capability. Modular Lightweight Load-carrying Equipment, or MOLLE, features with integrated shoulder straps added to its backside allow the bag to be worn like a backpack or attached to and carried on another pack.

"It's actually a two-bag system," Grady said. "The challenge was [working with] the fabric … and how unforgiving the fabric was. There's no room for error with the fabric."

Most of the work on the HARP was done at NSRDEC, but four other Army agencies and two outside companies ultimately were involved in the process.

Eight months after the need for the HARP was determined, four were sent to the REF, May 20. Another four systems are scheduled to be fielded to the U.S. Army Medical Materiel Agency for user evaluation aboard MEDEVAC aircraft.

"I think we did a great team effort on this one, because we got everyone involved and leveraged all of the necessary skills to get the job done," Williams said. "We have the capability here at Natick to take a Soldier's need and turn it into a reality. It's a cool effort."



Pattern Emerges

Army to field latest camouflage July 1

By Bob Reinert, USAG Natick Public Affairs / NATICK, Mass. (June 1, 2015)

If you can't see it, you can't attack it.

Since the conflicts of the 18th century, that's been the thinking behind military camouflage. Today, when it's applied to their uniforms, it can save Soldiers lives. That fact has driven the Army's decades-long efforts to improve its camouflage patterns.

The next step toward greater Soldier protection comes July 1, when the Army begins to make the Operational Camouflage Pattern available for the Army Combat Uniform in select Military Clothing Sales Stores. The pattern will replace the current Universal Camouflage Pattern. The UCP has been used for the past decade.

The transition period for the pattern will extend from July 1, 2015 to Sept. 30, 2019. The entire Army will be in the Operational Camouflage Pattern by Oct. 1, 2019. New Soldiers will receive ACUs with the pattern beginning in January 2016.

The Operational Camouflage Pattern will be made available to the National Guard, Army Reserve and Senior Reserve Officer Training Corps in summer 2016.

Prompted by Soldier feedback about the UCP, the Army in 2010 began providing the Operation Enduring Freedom Camouflage Pattern, or OEFCP, to Soldiers deploying to Afghanistan. During this period, the Natick Soldier Research, Development and Engineering Center also began developing the pattern that was later named the Operational Camouflage Pattern.

The Operational Camouflage Pattern testing and evaluation effort has been described as the most comprehensive ever conducted by the Army. Different camouflage patterns were evaluated for effectiveness in different operating environments with varied terrain, vegetation, seasons, and times of day.

The latest version of the ACU will come in the Operational Camouflage Pattern and will also incorporate changes resulting from Soldier feedback. These include modifications to the collar, pockets, knee and elbow patches, and trouser waistband. Instead of the current sand color, the Operational Camouflage Pattern will be worn with a tan 499 T-shirt and belt, and coyote brown boots.

The introduction of the ACU in Operational Camouflage Pattern is being phased in to reduce the cost to both Soldiers and the U.S. taxpayer. During this four-year period, Soldiers will also be permitted to wear uniforms and equipment in OEFCP.

The phase-in allows Soldiers to use their annual uniform replacement allowance to gradually replace current uniforms as they wear out. It also allows the Army to use existing stocks of uniforms and other camouflage-printed gear, such as backpacks.

The change is viewed as fiscally responsible. The Operational Camouflage Pattern ACU is expected to have a similar cost to the UCP ACU.

"All enlisted Soldiers receive an annual stipend for the purchase of uniforms and accessories," said Sergeant Major of the Army Daniel Dailey. "I myself will wait until I am issued my clothing allowance before purchasing a uniform with the Operational Camouflage Pattern.

"I encourage all Soldiers and leaders to do the same by budgeting for a new uniform, belt, boots and T-shirts as you receive your clothing allowance over the next two to three years."

During the transition period, Soldiers may mix and match items with either the OEFCP or the Operational Camouflage Pattern. They can also wear OEFCP Flame Resistant ACUs during that time.

"Presenting a professional appearance is very important to Soldiers, but we will not inconvenience or burden our troops," Dailey said. "We will still be the most lethal fighting force the world has ever known, even if our belts don't match for the next few years."

"Presenting a professional appearance is very important to Soldiers, but we will not inconvenience or burden our troops."

Sergeant Major of the Army Daniel Dailey

Photo: PEO Soldier

Photo illustration: Philip Fujiawa, NSRDEC Strategic Communications

Better Fit

3-D shape database improves clothing, equipment

By Jane Benson, NSRDEC Public Affairs / NATICK, Mass. (April 17, 2015)

A new database at the U.S. Army Natick Soldier Research, Development and Engineering Center, or NSRDEC, is a perfect fit for America's Soldiers.

The ANSUR II 3-D Shape Database uses three-dimensional shapes and contour data to improve the fit of clothing and equipment for warfighters. It incorporates the latest Army anthropometric survey data and 3-D whole body scans, providing a searchable platform for the data and the 3-D shapes.

The center completed the latest comprehensive anthropometric survey of Soldiers, called ANSUR II, in 2012. The previous survey was completed in 1988. The 2012 survey set out to address changes in Army personnel body size and shape, and the resulting data showed that Soldiers have increased in overall body girth since 1988. The new study also set out to document the sizing needs of the increasing number of women serving in the military.

The 2012 data collection included 3-D scans of the head, foot and entire body. This innovation provided geometric and morphological data on military personnel that could not be obtained through traditional body measurement techniques.

Dr. Peng Li, a computer scientist on NSRDEC's anthropology team, is working on a novel approach to use all of the 3-D scan information to define common shapes for items, such as body armor and helmets. Scans provide contour information that is essential for proper fit.

"Peng has been working on tools to make the body scans more accessible and more usable," said Steve Paquette, a research anthropologist and team leader for NSRDEC's anthropology team.

"We developed our own shape descriptor and query method for 3-D body scans," Li said. "It will help determine different shapes for body armor and protection and gear for heads and faces."

"The anthropology team's primary mission is to maintain 'the' data base on Soldier body size," Paquette said. "This has been true since Natick opened. Most of the data over the years have been traditional measurements that you take with calipers and tape measures. With the 2012 study, we also took body scans, and it's those 3-D scans that Peng has been working with. He is actually developing tools for searching 3-D shapes.

"Say if you want to search for someone with a narrow head, or a wide head, Peng has been working on a shape searching tool. We not only collect data on Soldiers, we also develop tools to better use the data."

"The ANSURII 3-D Shape Database is an integrated database that provides access to both traditional measurements and 3-D scans collected in ANSUR II survey," Li said. "It allows a user to search or query body dimensions and shapes, and to download search results in spreadsheet and 3-D surface files."

The goal was to acquire data from males and females to help Army engineers, scientists and designers develop equipment, clothing, shelters, kitchens, airplane cockpits, and vehicle crew stations that best serve the dimensions of the Soldier. The study included 7,435 men and 3,922 women.

Based on their access to data of body measurements and their ability to analyze the data, Paquette's anthropology team, which includes Li, a computer scientist, and Brian Corner, a 3-D morphologist, played a key role in the design of female body armor.

Women's body dimensions are very different from their male counterparts, and they need equipment designed for them specifically. Smaller versions of items developed for males do not fit female Soldiers properly. Team members devised eight new sizes based on the female anatomy data. They provided statistics based on those theoretical sizes.

"We worked with team leader Annette LaFleur and the design, pattern and prototype team, and they started making patterns based on that data," Paquette said. "Then we took those patterns and got prototypes made of those patterns. And then we put armor on actual women and tested it. Sometimes, you need to adjust the sizes or add an additional size."

Peng's work with 3-D shapes will help researchers to better use the shape data to solve problems of sizing and human interface.

"We work closely with human factors and biomechanics," Paquette said. "It's not just what size they are, but how the human interfaces with the environment or work station. Can they reach? Can they see? Anthropometry is just one piece of the whole picture."

3-D shape data has become an integral part of the product design process.

"First, the database allows the designers to more easily check population distribution with multiple range restriction," Li said. "For example, a designer can check how many subjects in the database fit into a box in three or five dimension ranges such as chest circumference, waist circumference and stature. Secondly, the designers can also look at a real 3-D shape of those subjects. Finally, if a user has advanced CAD [computer-aided design] systems, she or he can transfer 3-D whole body data to a CAD system as a model to be fit with a product's prototype design."

The shapes captured by the scanner help with the design of items where close, accurate fit plays an important role in providing optimum protection, as is the case with body armor, helmets and goggles.

"Comfort, performance, safety and fit - that's what it's all about," Paquette said. "If it doesn't fit right, you don't even want to wear it."

Test Case

Evaluating protective eyewear and soft-body armor

By Jane Benson, NSRDEC Public Affairs / NATICK, Mass. (June 9, 2015)

Researchers, at the Natick Soldier Research, Development and Engineering Center, or NSRDEC, have devised new, more operationally-relevant ways to evaluate protective eyewear and soft-body armor. These new test methods and apparatus are transitioning to the Aberdeen Test Center, or ATC, and will be incorporated into standardized test operating procedures.

The quick transition to ATC has been enabled by the Science and Technology, or S&T, Objective, or STO, Force Protection Soldier and Small Unit program, formerly TeCD 1b, which focuses on aligning and transitioning science and technology projects to programs of record and various customers.

"STO Force Protection: Soldier and Small Unit comprises 77 projects that are delivering knowledge products, materiel, and test methods - all aimed at understanding and increasing Soldier performance and protection in an operationally relevant environment," said Jaclyn Fontecchio, STO lead, NSRDEC Warfighter Directorate. "New and relevant test methods are critical to the ability to accurately assess products or systems during their S&T development. As new products emerge through research and development, the use of standard test methods, as is or modified, are not always applicable particularly when dealing with revolutionary or novel products and materials. In many cases, new test methods are required to measure parameters of interest and require an upfront investment. Failure to do so can lead to non-conforming products, shortened product service life, and increased testing costs."

