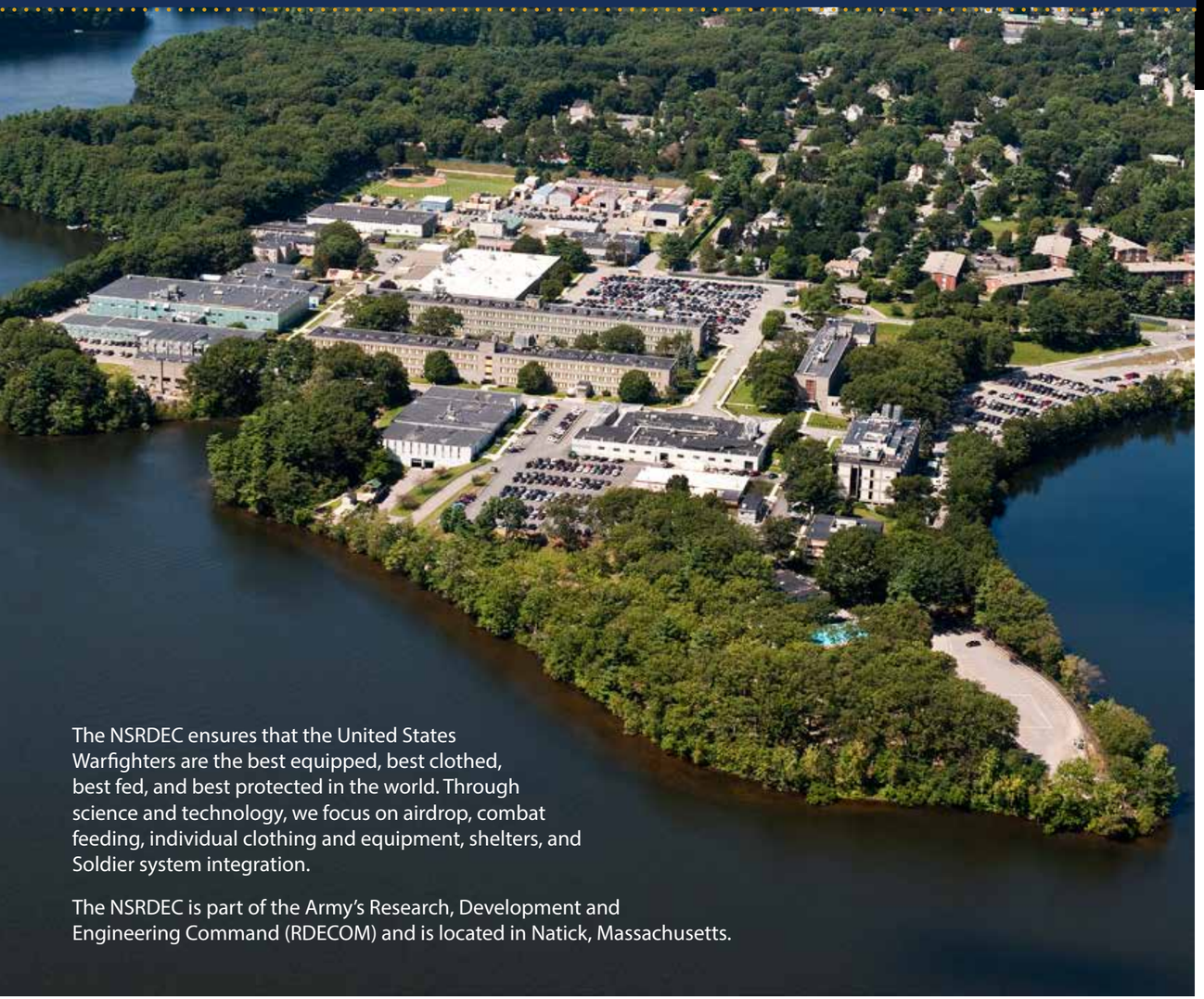
Fall 2015

# Soldier Science & Engineering

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

## Partnerships Drive Innovation

# 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.



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

## Partnerships Prepare Soldiers to Win

Since I arrived in August at NSRDEC, it has been exciting to immediately be working on initiatives that collectively link efforts to optimizing Soldier performance.

In June, MG Wharton directed NSRDEC to take the lead in developing an Army S&T Strategy for Soldier & Squad Performance Optimization (S2PO). S2PO will link efforts across the Army that relate to three major S&T thrust areas: Physical, Cognitive and Social Dominance, Soldier-Systems Integration/Human Systems Integration, and Enabling Technologies (materiel and/or non-materiel solutions) that contribute to Soldier & Squad Performance Optimization. Near-, mid- and far-term strategic goals that align with each of the above will be an essential part of strategy.

To further complement NSRDEC's unique facilities that support the science behind the Soldier, we have proposed a Soldier Squad Performance Research Institute (S2PRINT). The concept is for an innovative laboratory environment to systematically evaluate the impact on, and/or trade space between, equipment and Soldier performance using mission-driven tasks with operationally relevant metrics.