Natick's new test methods for protective eyewear and soft-armor protection were needed to evaluate evolving, state-of-the-art protection and new materials/designs, in situations where previous methods were incapable of testing the new materials/designs accurately.

The new test methods include a soft-armor flexibility test, a soft-armor durability test, an eyewear abrasion test, and an eyewear anti-fog test. The new NSRDEC-developed tests are consistent, accurate, reliable, repeatable, and most important, operationally relevant, to ensure that equipment better meets the needs of Soldiers.

SOFT ARMOR TESTING

Previous test methods, which existed for evaluating soft-armor flexibility and durability were written based on woven fabric constructions. These methods were inapplicable to new, higher-performance materials, which were not made of woven construction.

NSRDEC developed a flexibility test for soft armor, which consists of a spherical bend procedure that characterizes the flexibility of multilayer, soft armor ballistic panels.

"Previous soft-armor tests didn't really translate to someone wearing it in a real environment," said Robert DiLalla, ballistic and blast thrust area manager. "There was no means to say, was this too hard or too soft? So, we came up with a study that took soft armor panels that were comprised of materials of varying stiffness and put them on Soldiers and had them do a set series of tasks. We asked them how the overall comfort was and took goniometer and reach measurements. We then developed a method by which we could take a

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Photo: Department of Defense

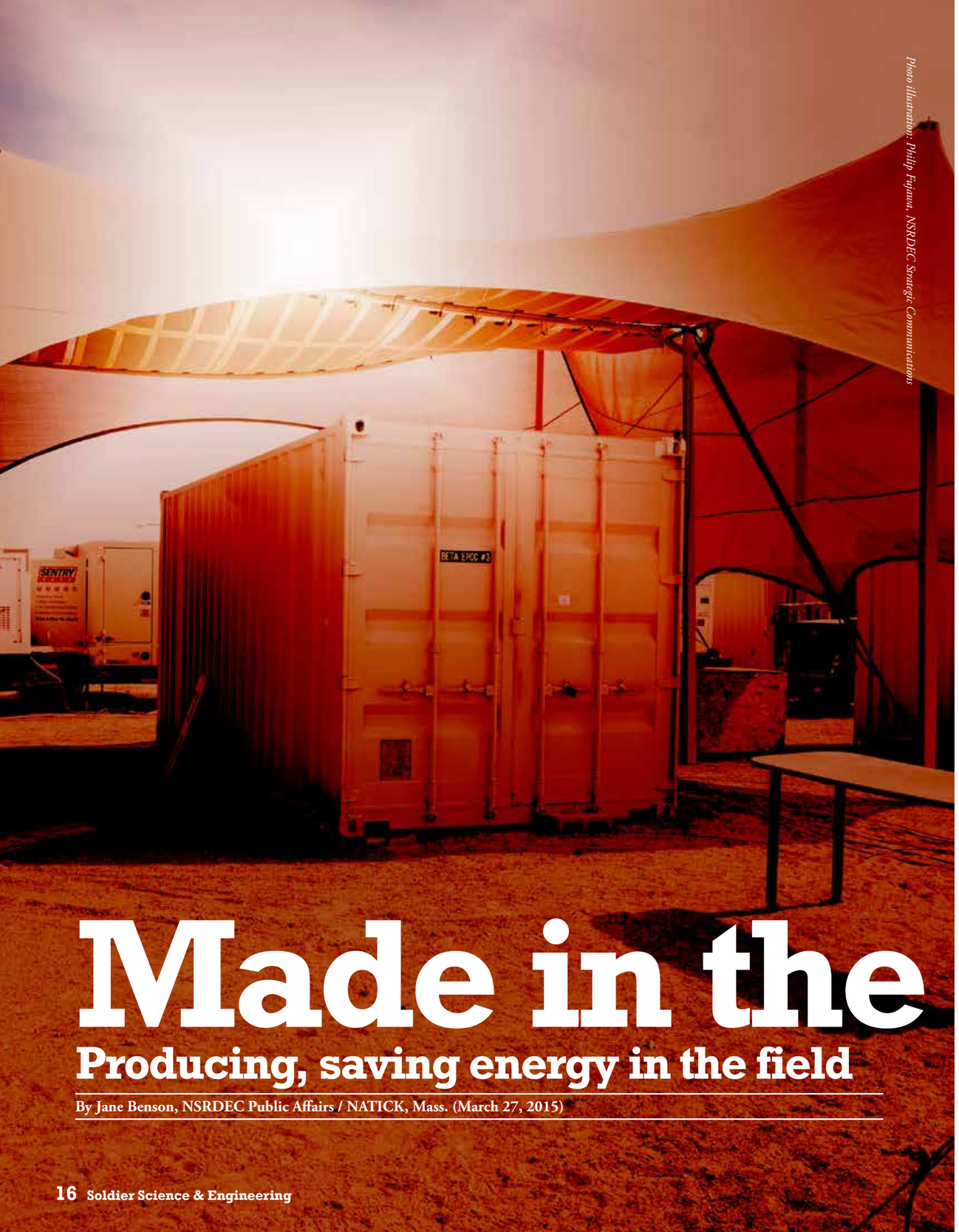


Photo illustration: Philip Fujawa, NSRDEC Strategic Communications

Made in the Shade

Producing, saving energy in the field

By Jane Benson, NSRDEC Public Affairs / NATICK, Mass. (March 27, 2015)

When it comes to energy conservation and energy production, Army researchers like Natick's Steve Tucker are working to ensure Soldiers have it made in the shade.

Tucker is a senior engineer at the U.S. Army Natick Soldier Research, Development and Engineering Center, or NSRDEC, on the Collective Protection Systems Team and is the lead project officer for the "PowerShade." Natick's work is part of the Army's commitment to conserving fuel and water and reducing waste.

In addition to providing shade and protection from the sun, the PowerShade is a durable solar shade structure that contains photovoltaic modules that generate solar power. The medium variant of the Gen I PowerShade generates 1.8 kilowatts of peak electrical energy that can be used to support military base camp operations.

"Saving energy is a Natick-wide effort, part of a larger Army effort," Tucker said. "The Army right now is very concerned with energy use. The PowerShade is part of the trifecta, where we are looking at power, waste and water. The goal is to bring in conservation technologies where less energy is needed to heat or cool shelters, generate power from alternative energy to remove the need for more fuel, and investigate 'waste to energy' technologies, where we take things that normally would be thrown away, and we use them to create power. The Army is also looking at water purification, where local water is purified and used for camp operations."

The PowerShade has several qualities that make it particularly useful to warfighters in remote, austere locations. The energy generated by the PowerShade is clean, quiet, sustainable and renewable. It generates electricity directly from the sun, produces zero emissions, and it requires no fuel and little to no maintenance.

The reduced logistical burden and reduced footprint that the PowerShade provides to warfighters are beneficial not only in terms of consumption but also in terms of safety. Eliminating the need for fuel deliveries reduces danger and vulnerability associated with such deliveries.

"A remote or austere environment is where everything is the most expensive," Tucker said. "It's where you have to transport your fuel the furthest. It's where security is the most risky because you may be deep in enemy territory. It's difficult to get supplies in. Sometimes you can't just drive them in, and you are forced to airdrop them in. Something that is self-sustaining like the PowerShade helps toward the goal of becoming "net zero," where we make as much energy on-site as we use. You can also minimize your footprint and your presence as far as your bringing people in and bringing supplies … Bottom Line? An austere environment, where logistics is the most expensive and challenging, is where alternative energy really shines."

Typically, the PowerShade is placed over a shelter that is used for the billeting of Soldiers. It reduces the power demand from the environmental control unit, or ECU, so less power is needed to cool or heat the shelter. The saved power can then be used to support other camp operations.

"So, by producing the power, you are actually harvesting the sun to enable energy-efficient camp operations, such as lighting or powering of convenience loads like a laptop, or a battery charger," he said. "LED lighting is very energy efficient, and we can support that with the power produced by the PowerShade. We can also take the energy from the sun, and we can recharge a battery for a Soldier's radio with it. Then we can take the power from that same battery later on when we need it, or we can use another application Natick developed and invert to make AC power like you would typically use from a wall socket."

Tucker has traveled extensively to train Soldiers to set up, tear down, and use the PowerShade. He helped oversee the use of the Gen I PowerShade under austere, remote conditions at Camp Lemonnier in Djibouti, located in the Horn of Africa. He is also supporting an ongoing research effort by the U.S. Army Construction Research Laboratory, or CERL, and the United States Military Academy at West Point to investigate the use of Super Insulated Panel, or SIP, structures as a more energy-efficient alternative to the wooden buildings known as "B-Huts." Soldiers are familiar with B-Huts from base camps in Southwest Asia.

"The idea behind bringing the PowerShade to West Point is to get that base camp net-zero effect, where they make as much power as they use," Tucker said.

A more powerful version of the original Gen I PowerShade is currently being developed. The Gen II PowerShade will use about the same deployed footprint as the Gen I PowerShade, but will be capable of producing about twice the power of the Gen I unit, further advancing the goal of achieving net-zero energy for base camps.

"The Gen II produces more power at less cost per watt than the Gen I," he said. "The Gen II is a slightly larger unit and has a 10-year rated lifespan versus a three-year (lifespan) for the Gen I."

Currently, the Gen I PowerShade is being used in Guam for a demonstration, and the Gen II unit is set up at Fort Leonard Wood in Missouri as part of the Sustainability Logistics Basing Science and Technology Objective.