NSRDEC has been given the lead to develop a strategy to align and synchronize Army efforts in Human Performance Optimization. The Soldier Performance Center (SPC) will be a method to more closely synchronize the HD with the other functions of the Army. It will establish a network and focal point for the receipt and sharing of data between DoD and non-DoD agencies, ultimately including academia and industry. The goal is to facilitate and expedite cognitive, physical and social enhancements to improve Soldier performance and close HD capability gaps, tying the great current and future work written about in this issue to larger Army goals.

Mr. Doug Tamilio
Technical Director (A)
Natick Soldier Research, Development and Engineering Center

### Feature Stories

**Planting the Seed:** *Combat Feeding tests hydroponic farming* ..... *Page 10*

**Down Under:** *NSRDEC, USARIEM advisers travel to exercise in Australia* ..... *Page 18*

**Gift for Doriot:** *Massachusetts gives $900k for chambers upgrade* ..... *Page 22*

**Power Up:** *Making base camps more energy efficient* ..... *Page 24*

### NSRDEC News

**Driving Innovation:** ..... *Page 4*

**Multi-material, multifunctional fibers from MIT's Fink Lab offer revolutionary possibilities** ..... *Page 6*

**Natick researcher collaborates with North Carolina State on textile technologies** ..... *Page 8*

**Science in small drops** ..... *Page 9*

**Natick developing new 'Battlefield Kitchen'** ..... *Page 12*

**Natick researchers are developing overhead protection for base camps** ..... *Page 13*

**Dry Run** ..... *Page 14*

**Food for Thought** ..... *Page 15*

**Training for Your Brain** ..... *Page 16*

**Nobody's Foil** ..... *Page 17*

**One step at a time** ..... *Page 26*

### Questions regarding NSRDEC Science & Technology?

RDECOM

The U.S. Army Natick Soldier Reserch, Development and Engineering Center is part of the U.S. Army Research, Development and Engineering Command, which has the mission to ensure decisive overmatch for unified land operations to empower the Army, the joint warfighter and our nation. RDECOM is a major subordinate command of the U.S. Army Material Command.

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# Driving Innovation

## Army science, technology lead the way

**By Maj. Gen. John F. Wharton, U.S. Army / ABERDEEN PROVING GROUND, Md. (July 27, 2015)**

Scientists and engineers from across government, industry and academia are searching for technology solutions to bring empower American warfighters. Innovation is the fuel for the Army of the future.

Army leaders have described how future Soldiers will "prevent conflict, shape security environments, and win wars while operating as part of our Joint Force and working with multiple partners" in the recently released Army Operating Concept, or AOC.

The AOC is our foundation, and it's driving our science and technology strategy.

"The AOC is a beginning point for the innovation we need to ensure that our Soldiers, leaders and teams are prepared to win in a complex world," Army Chief of Staff Gen. Raymond T. Odierno wrote when he introduced the concept.

Innovation is critical for both the operational and institutional Army, he said.

The AOC points out that innovation is the result of "critical and creative thinking and the conversion of new ideas into valued outcomes."

As the Army's principle innovators we have worked hard to balance the goals of this mandate by developing strategic partnerships that trigger innovation and aligning the command to be able to capture the spark of new ideas and convert it into the organizational energy that drives the attainment of valued outcomes.

We continually reach out to our industry partners as we seek to maintain the Army's decisive overmatch because we recognize the Department of Defense is not the sole source of key breakthrough technologies. Many groundbreaking technological innovations in robotics, advanced computing, miniaturization and 3-D printing come from the commercial sector. Collaboration with these innovators will breed new ideas and ensure our technological edge through the next several decades.

> **"The Army needs innovative methods to develop technologies that will optimize the capabilities of smaller units by increasing battlefield intuition, military judgment and decision making."**
>
> Maj. Gen. John F. Wharton

Our goal is to capture the benefit of those partnerships and fuse it with our own innovations. To tackle the Army's most important objectives, we have aligned ourselves across the U.S. Army Training and Doctrine Command's Centers of Excellence. The U.S. Army Research, Development and Engineering Command technical staff now works in the same seven portfolio areas defined by the Assistant Secretary of the Army (Acquisition, Logistics and Technology). All this is done under the Army Operating Concept philosophy to ensure our efforts address the Army's warfighting challenges.

Accomplishing this means investing in our most innovative capabilities, such as our prototype integration facilities. Innovative research and development leads to advanced prototyping, which enables smart design, which leads to lowering sustainment costs. Increased funding in coming years will enable our engineering teams to turn ideas into prototypes and then innovate capabilities informed by that prototyping. It also opens up the opportunity to re-engineer existing technologies to use them in different ways or different contexts to deliver new capabilities to Soldiers.

We recognize there are no "silver bullet" technological solutions. It's not about the technology or device but about enabling the Soldier. Our efforts incorporate innovative solutions to fill technology gaps and make our Soldiers safer, stronger and more situationally aware of their environments.

Innovation will ensure the United States maintains its technological edge. It counters challenges to our competitive advantages and focuses our investments while creating options for future leaders. The Army needs innovative methods to develop technologies that will optimize the capabilities of smaller units by increasing battlefield intuition, military judgment and decision making.

Across RDECOM, I applaud the research and development innovations that lead to technological advancements. Whether it is new sensors, better batteries, or stronger materials for armor protection, the goal is the same. We innovate because it's all about supporting our Soldiers with the best possible technologies to help them accomplish their missions.

Photo: Conrad Johnson

*Maj. Gen. John F. Wharton commands the U.S. Army Research, Development and Engineering Command at Aberdeen Proving Ground, Maryland.*

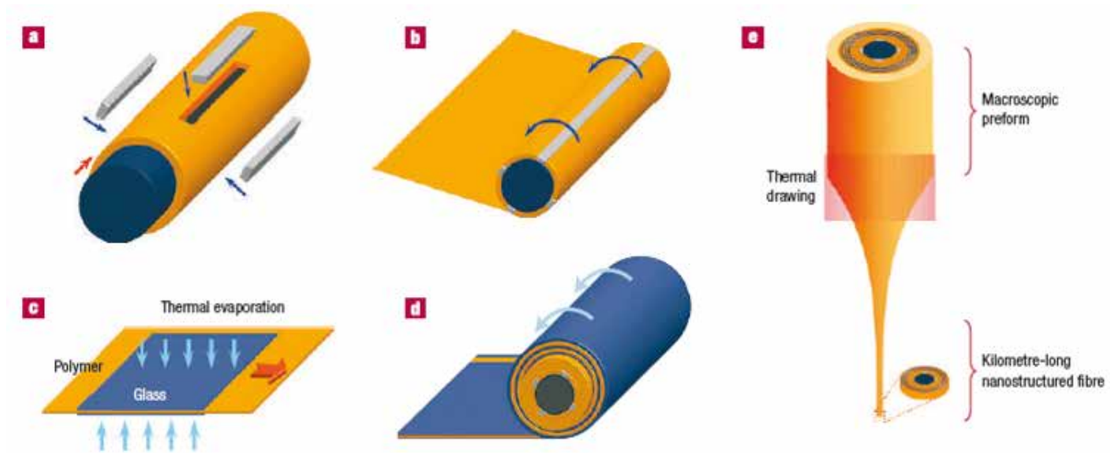
# Multi-material, multifunctional fibers from MIT's Fink Lab offer revolutionary possibilities

**By Dr. Ramanathan Nagarajan**

Monitoring global advances in basic and applied research is a critical step to ensure the insertion of innovative science and technology into warfighter equipment. This new column in Soldier Science & Engineering is designed to report on such advances that may be potential game changers in the future. I have identified one example that holds revolutionary potential and applicability not only to the Army but to all services, without travelling too far from Natick. This is the work coming out of Yoel Fink's laboratory at the MIT Institute for Soldier Nanotechnologies that is in its 13th year of Army support through the Army Research Office. This specific research has also been supported by the Navy, Air Force, the Defense Advanced Research Projects Agency, or DARPA, and other federal agencies.

The research at the Fink Lab bypasses the traditional research attempts of producing fibers with one or two types of polymers and then functionalizing the fiber with additional materials to impart new and needed properties; instead it creates novel fibers with all functionalities integral to the fiber. What is most remarkable is the multi-material nature of these fibers and especially their ability to incorporate disparate materials like semiconductors, conductors and insulators all into one system. The fiber now has more complex interfaces involving the organic polymer, metallic conductor and inorganic semiconductor compared to the relatively simpler interface between two polymers. The incorporation of semiconductors into the fibers makes possible the construction of fiber-based devices that could bring a Silicon Valley revolution to the field of textile fibers.

Conceptually, the technology developed at the Fink lab is simple. You first create a macroscopic preform that would resemble the eventual microscopic fiber. You can then use thermal drawing at very high temperatures to produce the fibers. A schematic of the preform-based fabrication of integrated fiber devices is shown in the figure. In this specific example, a chalcogenide semiconducting glass rod is assembled with an insulating polymer shell and four metal electrodes (a). Then a polymer sheet is rolled around the structure to form a protective cladding (b). The high-index chalcogenide glass is evaporated on both sides of a low-index thin polymer film (c) and the entire system is rolled around the cylinder prepared in the first step (d). Finally, a polymer layer is wrapped around the coated film for protection (e). The preform is consolidated in a vacuum oven and is thermally drawn to mesoscopic-scale fibers. The cross-section of the resulting fibers retains the same structure and relative sizes of the components at the preform level.




*This figure shows a schematic of the preform-based fabrication of integrated fiber devices.*

The choice of the material systems determines what functionality is associated with the fiber. Many material combinations have been demonstrated in the Fink Lab over the last decade. Of great interest is the demonstration that you can synthesize semiconductor materials in the draw process itself, resulting in fibers that have a completely different composition than the preform. This possibility was initially demonstrated for low-temperature materials, showing the formation of small domains of zinc selenide, and has later been extended to high-temperature semiconductors based on silicon and germanium and much larger domains. The ability to integrate such high-temperature semiconductor materials for fiber devices is of particular interest because their electronic and optoelectronic properties surpass those of the low-temperature materials. Another important discovery, based on controlling the flow behavior of the melt and fluid instabilities, is that the core fiber can be broken up into discrete droplets while the other materials can be drawn as continuous fibers. This offers the possibility of the integration of tens of thousands of devices in a single fiber to fabricate an integrated optoelectronic device that is composed of both semiconductor and metal in a silica-clad fiber.