Both the Gen I and Gen II PowerShades mean that Soldiers don't have to commit time to refueling or maintaining equipment.

"Anything that allows Soldiers to focus more on warfighting and spend less time on maintenance and other base camp tasks is beneficial to getting their mission done and them home sooner," Tucker said.

Top Expert

Army appoints new senior research scientist from NSRDEC

By Jeff Sisto, NSRDEC Public Affairs / NATICK, Mass. (May 26, 2015)

The Secretary of the Army announced the appointment of Dr. Ramanathan Nagarajan, a senior scientist and research chemical engineer at the U.S. Army Natick Soldier Research, Development and Engineering Center, to the position of Senior Research Scientist Soldier Nanomaterials.

As a senior research scientist, or ST, Nagarajan joins a select group of only 30 other Army STs charged with guiding new science and engineering programs across the Army S&T Enterprise, serving as scientific reviewers and advisors to Department of Defense S&T leadership, engaging key stakeholder support, and mentoring young scientists and engineers.

In this role, Nagarajan will serve as the Army's top expert in nanomaterials-based technologies, advising leadership on their potential application within Soldier-domain areas affecting the individual warfighter, small units, and future Soldier systems.

Having a resident expert in nanomaterials reinforces NSRDEC's Soldier-centric mission and positions Nagarajan's research at the forefront of Army S&T innovation — an opportunity he relishes.

"It's an exciting position and field to serve in," said Nagarajan. "I anticipate most new material solutions to future Soldier-domain challenges will come from nanomaterials research.

"Nanomaterials, including bionanomaterials, represent the most active development in current materials research, and I believe they will dominate all materials applications throughout this century."

Nagarajan's goals in the new position include leading and maintaining excellence in nanomaterials research, providing advice and consultation to the Army at all levels, and mentoring young researchers at NSRDEC. He also hopes to organize symposia and workshops on Soldier nanomaterials in order to foster collaboration among academia, industry and Army researchers, and monitor and disseminate international developments in nanomaterials research — especially those with long-range implications.

"It is my responsibility to align these broad goals and facilitate opportunities to make NSRDEC even better at addressing Soldier-domain issues," Nagarajan said.

In addition to his ST functions, Nagarajan will continue his research for NSRDEC, focusing on the development and integration of polymeric, biological, inorganic and carbon nanomaterials into Soldier protective clothing and equipment for chemical, biological, flame, ballistic and environmental protection.

"I remain committed to NSRDEC's mission to protect, empower and unburden the individual Soldier," said Nagarajan. "By emphasizing a systems approach to the Soldier-domain, we address the whole instead of the parts.

"I will continue to provide expertise in colloids, polymers and nanomaterials science to warfighter-related, fundamental and early applied research problems."

That expertise made Nagarajan an internationally recognized expert on molecular self-assembly and nanomaterials even before he became an Army civilian scientist.

Nagarajan received his doctoral degree in chemical engineering from the State University of New York at Buffalo in 1979. He received his bachelor's and master's degrees in chemical engineering from the Indian Institute of Technology, Madras, and the Indian Institute of Technology, Kanpur, respectively.

He went on to serve as a faculty member at Pennsylvania State University for 26 years, retiring in 2005 as Emeritus Professor of Chemical Engineering.

"In my academic career at Penn State, I collaborated with many faculty members, both in chemical engineering and in other related disciplines such as polymer science, food science, petroleum engineering and materials science and engineering," said Nagarajan. "This experience has allowed me to initiate a number of new collaborations as an Army civilian."

In 2006, he made the jump from academia to government service as a civilian scientist.

"Before I came here, I was not aware of the existence of Natick Labs," he recalled. "That is something I've worked hard to change and will continue to do so."

Since joining NSRDEC, in 2006, Nagarajan has served as the organization's representative to RDECOM's Nanotechnology Knowledge Center and as the program chair of the American Chemical Society's Division of Colloid and Surface Chemistry, which presented him with an Outstanding Service Award the same year.

As a chemical engineer for NSRDEC's Molecular Sciences and Engineering Team, Nagarajan has submitted more than 40 research proposals to external agencies for support of Soldier-related research. He has published four books on nanomaterials and self-assembly, 13 papers in scientific journals, written five book chapters, organized and held two symposium proceedings, and presented at 15 invited seminars and 29 professional society meetings, among a myriad of other professional achievements.

Nagarajan has also established collaborative research agreements with faculty from prominent institutions such as Clarkson University, Purdue University, Worcester Polytechnic Institute, UMass Lowell, University of South Carolina, University of California at Santa Barbara, University of Georgia, Boston University and Massachusetts Institute of Technology, or MIT.

"I want to help strengthen our place within the broader scientific community," Nagarajan said.

The ability to develop such research partnerships, garner support of key stakeholders for buy-in and funding, while managing both internal and external collaboration on nanomaterials, is an essential part of his new job.

"Interactions with industry, academic researchers and the international research community has given me the opportunity to represent Army technical interests to the international colloid, surface, and nanomaterials research community and to connect Army researchers to this community," he said. "My goal is to establish, expand, and leverage global resources — not just within the metro-Boston area, but around the world."

One of Nagarajan's most significant impacts at NSRDEC has been though his role as a mentor to promising undergraduate students, post-doctorate students and young NSRDEC researchers across many different scientific disciplines.

"More than 30 undergraduate students from various institutions such as Northeastern University, MIT, Worcester Polytechnic Institute, University of Connecticut, Johns Hopkins University, Assumption College, University of Massachusetts at Amherst, and University of Notre Dame have worked on a variety of experimental or computational projects in my laboratory," Nagarajan said.

According to Nagarajan, working with these students has been his "most satisfying and stimulating experience" at NSRDEC.

At his May 19 promotion ceremony, presided over by Jyuji Hewitt, the executive deputy to the commanding general of the U.S. Army Research, Development and Engineering Command, Nagarajan received The Senior Scientist Pin, which displays a stylized keystone symbolizing the center stone that holds all the stones of an arch in place.

The promotion also celebrates Nagarajan's reaching the highest level of government service in his field.

"It is a rare opportunity to do something you love," he said. "It is even rarer to do something you love while serving Soldiers. I am really glad I am doing that here."

"My goal is to establish, expand, and leverage global resources — not just within the metro-Boston area, but around the world."

Arrive Intact

New airdrop system could save cargo loads

By Bob Reinert, USAG-Natick Public Affairs / NATICK, Mass. (April 2, 2015)

It's great to be able to airdrop cargo to Soldiers in isolated areas. It's even better if the load arrives intact.

With the decades-old M-1 and M-2 cargo parachute release systems currently in the Army and Air Force inventories, that sometimes can be a hit-or-miss proposition. The Advanced Cargo Parachute Release System, or ACPRS, now being developed by Product Manager Force Sustainment Systems at Natick Soldier Systems Center, could change that.

"So that's really the impetus for this whole system is better reliability and taking care of the equipment that gets on the ground," said Scott Martin, an equipment specialist with PM FSS Cargo Aerial Delivery. "All it takes is just one airdrop load to roll over and destroy it, and that's what would happen with the old M-1 and M-2. It would hit the ground, it wouldn't release, and the wind would catch the parachute and would roll the load over and destroy the load."

PM FSS began looking at several systems in 2010 and settled on the ACPRS, which can accommodate loads ranging from 200 to 42,000 pounds. One or two systems can be used with between one and eight parachutes, depending on load size.

Instead of the mechanical timer employed by the old systems, the ACPRS uses an electro-mechanical system that automatically disengages the parachutes when the load hits the ground.

"There's actually a battery in it, and it uses a pressure sensor, a barometer and some other accelerometers to figure out what's going on in space," Martin said. "It has a motor that releases the parachute, so it's much more reliable.

"A lot of the worry is how the Soldiers work and deal with these things. It's pretty darned simple. There's very little that the Soldiers have to do with it."

According to Martin, partnerships with the Rhode Island Air National Guard, Rhode Island National Guard, Connecticut Air National Guard, and New York Air National Guard have aided in the ACPRS development.

"We're very lucky to have three C-130 units within our neighborhood, between Rhode Island, Connecticut and New York," Martin said. "This is an opportunity for us to use our equipment – see how it works – while they're being exposed to new equipment, and (it) prepares them better for when they go out and do training."

It wasn't love at first sight for the Rhode Island Air National Guard, however.

"Initially, there was some hesitation for the new (system) from the older generation," said Master Sgt. Kyle C. Gurnon of the RIANG. "This attitude quickly changed once people got their hands on it. After academic and hands-on training, the group was impressed by the simplicity of the ACPRS."

Gurnon called the ACPRS "a great replacement to the M-1/M-2, and I think it will mitigate malfunctions due to timer block assembly failure. Further, I think the lack of unit level maintenance on the ACPRS will save man-hours, as I was told that you ship the unit back to the manufacturer if it fails the built-in-test. The longest part of rigging it is charging it.

"I can't wait to see nothing but ACPRS in the system."

The ACPRS sailed through testing. For now, the system is in use only at Little Rock Air Force Base, Ark., and at the U.S. Army Quartermaster School at Fort Lee, Va. The next step is fielding the system throughout the services.

"I think within the next year it will be available in the supply system," Martin said.

Though the ACPRS costs about three times as much – about $5,000 apiece – as the systems it's designed to replace, Martin brought that into perspective.

"If you save one load, you've paid for it how many times over?" Martin said. "I don't think it's going to be a stretch to say that loads will be saved by using this.

"I think it's just going to quietly take over, and people are not going to notice. I think that might be the true measure of success."

Photos: Bob Hawley, NSRDEC Strategic Communications

The New Sixty

Technologies developed to cut convoys to forward operating bases

By C. Todd Lopez, Army News Service / WASHINGTON, D.C. (May 15, 2015)

Army research to reduce the use of fuel and water, and to reduce waste output at forward operating bases, or FOBs, promises to dramatically reduce the number of convoys and hours Soldiers are exposed to threats.