By controlling the choice of materials, interfaces, geometries and length scales, a single fiber can be designed to have tens of thousands of devices. Each single fiber can have a distinct functionality. Fibers of multiple functionalities can be combined as 2D or 3D arrays or fiber bundles to generate intrinsically multifunctional materials in an integrated fashion.

Photonic bandgap transmission fibers, optical cavity reflecting fibers, surface emitting fiber lasers, thermal detector fibers, optical detector fibers, acoustic detector fibers and emitter fibers are examples of functionalities derived from this technology innovation. One can visualize products such as fabric displays, health-monitoring systems, logic and computation devices, electrical power generation and storage, all to be derived from this innovation.

To take advantage of this innovation for warfighter equipment, it is necessary to reach stages of product development and deployment. What we need are manufacturing methods and initiatives to translate this innovative applied science outcome, which has been extensively demonstrated, into commercial fibers that can be used to construct deployable products for warfighter use. It is a challenge before the industry now to create these fibers in a manufacturing context.

*Note: This issue of Soldier Science & Engineering introduces a new, regular column by Dr. Ramanathan Nagarajan, Senior Research Scientist Soldier Nanomaterials at NSRDEC.*

Photo: U.S. Army

# Natick researcher collaborates with North Carolina State on textile technologies

**By Jane Benson, NSRDEC Public Affairs / NATICK, Mass. (Oct. 15, 2015)**

Army researchers are partnering with universities to improve Soldier capabilities and protection.

At the U.S. Army Natick Soldier Research, Development and Engineering Center, or NSRDEC, senior research biologist Kris Senecal collaborates with North Carolina State University, which has resulted in the development of nonwoven, multifunctional materials. Senecal partnered with NC State's Nonwovens Institute, or NWI.

In a separate effort, she is developing novel textile coatings using atomic layer deposition, or ALD, with Dr. Gregory Parsons, director of the NC State Nanotechnology Initiative.

"NC State University is one of the largest textile colleges in the United States," Senecal said. "The fact that Natick has a significant textile focus makes it very important that we continue to interact with NC State."

NWI is a consortium that encourages cooperation among government, private industry and academia. Senecal will be the chair of the consortium's Industrial Advisory Board's Executive Committee in 2016.

"Companies, such as Nike and Kimberly Clark, are involved," she said. "It's really a special consortium that is getting national attention."

Rather than being knitted or woven, nonwoven fabrics are made by connecting fibers with adhesives or by entangling fibers mechanically, chemically or thermally.

"Nonwoven materials include felt, cleaning wipes, filters for cars and air conditioners, or brake pads for your car," Senecal said. "As more demands come up for the warfighter, nonwoven materials could help solve certain needs. The institute is investigating nonwoven topics that we have a lot of interest in, including conductive textiles and antimicrobial textiles."

Through the institute, NC State graduate students are involved in research work on projects selected by the companies involved.

"The students love the chance to do Soldier research," Senecal said. "The students are very well trained, and the work gives them real-world experience. We give them input and provide feedback, and we interact with the main professors, as well. In return, it gives us fresh perspective, and we can leverage the research that is accomplished through the NWI."

As part of her own research, Senecal will be working with nonwoven materials supplied from member companies associated with the Nonwovens Institute on textile capacitors. The goal is to provide lightweight materials for wearable energy storage.

"Soldiers will have extra power capabilities built into the uniform, with no added weight penalty," Senecal said.

Senecal's collaboration with Parsons on ALD textile coatings will increase capabilities on existing fabric systems. In addition to being the director of the NC State Nano-technology Initiative, Parsons is an Alcoa professor in the department of Chemical and Biological Engineering.

"This research area applies a deposited conformal coating that is in the nanometer range," Senecal said. "You can tailor fabric properties specifically for differing environments by applying metal oxides and/or organic coatings using this coating technology, yet not increase fabric weight."

Research indicates that coatings could be used to improve Kevlar protection, she said.

"I was looking at putting the coatings on Kevlar, to improve cut- and puncture-resistance, and at the same time not degrade ballistic protection capabilities," Senecal said. "Initial results using ALD coating showed improvement on both cut- and puncture-resistance on Kevlar."

Coating technologies allow for the creation of multifunctional capabilities for the Soldier.

"The multifunctional capabilities include flame resistance, antimicrobial protection, and additional cut protection, as well as other capabilities," Senecal said. "You can tailor the coating technologies depending on what you need. The coating technologies can be added directly to an already existing uniform fabric."

"Working with Kris Senecal has been tremendous," Parsons said. "She is a highly energetic and highly creative researcher dedicated to new technology to promote Soldier safety and well-being. By sharing her passion with our group at NC State, she inspired us to find new solutions to protect Soldiers in the field from physical harm. She has helped teach students in my group the importance of DOD basic and applied research, and her insights push my students to address problems and create solutions well beyond the obvious next steps."

"It is great when something theoretical becomes everyday use," Senecal said. "I love to do the research, but I actually love to see that it has an impact. If it can make the Soldier safer, more comfortable, without adding any weight, that's rewarding."

"Kris is an excellent research partner who is willing to take on and solve the most challenging problems," Parsons said. "Her skills in personal engagement and enthusiasm for her work make her a tremendous asset for our research group and for the Army in general."