About 60 new technologies are being tested as part of a sustainability project that was on display at the Pentagon, May 14, at the first "DOD Lab Day" there. Dozens of Army researchers and scientists from Army labs around the nation put their most interesting research projects on display for viewing by Pentagon officials and the press.

Ben Campbell of U.S. Army Natick Soldier Research, Development & Engineering Center, is the lead systems engineer of the Army's Sustainability Logistics Basing - Science and Technology Objective Demonstration.

In the courtyard of the Pentagon, he had a small model of an Army base camp, one that would house about 50 Soldiers, labeled to indicate where several of the technologies his team is evaluating for the Army might be put to use. Included among those was a system that pulls drinking water from the air, a nanogrid power management system, bidirectional on-board vehicle power systems and shading systems to reduce the amount of power needed to cool shelters.

Campbell said Army goals for the research he leads is to reduce fuel resupply to such installations by 25 percent, reduce water resupply by 75 percent, and reduce waste generation and waste backhaul — the need to remove waste material — by 50 percent.

The 60 technologies being developed are meant to support these goals, Campbell said, and his team put them into realistic scenarios, such as at a recent demonstration at Fort Leonard Wood, Missouri, in April — where they outfitted a 1,000-man base camp with such technology.

At Fort Leonard Wood, they evaluated a new kitchen concept that feeds 80 Soldiers three meals a day. The new kitchen, he said, is more energy efficient — it puts more heat into the food rather than into the kitchen environment where it not only makes Soldiers working there uncomfortable, but also wastes energy, he said.

His team's technologies have proven successful in one of the Army's most primary goals — keeping Soldiers out of harms' way, Campbell said.

"Our initial analysis in one base camp scenario we had set up was almost a half a million Soldier threat exposure hours we are able to eliminate in a 180-day base camp scenario," Campbell said.

One goal of water-saving, energy-saving and waste-reduction technology is to reduce the need for Soldiers to bring those things to a forward operating base via convoy.

If an Army FOB can implement technology that allows it to use a quarter of the fuel it might otherwise use, or reduce the fresh water it needs delivered by 75 percent, then it will reduce the need to have convoys to deliver those supplies. For every four fuel convoys it might have needed before, it now only needs three. And it might need only one water convoy where before it needed four. That means fewer Soldiers on the road in convoys, where they are exposed to improvised explosive devices and other threats.

Another benefit, Campbell said, is that by reducing the logistical support requirements for an installation, it can be moved farther away from a logistics supply base. A FOB could be moved father out, closer to the fight.

"Resupply by air drop becomes more economically feasible and things of that nature," he said. "If you only need resupply every seven days instead of three days, then maybe you can have the base more forward deployed."

With more energy- and water-efficient installations, fewer Soldiers on a FOB are involved in sustainment, Campbell said.

"The more self-sufficient you can make the base camp, the more independent they can be," he said. "That means more Soldiers doing the mission rather than supporting the base camp."

Among the technologies that Campbell said are being evaluated by his team are those that recycle waste water, those that burn trash to create energy, and one that allows a tactical vehicle to be used to provide power to an installation until generators can be brought in.

Campbell also said that while working toward the water, energy and waste goals are important, equally important is sustaining quality of life for Soldiers — something he said has to be maintained.

"The base camp is a platform to support Soldier readiness," he said. "A Soldier comes here to rest, reset, and launch missions off of. So we conduct evaluations to understand the impact of these technologies in generating quality of life support for the base camp."

Campbell's team is planning another evaluation at Fort Devens, Massachusetts, in July. There they will outfit one of two 150-person base camps with their technology to evaluate its effectiveness.

Ben Campbell, of U.S. Army Natick Soldier Research, Development & Engineering Center, is the lead systems engineer of the Army's Sustainability Logistics Basing - Science and Technology Objective Demonstration.

"The more self-sufficient you can make the base camp, the more independent they can be. That means more Soldiers doing the mission rather than supporting the base camp."
Ben Campbell, NSRDEC

Photo: C. Todd Lopez

Photo: Department of Defense

The Big Picture ... is Small

by Jane Benson and Craig Rettie, NSRDEC

Natick looks to nanotechnology to advance future food packaging and textiles, creating new and better ways of wrapping everything from MREs to Soldiers themselves, and potentially creating whole new categories of super products—clothing that rarely or never needs washing, lenses that never fog, and packaging that can keep food nutritious for extended periods.

Thinking small is the key to developing future food and clothing technologies for the Soldier—such is the conclusion of researchers at the U.S. Army Natick Soldier Research, Development and Engineering Center. Scientists there are using nanotechnology, the engineering or manipulation of materials or systems at an atomic or molecular scale, to improve packaging—both for the food Soldiers eat and their own packaging—i.e., clothing.

NSRDEC's efforts include the development of high-barrier, nonfoil food packaging materials—polymer films that prevent oxygen and water from transporting through them. Nanoparticles within a polymer film make it difficult for gas molecules to get through, improving the barrier to oxygen and moisture, both of which can speed the deterioration of food.

By working on the nano level, NSRDEC's scientists and engineers have the opportunity to expand the applications of this technology for the good of the Soldier.

THE PERFECT NONFOIL

The Advanced Materials Engineering Team (AMET), part of NSRDEC's **Combat Feeding Directorate** (CFD), is investigating high-barrier, polymeric materials for military ration packaging and for food packaging that supports deep space missions for **NASA**. Nanocomposite materials are an ideal packaging choice for shelf-stable processed foods because they can improve the barrier, mechanical and thermal properties of nonfoil food packaging. Polymeric laminates with foil as the barrier are currently being used for ration packaging. These structures provide an exceptional barrier to oxygen and moisture, but can also experience stress cracking and pin holing.

"Single inventors, such as Edison and Einstein, are now much rarer. Our world remains complex, but more and more scientists and engineers are trained in their specialized areas. Therefore, collaboration is a necessity for new inventions and discoveries."

Quoc Truong, NSRDEC physical scientist

NSRDEC is also working on developing and advancing omniphobic and super-omniphobic textiles and other products, which resist dirt, dust and liquids. Omni means "all," and, in chemistry, phobic doesn't so much mean fearful as it does a chemical aversion. An omniphobic coating, therefore, is averse to both water (hydrophobic) and oils (oleophobic). Omniphobic coatings contain micrometer-sized (one 1 millionth of a meter) particles, such as silica, or a combination of micro- and nanometer scale particles. (A nanometer is one 1 billionth of a meter.) When these coatings are applied onto textiles or hard surfaces, such as glass or metal, their surfaces are modified with micro- and nanoscale surface features. These features are similar to a lotus leaf's hierarchical nonwetting surface, which enables the plant to float and glide on water, or a water strider's feet, which let the insect walk on water without sinking.

"The incorporation of nanotechnology into barrier films has proven to be a critical ingredient in our packaging design that will allow us to achieve food protection properties only seen before through the use of foil-based systems," said Dr. Christopher Thellen, a Ph.D. materials engineer in the CFD. "The exfoliated dispersion of nanoparticles in polymers forces penetrating oxygen and water vapor molecules to follow a tortuous pathway through the packaging material, thereby increasing the time needed to penetrate the packaging and improving barrier properties."

Nanocomposite packaging can be lighter in weight and less expensive than foil pouches. That reduction in size can not only reduce the amount of solid waste and enhance the quality of the rations by preserving them better and longer, but it also reduces the warfighter's logistical burden. NSRDEC is exploring technology that is based on incorporating nanoparticles into thermoplastic resins to create a nanocomposite material that is 1,000 times smaller than conventional composite material fillers. Nanoparticles have proven to be cost-effective and compatible with many polymers used in packaging.

As a result, the high-barrier, nonfoil polymeric packaging will comply with the Meal, Ready-to-Eat requirement of maintaining a three-year shelf life. For space applications, it will maintain up to a five-year shelf life.

NOT YOUR GRANDMA'S CANNING

Food sterilization techniques, in combination with proper packaging, play an important role in extending shelf life. Retorting, similar to pressure cooking, is the food industry's most common commercial sterilization process for prepackaged, low-acid foods. This process exposes food packages to high moisture and high temperature conditions under pressures of up to 2.5 atmospheres. In some cases, the long retort process leads to a reduction in food quality and limits the types of packaging materials that can be used.

Dr. Jo Ann Ratto, AMET team leader, whose doctorate is in plastics engineering, said that the implementation of a nonfoil structure into food packaging will make it possible to consider novel sterilization methods, such as microwave-assisted thermal sterilization (MATS) and pressure-assisted thermal sterilization (PATS). MATS and PATS are desirable alternatives to retort sterilization because they reduce the time needed to raise the product temperature to that required for the thermal lethality of target bacteria—that is, it kills botulism and other toxins faster. A shorter process time can improve food quality and nutrient retention at a lower cost, which is one reason these methods are so attractive for both the U.S. military and NASA.

AMET is exploring polymeric packaging for these novel methods in collaboration with CFD's Food Processing Engineering and Technology Team. The two teams are also studying the effect of the various processing methods on vitamin stability in an effort to preserve freshness and food safety and prevent nutrient loss.

"The nanocomposite research and development work has been challenging and rewarding for the Advanced Materials Engineering Team. After further demonstration and validation work, we will know if these materials have acceptable performance to be considered for incorporation into ration packaging for the warfighter," said Ratto.

'SO' CLEAN

Soldiers are frequently in muddy, dusty and oil-contaminated environments. NSRDEC and its industry partner, Luna Innovations Inc., have worked together to develop omniphobic coatings for fabrics. Omniphobic surfaces do not become wet when exposed to water, liquid chemicals, organic solvents and some oils, such as cooking and motor oils.

Unlike omniphobic surfaces, which can be found in nature, super-omniphobic (SO) surfaces are purely man-made, engineered surfaces based on a 2007 discovery by the Massachusetts Institute of Technology. SO surfaces are both super-hydrophobic and super-oleophobic and theoretically repel most, if not all, known liquids, including those that with extremely low surface tensions, such as the solvents heptane and hexane, which would make most surfaces, without SO protection, wet.

NSRDEC's research and development of omniphobic and SO technologies, which will be used in protective clothing applications, will improve warfighters' quality of life and lessen their logistical burden. Omniphobic fabrics require much less frequent washing, reducing water and detergent usage. NSRDEC is also investigating the development of SO coatings, inherently SO fibers and micro- and nanosurface transparent films.

Besides being super-repellent to liquids when applied onto protective clothing, SO coatings will also contain an antimicrobial additive to retard the growth of microbes responsible for causing body odors. The SO fibers with the antimicrobial additive will be woven into yarn, made into fabric and finally fabricated into protective clothing that will require no laundering and remain clean, dry and odor free. The hierarchical micro- and nanoscale SO transparent films will be applied onto protective lenses, goggles and visors to provide the Soldiers with "always clear vision" by shedding water, oils and chemicals on the outer lens surface while preventing fog from forming on the inner lens surface. These features will help Soldiers better complete the vision-dependent aspects of their missions, including driving, firing, viewing maps and operating electronic equipment in multiple environments, especially under wet and rainy conditions.

To bring Soldiers the very best science has to offer, NSRDEC is combining its expertise with the expertise of academia and industry. Quoc Truong, an NSRDEC physical scientist, emphasized the importance of these collaborations. "NSRDEC provides concepts and ideas, technical approaches and guidance and methods of testing and evaluation to best meet our Soldiers' needs," he said. "We also have a thorough knowledge of user requirements and materials specifications, while our collaborators have expertise, technical knowledge, resources and personnel who are academically trained and also have experience" in a range of related disciplines. Those collaborators include nanomanufacturing experts at the University of Massachusetts Lowell; fiber spinning experts at Clemson University; experts in re-entrant nanosurfaces, theories and modeling at MIT; and experts in omniphobic coating processes at Luna Innovations.

"Single inventors, such as Edison and Einstein, are now much rarer," said Truong. "Our world remains complex, but more and more scientists and engineers are trained in their specialized areas. Therefore, collaboration is a necessity for new inventions and discoveries. This way, we can put our heads together in solving longstanding problems or coming up with new and innovative products and practical solutions, to help our Soldiers complete their mission in the safest and most efficient manner."

INHERENTLY 'SO'

According to Truong, the characteristics of the SO coating will provide a significant improvement over the omniphobic coating. Moreover, SO surfaces will cause most liquid droplets to roll off and will minimize dirt and dust attraction. In addition to coatings, NSRDEC researchers are now working with academia and industry partners to develop fibers and transparent films that are inherently super-liquid-repellent based on their surfaces' physical nanoscale structures and features.

"Clothing and shelters fabricated from fabrics woven using inherently SO fibers will simply stay clean," said Truong, adding that yarns made from inherently SO fibers, then woven into cloth and made into clothing, are expected to be much lighter and more flexible and, therefore, more comfortable to wear.

The fabric made from SO fibers will be more breathable because of a physical structure that has multiple "micro-scale" air channels (with nano features on its fiber surface) that run the entire length of the fibers. Since the inherently SO fibers will no longer require the added step of coating, the clothing is also expected to have a lower manufacturing cost.

CONCLUSION

SO coatings, inherently SO fibers and SO micro- and nano-surface transparent films have different applications. The coatings will be used on soft and hard shelters, textiles, cables, solar panels, intricate shapes and objects, and flexible and hard surfaces, including windows, cars, ships and airplane exteriors. The inherently SO fiber technology will be used on textiles and filtration products.

"With SO technologies, Soldiers will have clothing that always stays clean and fresh," said Truong. "Their goggles, visors, vehicle windshields and windows will always stay clean, which allows them the clear vision to fight and complete their missions. Applying the technologies to ship hulls will allow them to move much faster on the water surface with less fuel consumption."

Like SO coatings, SO films will be used on durable, hard surfaces—solar panels, windows or airplanes, for example—to make them repellent to dust and dirt, and super-repellent to water, oils and other liquids.

"It is my hope that these new breakthrough technologies will help to enhance existing technologies the same way that carbon fibers improved the structural strength of buildings and cars," said Truong. "However, these SO materials, which are just about a year or two away from their formal introduction to commercial applications, will have vastly more potential, especially because of transparent SO film."

Being super-clean means being more mission-ready and more hygienic, with enhanced protection from contaminated water and liquid chemicals. "This exciting research and development project work is underway, and it is expected that sample-size fabrics and lens products will be available for further testing and evaluation by December of 2015," said Truong.

Photos: Tazanyia L. Mouton, USAG-Natick Public Affairs

Design Challenge

Students participate in Air Force Research Laboratory event at Natick

By Tazanyia L. Mouton, USAG-Natick Public Affairs / NATICK, Mass. (April 21, 2015)

More than 150 students from 17 colleges and universities and three service academies were on hand at the Natick Soldier Systems Center April 13-17, as they partook in the 2015 Air Force Research Laboratory University and Service Academy Design Challenge.

The AFRL is a scientific research organization operated by the U.S. Air Force Materiel Command dedicated to leading the discovery, development and integration of affordable aerospace warfighting technologies.

The laboratory, formed in 1997, has conducted numerous experiments and technical demonstrations in conjunction with a wide range of agencies to include the Department of Defense.

The AFRL design challenge makes great efforts to deliver creative solutions to challenging problems, and presents an exciting opportunity for students to exercise their talents and contribute to our nation's defense.

This year's challenge asked students to design and prototype a heat stress prevention kit that could safely, rapidly and effectively remove undesired heat away from body exteriors during special operations in hot and humid environments.

The biggest constraint students had to work with was the fact that in hot environments, it is often difficult for the warfighter to wear heavy protective equipment.

The challenge also called for the kit to be rapidly deployable, self contained, and portable.

In September, students were given their mission, and they have had the last seven months to develop their ideas and create their prototypes.

Due to the nature of this year's challenge, it was only fitting that students' prototypes would be tested in the U.S. Army Natick Soldier Research, Development and Engineering Center's Doriot Climatic Chambers.

The chambers are a one-of-a-kind facility that can reproduce environmental conditions that occur anywhere in the world, producing tropic wind with temperatures as high as 165 degrees, and arctic wind with temperatures as low as minus 70 degrees.

The chambers can also simulate rain up to four inches per hour and wind up to 40 miles per hour.

Through these extreme conditions, testing of physical properties of military equipment, as well as testing of physiology and adaptations of human subjects, can be performed here.

Josh Osborne, an aerospace engineer and AFRL Design Competition program manager, said the challenge is unique because it can present a solution to a real-world need for Air Force Special Operations.

"The overall purpose is to get a system (or) an idea together to solve the problem," said Osborne. "At the same time, grow the future engineers that are ready to graduate and get them interested."

Osborne added that the students also had to consider the dimensions of the system.

"When a special operations person takes something with them, they have to think, 'Would I leave a (Meal, Ready-to-Eat) behind to take this?' So it has to be important enough for them to bring it to begin with, so weight and size is a big thing," said Osborne.

After several months of working on their innovations, the challengers tested their prototypes in the chambers.

Test subjects donned the students' prototypes and walked on a treadmill for one hour at an approximate pace of three miles per hour with temperatures nearing 100 degrees Fahrenheit with 40-percent relative humidity.

Osborne said throughout the test, subjects' heart rates and skin temperatures were monitored.

Cadet Ioannis Wallingford, a senior at the U.S. Military Academy at West Point, said he's proud of the work his team has done.

"It feels great; it's something that actually touches me pretty deep," Wallingford said.

Wallingford explained that during cadet basic training, a classmate of his died due to a heat-related incident.

"I chose this capstone because this is something that would have decreased the risk for an incident like that to happen," Wallingford said.

Wallingford described his teams' prototype as sophisticated but also simple.

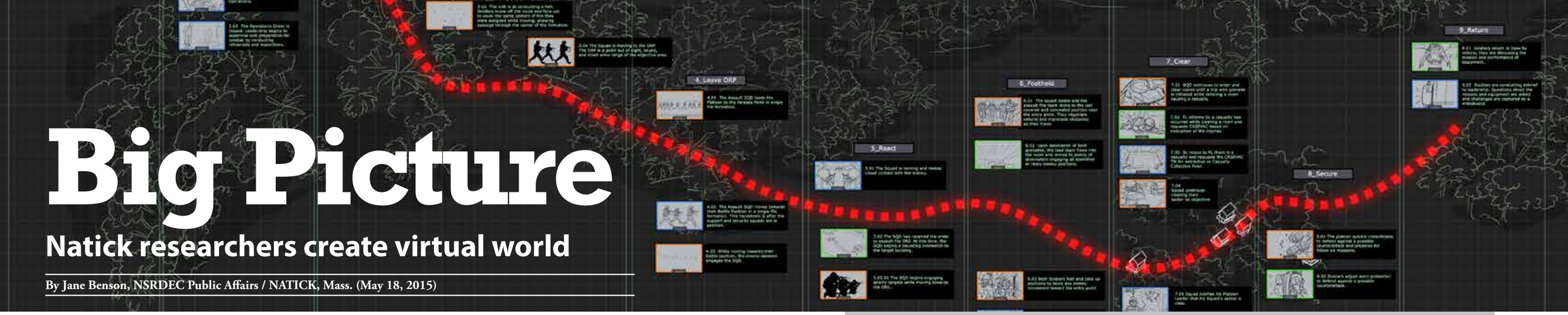
"Our system uses a passive system combined with an active system because we realized our passive system alone would not produce the cooling capacity required," said Wallingford. "It creates a synergistic effect between the two."