For Molly Clay, great science comes in small drops.

Clay works on the Integrated Protective Fabrics System project and is a research chemical engineer on the Chemical Technology Team at the Natick Soldier Research, Development and Engineering Center, or NSRDEC. Researchers on the team measure chemical agents entering barrier materials, such as clothing, by using different experimental techniques. Clay is working on a new approach that involves tracking a minuscule drop of liquid placed on the surface. The method is convenient and well-suited for working with toxic materials in the laboratory.

"We have all these new protective barrier materials that can be applied to uniforms, boots, gloves, face masks — anything you use to protect yourself," said Clay. "We needed a way to characterize these materials. We wanted a way to measure how liquid chemical agents go through the materials to see if these materials have the qualities we want."

"NSRDEC researchers look to innovate in many ways," said NSRDEC's Dr. Ramanathan Nagarajan, Senior Research Scientist Soldier Nanomaterials. "Molly's work is an example where the experimental technique has been known in the literature and is not new. However, the technique is not used as a routine test method because the data analysis requires time-consuming and costly numerical computations.

"Molly's innovation is in the creation of a simple analytical model, which totally eliminates the computational complexity and is also very accurate. This innovation in modeling will allow us to use this drop-image technique as a standard test method to evaluate how well any barrier material prevents the entry of a liquid chemical agent."

Sometimes in the past, immersion methods were used and relied upon large quantities of liquid. Clay explained that measuring changes in large quantities can prove difficult at times, and she has instead has opted to work with very small quantities, using only one to two microliters.

"We first look at the droplet on an impermeable surface, like stainless steel or aluminum, because you know liquid is not going to diffuse into the surface," said Clay. "Any changes in volume are due to evaporation going into the air — so we first account for any

# Science in small drops: researcher measures barrier effectiveness

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

evaporation. I then monitor a droplet on a permeable substrate. I can take any evaporation into account and only look at what is going into the substrate. This is going to give me a diffusion coefficient and show how fast something is going to diffuse into the barrier material. And from that you can determine the level of protection."

Using only a drop is a safer, more cost-effective and more efficient way to test the level of protection than using larger quantities of liquid. To measure contact angles, Clay uses a goniometer, which is an automated instrument that monitors continuously the drop shape on the surface.

"We're taking that one to two microliter droplet, and we are placing it on the surface," Clay said. "I'm monitoring it over time and measuring the contact angle of the liquid with the surface. And through the geometry of the shape of the droplet, you are able to determine the volume. So, now we have volume versus time on a specific surface. From there I developed a model that will determine the diffusion coefficient."

That information is then used to improve products for the warfighter.

"We can use the information to determine the most effective existing materials or to aid in the development of novel materials," said Clay.

A little drop of science can have a huge effect.

"My work is at the basic research level, including developing new tests that will help enable us to make better decisions regarding products for the Soldier," said Clay. "To have that kind of impact, to be doing something that is going to benefit the Soldier down the road, is the best part of the job."

# Planting the Seed

## Combat Feeding tests hydroponic farming

**By Bob Reinert, USAG Natick Public Affairs / NATICK, Mass. (Oct. 15, 2015)**

Don Holman was raised on a farm in Michigan and served 30 years in the Navy, which makes him a perfect fit to help test whether American warships could one day grow their own fresh vegetables.

Inside a re-purposed former refrigerated shipping container tucked behind the Combat Feeding Directorate at Natick Soldier Research, Development and Engineering Center, Holman has been growing lettuce since August in a climate-controlled, 40-by-8-foot "hydroponic farm." What will be a year-long effort has been undertaken for the Navy, which aims to explore the capability of growing produce at sea utilizing hydroponics technology.

"I want to see what can grow and what can't grow," said Holman, an engineering technician with the Joint Foodservice and Engineering Team at CFD and a retired command master chief. "We want to experiment with all varieties of vegetables and see how much produce we can produce.

"The end goal is to provide the Navy a technical report detailing the test results of the equipment, its possibilities and limitations."

Currently, ships on long deployments receive fresh fruit and vegetables by helicopter or by tensioned cable between ships with pulley system.

"Much of it comes from locally procured overseas sources," Holman said.

The hydroponic farm is growing produce from seeds without using soil. Seeds germinate and grow first in peat moss plugs placed in trays and then are transferred into vertical "towers." Through each step, the seedlings and, later, plants are moistened with nutrient-enriched water that is pH balanced.

> "I want to see what can grow and what can't grow. We want to experiment with all varieties of vegetables and see how much produce we can produce."
>
> Don Holman, Combat Feeding Directorate

"You can grow more plants in a vertical arrangement, rather than a horizontal configuration," Holman said. "It takes up very little floor space when it's hung vertically. There is more growth in less area."

The space is illuminated with light-emitting diode lights, and the 24-hour operation simulates daytime and nighttime conditions and accelerates plant growth. The container has Wi-Fi and Bluetooth capability and is equipped with an infrared camera.

"All functions are instrumented and automatically controlled, which simplifies data collection," Holman said. "The Wi-Fi allows one to monitor the farm from an iPhone at home, to ensure the farm's operating correctly."