The winning university team of the AFRL challenge was not only awarded a symbolic "Wright Brothers" trophy, but the potential for a $100,000 grant to further develop their innovative idea.

The service academies were in a separate competition amongst themselves, where they had a chance to win bragging rights for the next year, as well as a trophy of their own.

Students also "win" by experiencing solutions to real-world problems, while getting an opportunity to contribute to products that could potentially help save the lives of our nation's warfighters.

If you would like to learn more about the AFRL University and Service Academy Design Challenge, you can visit http://www.afrlchallenge.com/.



Big Picture

Natick researchers create virtual world

By Jane Benson, NSRDEC Public Affairs / NATICK, Mass. (May 18, 2015)

Natick researchers are creating a virtual world to provide an accurate, instant and interactive snapshot of the Soldier and his or her equipment.

With optimal performance in mind, Rick Haddad and the Soldier Capabilities Integration Team from the U.S. Army Natick Soldier Research, Development and Engineering Center are working to ensure the Soldier and equipment work together in concert.

"We developed a likely task scenario environment that a Soldier or squad would be operating in and took every protection project and found where it most likely would have value to the warfighter within the scenario," Haddad said. "We created a visual where people could see how their project fits in the operational environment and how it works with other products."

The team created a virtual demonstration of 77 projects. In the long-term, Haddad said he hopes the virtual demonstration will spark the development of a web-based interactive tool that will extend across Army Science and Technology to make products for the Soldier more compatible and enhance Soldier performance.

By making subject matter experts aware of this novel demonstration methodology, researchers hope others within the Army S&T community will get involved and provide information about their own projects.

The virtual demonstrator increases SME awareness of where Soldier products fall in the big scheme of things, where a product lies in the execution of a Soldier's mission, and how different components need to work together.

Scientists, engineers and other subject matter experts will ultimately be the users who will interface with a data architectural environment, so getting their input now is crucial. The virtual demonstrator is part of a much larger, Army-wide, Soldier System Engineering Architecture effort.

Natick's focus areas include the Combat Feeding Directorate, Warfighter Directorate, Aerial Delivery Directorate and the Expeditionary Basing and Collective Protection Directorate, which Haddad said makes NSRDEC a good starting point for the virtual demonstration. Each area has a role spanning across warfighter missions, from the base camp to the complex area of operation.

"We are the Soldier domain," said Mary Giacalone, an NSRDEC program analyst who is working with Haddad on early deliverables. "We're here to support the needs and requirements of the Soldier."

When looking at the Soldier as a system, experts at NSRDEC recognize that not only is the sum greater than all the parts, the parts need to work together seamlessly in order for the nation's warfighters to be at their very best.

Currently, Army scientists and engineers develop Soldier equipment to enable Soldiers to reach optimal performance. Sometimes, it is hard to know what researchers in other areas have developed, and this can lead to unforeseen compatibility problems or to the Soldier's load becoming too heavy, Haddad said.

"Even a pound, when multiplied over the course of a mission, can have a tremendous impact on Soldier performance, depending on the task he or she is asked to execute," he said.

The team is working to make information accessible, sortable and leverageable. The demonstrator features clickable panels to navigate a mission and the necessary technologies to support that portion of the mission. Down the road, this information will be available via website.

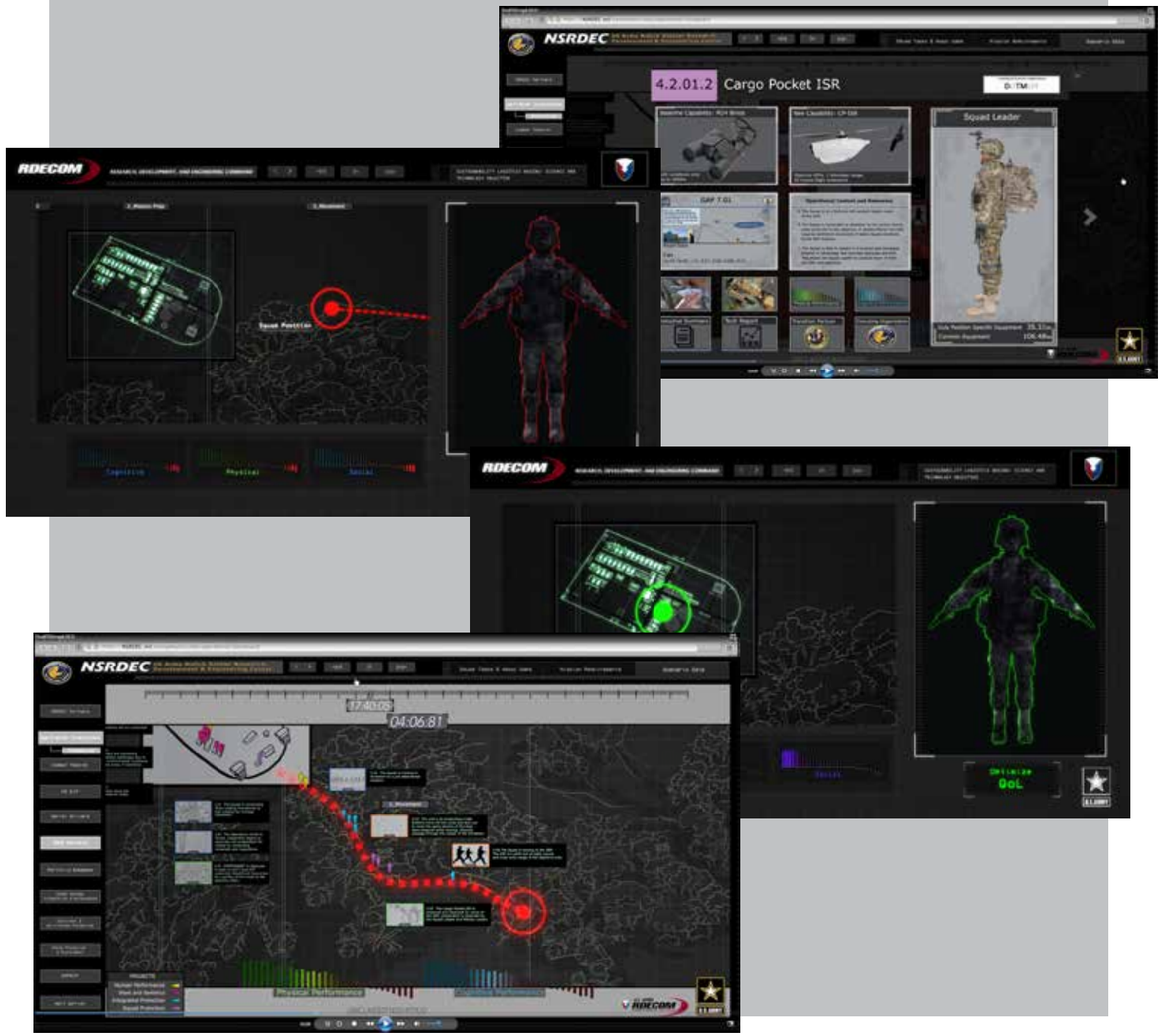
"It's an integrated approach," Haddad said. "We need to develop tools that enable consideration of the Soldier, the equipment and the task."

The goal is to see projects laid out from the base-camp-planning phase to the mission-execution phase and every step in between.

"Operational context is important," he said. "Good science doesn't always equal good outcome. This project will help our scientists, engineers and user community partners become more aware of the operational impact of our proposed capabilities that we want to deliver to the warfighter. We want to get people onboard with shaping their future computing environment, their future database experience.

"If we have their input, we will have a better user interface. We want it to get to the point where someone can type in, for example, 'protection for the torso,' and several material and nonmaterial solutions that need to be taken into consideration will pop up," he said. "That's where we hope to get to."

Haddad and Jaclyn Fontecchio are co-leads for the Force Protection, Soldier and Small Unit, Science and Technology Objective Demonstration.



Brain Domain

Natick, Tufts team up to create new center

By Jane Benson, NSRDEC Public Affairs / NATICK, Mass. (June 29, 2015)

Army researchers have teamed up with the Tufts University School of Engineering to create the Center for Applied Brain and Cognitive Sciences, or Center for ABCs.

The center is co-directed by Dr. Caroline Mahoney, team leader for the U.S. Army Natick Soldier Research, Development and Engineering Center, or NSRDEC, cognitive science team, and Dr. Holly A. Taylor, a professor of psychology in Tufts' School of Arts and Sciences who also has an appointment in mechanical engineering at Tufts.

"The new partnership between Tufts and NSRDEC will allow NSRDEC scientists opportunities to partner with Tufts faculty and students and utilize unique center resources," Mahoney said. "It will also afford the opportunity for Tufts faculty, undergrad and grad students to gain further real-world experience working collaboratively with NSRDEC scientists to solve Soldier problems in specialized NSRDEC facilities, such as the climatic chambers, that are not available to them at the university."

"This partnership will also extend the expertise available for innovative, collaborative projects for Tufts researchers and graduate students by involving the NSRDEC researchers," Taylor said. "Interdisciplinarity is highly valued at Tufts already, and this center fits that emphasis."

By bringing together experts in engineering, neuroscience, psychology, linguistics, computer science and robotics, the collaboration aims to advance researchers' understanding of how people think, respond and perform in demanding, real-world situations. The center will ultimately provide insight into how Soldiers think in response to ever more complicated and challenging environments.

"Our objective at the cooperative center is to identify innovative, interdisciplinary approaches to monitoring Soldier physiological and mental states, predicting how those mental states influence operational behavior, and optimizing behavior via adaptive, multimodal interfaces and robotic platforms," said Dr. Tad Brunyé, center program manager and member of NSRDEC's cognitive science team. "This objective is accomplished through fundamental and applied interdisciplinary research to inform the design and development of next-generation support and augmentation systems, enhancing future Soldier capabilities and performance during kinetic operations."

The center's research will be divided into four areas.

The first area will examine the principles, which govern interactions between people and intelligent supporting systems.

"These include hand-held and person-borne devices [smart phones, head-mounted displays and tablets] and autonomous robotic platforms aimed at augmenting and optimizing human cognition, effect, and/or physical capabilities in mixed initiative teams," Mahoney said.

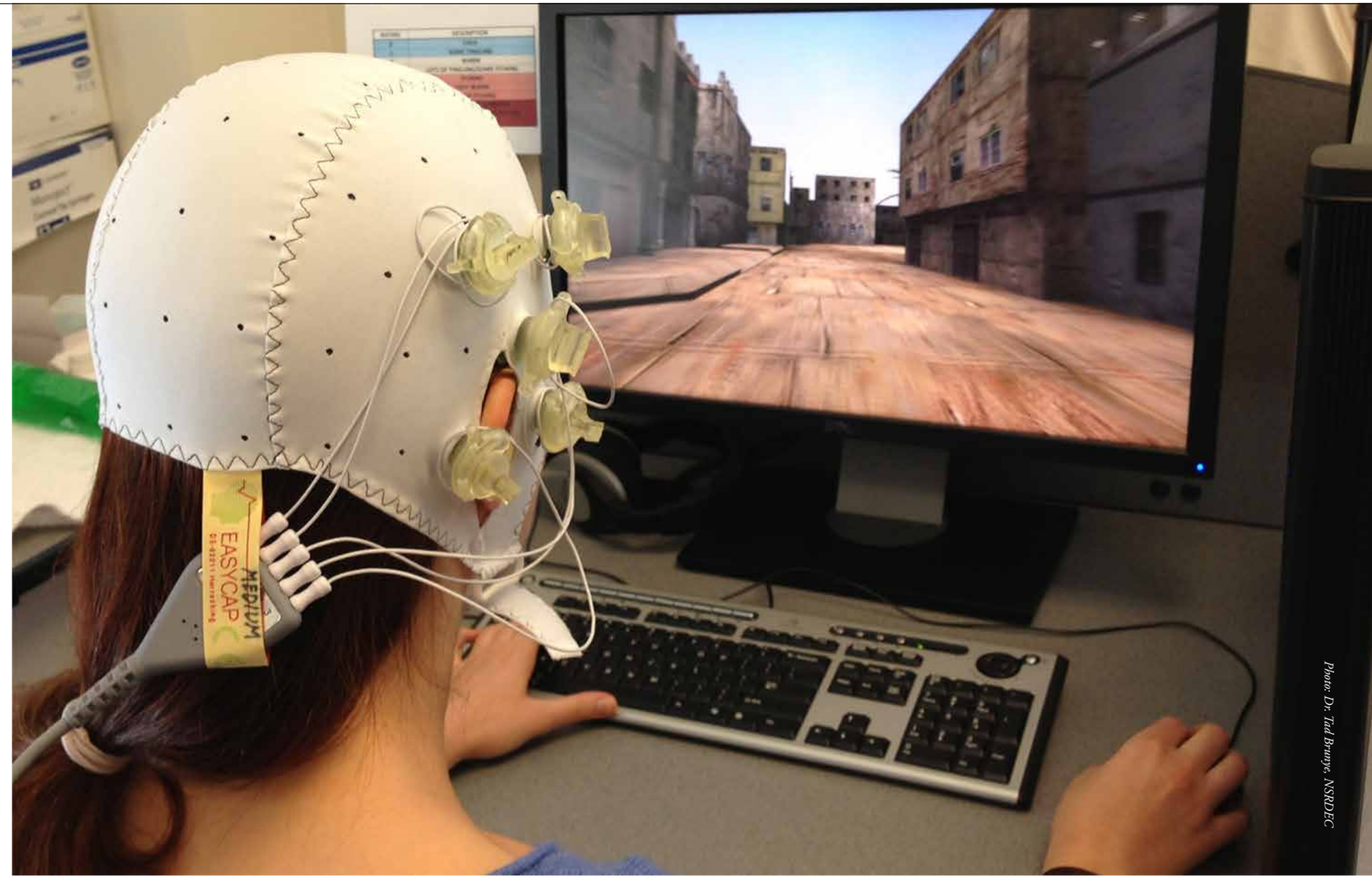


Photo: Dr. Tad Brunye, NSRDEC

Scientists at the Center for Applied Brain and Cognitive Sciences collect data on the efficacy of administering targeted brain stimulation on memory and navigation performance in novel environments.

The second area involves monitoring, characterizing and optimizing cognitive and non-cognitive states.

"Research efforts will focus on establishing and testing multimodal - physiological, neurophysiological, behavioral, hormonal - measures and metrics for monitoring and characterizing relevant cognitive and non-cognitive states such as frustration, mental workload, stress, readiness for problem-solving, fear, uncertainty and fatigue - cognitive and physical," Mahoney said.

The third area involves studying ambulatory human performance of cognitive and physical tasks. The area will examine warfighters on the move engaged in environments based on real-world conditions and demands.

The fourth area of study will focus on applying cognitive science findings to team-based situations, which require interaction, communication and cohesiveness among team members.

Mahoney is excited about the center's possibilities.

"The Center for Applied Brain and Cognitive Sciences is a tremendous opportunity for NSRDEC human sciences to pioneer a truly innovative environment that brings together a multidisciplinary group of world-renowned experts in the fields of cognitive science, psychology, neuroscience, computer science, robotics, engineering, linguistics, and nutrition to push the state of the science on measuring, predicting and enhancing cognitive capabilities and human-system interactions for individuals and teams working in naturalistic high-stakes environments," Mahoney said. "The research focus for the center is the dismounted Soldier, but certainly data and knowledge products developed will have the potential to make a significant impact on law enforcement, emergency first responders, and the medical community, as well."

The Tufts School of Engineering is one of the eight schools and colleges that make up Tufts University. The school, located in Medford/Somerville, Massachusetts, offers undergraduate and professional degrees in several fields of engineering and computer science.

Research steers Soldiers in right direction

By Jane Benson, NSRDEC Public Affairs / NATICK, Mass. (May 6, 2015)

Soldiers face special challenges during navigation. Their jobs are physically demanding. They are often under extreme stress, and they often need to make quick decisions in an ever-changing and sometimes dangerous environment. They may be cold, hot, hungry or tired. All of these factors can affect the ability to make wise navigation decisions.

Army researchers use virtual reality to test to test Soldiers and discover influences on choices people make when choosing a route.

Dr. Tad Brunyé, a member of the Cognitive Science Team at the Natick Soldier Research, Development and Engineering Center, investigates spatial and non-spatial influences on Soldier navigation choices.

"This type of knowledge will help optimize Soldier performance," Brunyé said. "Soldiers also show reliable biases in memory for landmark locations due to the emotional nature of events that transpired at that location."

Spatial influences pertain to things in an actual space, such as topography, local and distant landmarks, or the position of the sun. Non-spatial influences are a little harder to define and can include a Soldier's emotional state, level of stress, mission and task demands, skills, abilities, traits, and his or her past experience in a geographical area, all of which can affect navigational choices.

"We are still trying to identify and characterize the full range of spatial and non-spatial influences and how they interact with emerging representations of experienced environments," Brunyé said. "We all have our current mental states. So, you may see the same landmarks as I do, you may see the same topography that I do, but I might be in a very different state that leads me to interpret and use that same information in very different ways.

Virtual reality capabilities, including head-mounted display systems, have revolutionized cognitive science research by allowing Soldiers to get engaged in visual worlds, scenarios and tasks that accurately emulate aspects of operational experience while maintaining important experimental controls.

"As part of our goal to understand, predict, and optimize navigation behavior, we have leveraged virtual reality research and technologies to advance the state of the art in spatial cognition research and gain new insights into the brain mechanisms, strategies, and biases that Soldiers use when selecting routes, learning new environments, and solving complex problems," he said.

Individual cognitive abilities and individual personalities can also affect navigation choices. Brunyé has found that good navigators tend to be more open to new experiences and are less anxious than poor navigators.

"How confident do I feel in my environment? Is there a history of enemy activity? Are there certain areas I want to avoid? Are there certain safe spots that I want to keep in mind? There is always interplay between what you sense in the environment, what you perceive, what you know, what you predict will occur, and ultimately how you act."

There are also misperceptions that influence navigation choices. One of the key discoveries made by Natick Soldier Research, Development and Engineering Center researchers is that many people will choose a route that goes south because they equate going south with going downhill. They perceive a southern route as easier than a northern route, which they equate with going uphill. This incorrect assumption can lead to less than optimal navigation choices.

"This finding has been coined the 'north-is-up' heuristic, and has been replicated in not only the USA, but also in Bulgaria, Italy, and the Netherlands," Brunyé said.

Moreover, Brunyé said that right-handed people tend to prefer making right turns. Left-handed people prefer going left, and most people will chose a route that is straight initially, even if it curves and becomes suboptimal later in the journey.

"At this stage of our research we are tasked with understanding and quantifying the conditions under which various heuristics and behaviors emerge, and how they might interact with one another to guide navigation behavior," Brunyé said.