The current hydroponic farm runs efficiently, consuming approximately 6.8 kilowatt-hours of electricity during daytime operations and 1.2 kWh at night.

"The power requirements are minimal," Holman said. "We're still collecting power consumption data, as well."

Only 10 of the 280 gallons of water circulating through the farm's vertical towers are consumed daily.

"You can't do that on a dirt farm," Holman said. "It's going to take a lot more water than that. The manufacturers estimate a 90-percent reduction in water consumption."

As Holman pointed out, there are other advantages over outdoor farming.

"There are no insects," Holman said. "We do not have the diseases normally associated with a dirt farm. The atmosphere is controlled for temperature and humidity as well as the nutrients and pH levels of the water — an obvious advantage over a dirt farm."

The first lettuce crop was harvested Oct. 14. After it's thoroughly tested by a Combat Feeding microbiologist, the produce may be used in the Natick Soldier Systems Center dining facility.

"We continued for several weeks planting lettuce to learn the farm and to make necessary modifications," Holman said.

Broccoli, Brussels sprouts and bush beans – currently growing in trays – will move to the towers next.

"Now that we've learned how to operate the farm, we're going into full test mode, to determine the farm's production output," Holman said.

According to the manufacturer, the farm will produce the equivalent of an acre of land.

"It remains to be seen," Holman said. "That's why we're testing."

Does an old salt such as Holman believe that hydroponic farming technology will translate well to today's warships?

"Space is always a premium aboard ship," said Holman, "but once that issue is resolved, I don't think the challenges are going to be that great."

Holman went even further than that.

"If the farm tests well, its potential wouldn't be limited to just the Navy," Holman said. "The Army and Marine Corps would benefit greatly from reduced produce costs, shipping costs, and the logistics of moving produce on the battlefield. I think the applications for all the services are great."

## By the Numbers

### Hydroponic Farm

**90%** *Percentage reduction over water consumption used on an acre of land*

**24** *Hours a day that it operates*

**10** *Days it took to get the farm up and running*

**12** *Heads of lettuce in each grow tower for first harvest*

*Photo: Michael Stepien, NSRDEC Combat Feeding Directorate*

# Natick developing new 'Battlefield Kitchen'

**By USAG Natick Public Affairs / NATICK, Mass. (Sept. 30, 2015)**

*The BK features closed-combustion, thermostatically controlled appliances that will make roasting, grilling, boiling, frying and baking food a cooler, cleaner and quieter process.*

Mention "BK" to some people, and a certain fast-food establishment might come to mind. At the Natick Soldier Systems Center, however, those two letters refer to the latest in field feeding technology.

The Battlefield Kitchen, or BK, being developed in a cooperative effort between the Natick Soldier Research, Development and Engineering Center, or NSRDEC, and Product Manager Force Sustainment Systems, or PM FSS, is a self-contained, efficient mobile kitchen that can provide up to three hot meals daily to as many as 300 Soldiers during military operations. The BK can serve a full range of individual and group rations.

"It's like walking into a restaurant. It's like walking into a real kitchen as opposed to a piece of military equipment," said Joe Jordan, team leader, Food Service Equipment Team, PM FSS/Combat Feeding Directorate, NSRDEC, who added that the BK would provide "a better ability to provide good meals to the Soldiers."

A trailer-mounted system, the BK can be towed by a truck and can be transported by sea, rail or air. It will replace the Mobile Kitchen Trailer, or MKT, which was introduced in the 1970s and uses inefficient open-flame combustion appliances that also vent burner exhaust into the kitchen. The BK features closed-combustion, thermostatically-controlled appliances that will make roasting, grilling, boiling, frying and baking food a cooler, cleaner and quieter process.

"In hot ambient conditions, it gets very, very hot inside of the current kitchens," said Tim Benson, program integrator, field services and field feeding, PM FSS. "[The BK is] going to be a healthier environment for the cooks and the customers, not having the burner exhaust going into the kitchen."

The process also becomes significantly more energy efficient, according to Benson.

"We're looking for at least a 20-percent improvement in fuel efficiency over the current set of appliances, with an objective of 40 percent," Benson said. "But the main benefit of the appliances is that they're closed combustion. The current appliances are open combustion, which means that all the heat and the exhaust and the noise from burners goes into the kitchen environment, and less [heat goes] into the food."

"Using heat from combustion to directly heat the appliances is so much more efficient than using electrically powered appliances," Jordan said. "A kitchen this size can use a 3kW generator as opposed to a 30kW or 60kW generator required by electric appliances. That allows the kitchens to be truly expeditionary, carrying the generator right onboard the kitchen while still providing a quiet and quality product."

The BK appliances aren't only more efficient, they produce better results.

"The appliances are designed with heat exchangers that better distribute the heat so that you get more uniform, better quality cooking, on average," Benson said. "You're capturing all that heat that used to escape into the environment, [and] putting it [where] it needs to go."

The Army expects to acquire about 1,500 of the systems, which also include running water, refrigeration and on-board power generation. Development should take place in fiscal years 2016-18, and production is planned to begin in FY 2019.

# Natick researchers are developing overhead protection for base camps

**By Jane Benson, NSRDEC Public Affairs / NATICK, Mass. (Sept. 16, 2015)**

Natick's ideas for protecting the warfighter are looking up.

Researchers at the Natick Soldier Research, Development and Engineering Center, or NSRDEC, are developing Overhead Threat Protection, or OTP, to be used primarily in expeditionary base camps.

The OTP protects both shelters and equipment, providing warfighters with overhead ballistic protection that is easy to deploy and set up. Four people can set up the system in fewer than two hours.

"Having the addition of overhead protection really gives Soldiers peace of mind from day one," said Karen Horak, lead program engineer, Collective Protection Systems Team, Expeditionary Basing and Collective Protection Directorate at NSRDEC. "With this system, the Soldiers have protection from multiple threats affecting base camps. This really allows them to be mission focused."

The OTP system provides protection against prevalent base camp threats and leverages technology developed by NSRDEC and the University of Maine for the Modular Ballistic Protection System, or MBPS. The MBPS provides sidewall protection against similar basecamp threats.

Like the MBPS, the OTP system is highly mobile, re-deployable, reusable and quickly erectable.

"It can be set up over an existing shelter so the shelter doesn't need to be taken down," said Horak. "It can be used in conjunction with the MBPS."

The OTP uses a two-layer system, which increases its protection capability and greatly lessens the impact of a hit.

"The Overhead Protection System has to be super strong because it protects against direct hits," said Horak.

"The round will hit the pre-detonate layer (top layer)," said Lisa King-Schiappa, a mechanical engineer on the Collective Protection Systems Team. "Then it will detonate and the second layer will catch the fragments."

"The idea is to keep the explosion above and away from Soldiers," said Horak.

NSRDEC is overseeing the research and development of the system and has partnered with universities and private industry.

"This is a collaborative program," said Laura Biszko of NSRDEC's Collective Protection Systems Team. "We are working with TPI (Technical Products Inc.). TPI is making the frame and Compotech, a spin-off from the University of Maine's Advanced Structures and Composite Center, is providing the panels for this system."

NSRDEC has also partnered with the University of Rhode Island, which operates a satellite campus with a blast range, to test the system.

"We test and re-test," Horak said. "We want Soldiers to be confident in the protection."

"Our work is extremely gratifying — helping warfighters by providing expeditionary day-one protection, giving them peace of mind and allowing them to focus on their mission," said King-Schiappa.

# Dry Run

## New technology could aid ration development

**By Jane Benson, NSRDEC Public Affairs / NATICK, Mass. (Aug. 5, 2015)**

Natick Soldier Research, Development and Engineering Center scientists are looking to vacuum microwave drying, or VMD, technology to create new, quality items for rations that may also reduce the warfighter's carrying load.

NSRDEC researchers hope to acquire the pilot scale equipment to develop items that meet the stringent requirements of military rations that must be shelf stable for years in extreme climates with no access to refrigeration.

The rapid drying technology would enable the creation of lightweight, nutritious, inexpensive shelf-stable foods, including cheese, fruits, vegetables and meats. Such items could be incorporated into the following rations: Meal, Cold Weather; Food Packet, Long-Range Patrol; and Meal, Ready-to-Eat.

"Some of the conventional drying methods are not efficient," said Dr. Tom Yang, a food technologist in NSRDEC's Combat Feeding Directorate, or CFD. "For example, sun drying takes a long time and is dependent upon Mother Nature. And it is not very sanitary. Another method is mechanical drying, which involves using a hot oven with hot air to remove moisture. But drying foods at a high temperature can affect quality, taste and texture. It is edible, but it can be hard like a rock. Drying foods can also take away nutrients. The food can shrink and the color can become dark. Not very appetizing."

VMD combines vacuum and microwave technology, heating foods uniformly through a quick, gentle process.

"Since you combine vacuum technology with microwaving to remove water, you can do so at a lower temperature," said Yang, who is part of CFD's Food Engineering and Analysis Team. "You maintain nutrients since the rapid drying process doesn't destroy heat-sensitive nutrients. The colors remain appetizing and the texture doesn't become hard and brittle."

In addition to producing higher-quality foods, the process takes less time than conventional air drying or freeze drying. Yang explained that freeze drying, which was pioneered at Natick years ago, is effective and retains good food quality but has some drawbacks.

"VMD takes freeze drying to the next level," said Yang. "It is much less expensive and uses much less energy."

Foods created by VMD are nutritious and pleasing to the palate. The technology also fits into NSRDEC's mission to lighten the warfighter's carrying load.

"It is low weight. It is very easy to eat on the move," said Yang. "You don't need to store it anywhere."

The Food Engineering and Analysis Team, led by Lauren Oleksyk, hopes to obtain its own VMD machine for its Food Innovation Lab, where it will be used to create new foods for the warfighter and improve existing offerings.

"Our Soldiers deserve the best," said Yang. "Soldiers do so many important missions. They are under a lot of stress. They need to be well fed. Their physical and mental state needs to be in top shape. We are hoping to get a [vacuum/microwave] unit so that we can use it as a tool to try out many ingredients and recipes that we know Soldiers would like to have."

Yang said he thinks it is important to create some favorite foods for Soldiers far away from home.