By studying and monitoring people's choices in navigation (through non-intrusive devices and methods) and by observing patterns of physiology and neurophysiology, Brunyé is developing ways to predict behavior and optimize navigation performance. The goal is to incorporate his observations into Soldier training, providing Soldiers with concrete tips for becoming better navigators in a variety of situations. In addition to training, Brunyé is exploring redesigning tasks and support technologies to better match individual and contextually guided Soldier capabilities and limitations.

The team is also investigating stimulating areas of the brain with low-current, electrical charges. Brunyé said that the low-current charges have been shown to help some poor navigators become better navigators, but the charges do little to help those who are already competent navigators. Brunyé pointed out that brain stimulation could also ultimately be used to accelerate learning or help Soldiers overcome barriers to flexible performance, such as fear, anxiety or lack of confidence.

"Being a scientist at NSRDEC affords working on a wide range of impactful research programs that result in innovative technological solutions for optimizing Soldier cognition and action," Brunyé said. "This project has been particularly rewarding given its direct fit with my training and expertise, and its direct relevance to a real-world problem space."

The research is expected to have a major impact in the future.

"The knowledge garnered from this research could ultimately affect military strategy, including predicting which way an enemy will go," Brunyé said. "The research also could help predict the movement of friendly personnel who are disoriented or lost. By understanding the way the mind works, we can make some predictions about what people are going to do when they are lost or isolated. This knowledge will help improve survivability and mission effectiveness."

Test Case continued

sample of that soft armor, plunge it through an eight-inch-diameter hole, and we measured how much force it took to plunge it two inches through. We took all that data of all those designs and compared it to the human-factors assessment. And believe it or not, as you got panels that took more force to plunge, you could see that the Soldiers would say it was too stiff or prohibited range of motion. We found the threshold where Soldiers didn't like it. We also found a lower threshold where they started to say that it was too soft."

Thus, the new test methods are a standardized way to evaluate soft armor based on direct Soldier input.

"It is very simple, reliable and repeatable," DiLalla said. "The apparatus provides an accurate way to test current armor and future designs. The reason that this test is better is that we can actually test a system level, multi-layered system unlike the previous method of measuring the fabric stiffness of a single ply. We wanted to come up with a method that was operationally relevant and that reflected what the Soldiers would think, and at the same time not prohibit new materials/constructions from being used."

The second new test method measures wear durability with an apparatus that subjects an armor sample to load conditions that replicate physical movements used frequently by warfighters - including squatting, bending and twisting - in a single mechanical stroke.

"In this case when we say durability, we are trying to predict wear life or say that the system will at least last for some period of time. If Soldiers are in theater and wear this every day for a year - will the protection hold up to wear over 12 months? We don't want a system that will degrade in performance from normal, expected field use. We developed a test method to measure that. We came up with an apparatus that can mechanically work an armor sample in one stroke, and it's repeatable. Previously, there was no test method available to show how long the ballistic protection would last with typical use."

PROTECTING EYEWEAR TESTING

Previous testing methods for eye protection, including goggles and spectacles, did not adequately test for real-world conditions, including the desert conditions that have been prevalent in many Soldier operations.

"Our eyewear must be scratch resistant, fog resistant, and protect from dust and sand infiltration," said Michelle Markey, NSRDEC science and technology researcher. "This can be accomplished through design and specialty coatings. More ventilation can mean less fog, for example, but it can also mean more dust and sand gets in. It's a challenging balance that continuously needs to be looked at."

Previously, there wasn't a very reliable, effective test method for the laboratory. So, researchers had to rely on user field test data, which is time consuming and expensive. NSRDEC developed a new fog test and apparatus that measures anti-fog performance and provides quantifiable measurements that apply to real scenarios.

"Instead of having to test products in the field or a large chamber, we can now do it at a laboratory scale," Markey said.

Eyewear for Soldiers also needs to work, as part of a system and in conjunction with a helmet, which made private industry test methods inapplicable.

"Wearing eyewear with a helmet can affect air flow," Markey said. "The existing test methods didn't account for design, style, how it is worn, and the various environmental conditions the eyewear is used in. So, Natick came up with a test methodology to look at all these different considerations.

"A heated moisture bath in the head form is used to simulate heat and moisture from the eyes. Mounting on a head form also allows the space factor between the eyewear and the head to be considered, as well as the effect of other equipment, such as helmets. The environment is also a factor. Is it cold? Is it warm? What is the relative humidity and what effect does it have? The test apparatus addresses all of this, and is enclosed in a chamber, basically creating a miniature controlled environment for consistent test conditions."

SERVICE

This type of testing will improve Soldier safety because Service members will be more likely to keep their protective goggles and spectacles on if they do not have problems with fogging.

NSRDEC also developed a new standard test method for abrasion resistance. The method incorporates the use of rapidly blowing sand to replicate real-world conditions. None of the previous methods could accurately replicate this type of damage. In fact, eyewear that performed well under previous methods sometimes performed poorly when exposed to the blowing sand test mechanism.

"Abrasion resistance is always a key concern with eye protection," Markey said. "It's a challenge because of the nature of the impact-resistant material we use. It is soft and has to be coated to keep it from scratching. The durability of those coatings must be tested, ideally with something similar to what is experienced in the field. In a desert environment, blowing sand can be quite abrasive."

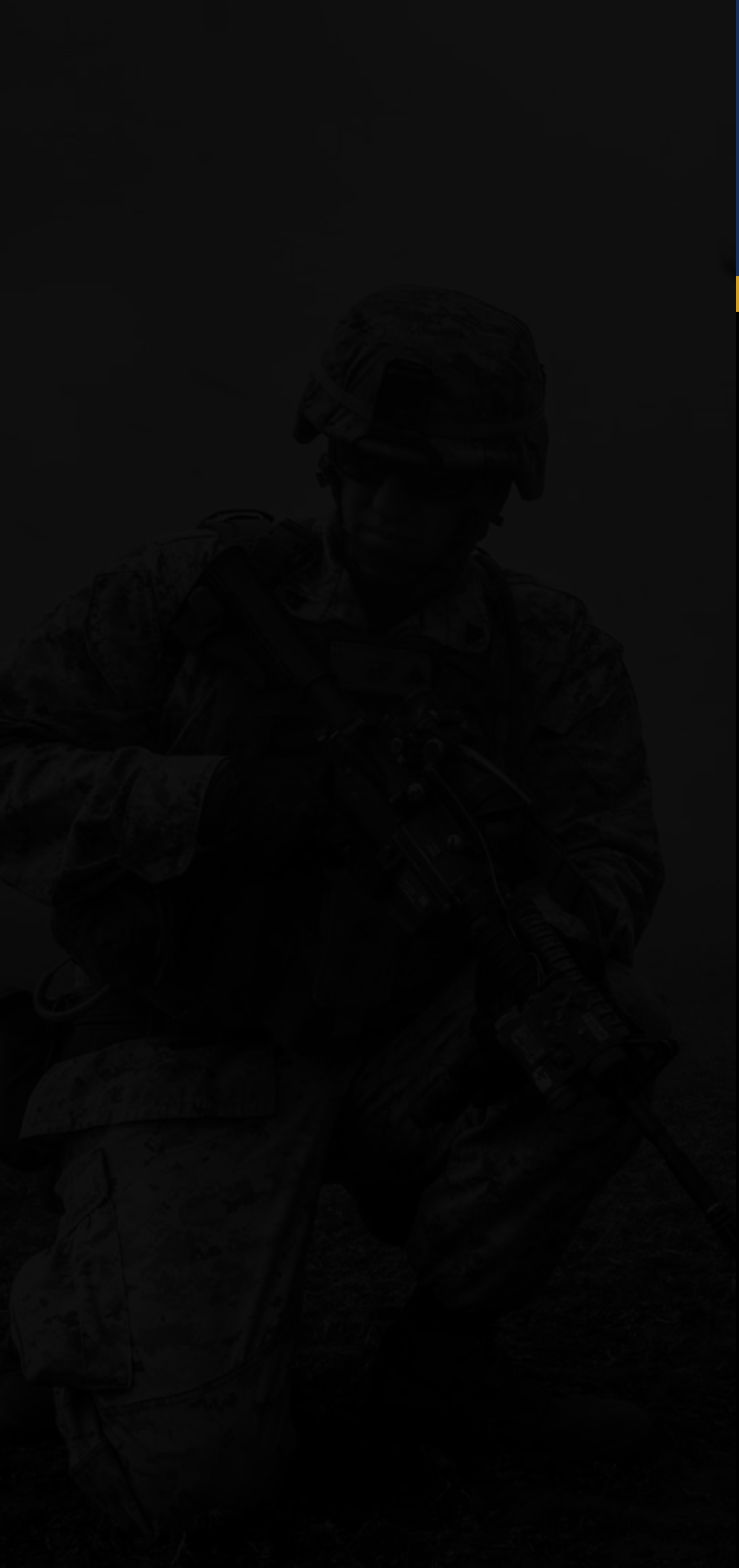
CONCLUSION

"People tend to focus on just the products, but they don't realize that behind the scenes we are working diligently to develop new methods to better assess the performance of these products," DiLalla said. "In many cases, old-test methods can't be applied to the new products. So, we need to be the lead, not only in developing these new products, but in developing operationally relevant methods to assess them.

"TECD Force Protection Soldier and Small Unit has been committed not only to developing new material solutions and knowledge products, but also to the development of improved test methods, which is one part of providing better capabilities to the Soldier. The program is set to wrap up at the end of FY2016 with numerous products transitioning to multiple stakeholders."

"People tend to focus on just the products, but they don't realize that behind the scenes we are working diligently to develop new methods to better assess the performance of these products."

Robert DiLalla, NSRDEC



Soldier
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