"I have an idea for a shelf-stable cheeseburger with a layer of dried cheese, a layer of dried meat, and a layer of dried bread," Yang said. "A regular cheeseburger would be highly perishable, but this one would be shelf stable for three years. This is one of the concepts I want to explore.

"I like to explore new technology and new products. I like to see technologies that work, save money, and produce great rations that get into the hands of Soldiers."

Photo: Michael Stepien, DOD Combat Feeding Directorate

*Updates to the Combat Rations Database will make the website even more useful to warfighters seeking nutritional information about what they eat in the field.*

# Food for Thought

## Combat Rations Database receives update

**By Bob Reinert, USAG Natick Public Affairs / NATICK, Mass. (Aug. 10, 2015)**

The Combat Rations Database unveiled earlier this year is already receiving updates designed to make the website more useful to warfighters, military dietitians, food service officers and leaders.

The database — ComRaD, for short — debuted in March with accurate nutritional information about combat rations. It was the result of a collaborative effort between Department of Defense's Human Performance Resource Center, the Natick Soldier Research, Development and Engineering Center, or NSRDEC, and the U.S. Army Research Institute of Environmental Medicine at Natick Soldier Systems Center.

The database contains information about the Meal, Ready-to-Eat; First Strike Ration; Meal, Cold Weather; and Food Packet, Long Range Patrol.

Later this month, a cart feature will be added to the site that will allow users to track what they have eaten by adding and removing ration components in order to view their overall daily nutritional intake. In September, information on group rations will follow.

ComRaD provides public access to accurate information at a time of increasing emphasis on performance nutrition in the military. Military dietitians want warfighters to better understand how to fuel themselves before, during and after missions.

"It will be interesting to see how the individual warfighter actually uses it," said Julie Smith, senior food technologist with the Department of Defense Combat Feeding Directorate at NSRDEC. "We haven't received that feedback yet."

Early analytics from the website (http://hprc-online.org/comrad/) showed that it was receiving heavy use, however. From Jan. 1 to April 30, ComRaD had 10,051 page views. Visitors had spent an average of 2 minutes, 28 seconds on the site.

"For now, I think we've delivered what the customer wants," said Smith, "and I'm excited to be a part of the website development and launch."

Smith pointed out that adding group rations to the database was a bit more complicated than it was with the individual rations.

"Because we do have to change some of the features," Smith said. "The way that the (group ration) menus are planned are for added variety. In group rations, there's a lot of split menus that enable an individual to choose one entrée or choose the other entrée.

"It's actually more difficult for warfighters to learn about group rations, because the nutrition facts label is not in front of them when they eat it. They don't have easy access to nutrition information."

As ration menus change in the future, items will be added or dropped from ComRaD.

"I think as people use it, I'll be excited to get feedback," Smith said. "I think that will really drive if additional work needs to be done.

"But we know as time goes on, there might be new features that people would want."

For more information about ComRaD, email usarmy.natick.nsrdec.mbx.nati-amsrd-nsc-ad-b@mail.mil.

Photo: Dr. Caroline Davis, NSRDEC Cognitive Science Team

# Training for Your Brain

## Natick scientists investigate ways to help Soldiers recover from stress

**By Jane Benson, NSRDEC Public Affairs / NATICK, Mass. (Sept. 2, 2015)**

Soldiers can't avoid stress, but researchers at the Natick Soldier Research, Development and Engineering Center, or NSRDEC, are leading a study to investigate ways to help Soldiers increase their cognitive resilience under stress.

NSRDEC is working in collaboration with the Human Research and Engineering Directorate, or HRED, at the U.S. Army Research Laboratory, or ARL, located at Aberdeen Proving Ground.

"A Soldier who is out in the field in a battle-type context is under very high demands – mentally, emotionally and physically," said Dr. Marianna Eddy, a research psychologist on NSRDEC's Cognitive Science Team. "They can be emotionally and physically fatigued. Cognitive resilience is the ability to perform well under those stressors. Performing well can mean a variety of things, such as making a good decision. For instance, deciding whether to call for reinforcements or making a split-second shoot or not-to-shoot decision."

"We are interested in characterizing individual differences in the way that cognitive processes can break down under stress," said Dr. Caroline Davis, who has a background in emotion, stress and anxiety research and is a research psychologist on NSRDEC's Cognitive Science Team. "During an acute stressor, some people are able to maintain peak performance much better than others. Our goal is to identify metrics that predict such individual differences, and to use this information to develop training strategies that will allow all Soldiers to maintain optimal cognitive performance both during and immediately following extreme stress."

NSRDEC and Tufts University, which jointly created the Center for Applied Brain and Cognitive Sciences, are also conducting a parallel effort examining cognitive resilience in the civilian population.

"The work at the center can be used as a foundation for the work we are doing in collaboration with ARL-HRED," said Eddy.

"The studies we are conducting at the Center for Applied Brain and Cognitive Sciences are being conducted in a lab where we have tight experimental control," said Davis. "Our collaboration with the Cognitive Assessment and Simulation Engineering Laboratory at ARL-HRED allows us to move these laboratory-based studies into a somewhat more realistic, Soldier-relevant environment."

Stress affects a Soldier's memory and decision-making as well as the ability to act and react.

"We want to know what it is that allows some people to overcome these challenges and perform well," said Eddy. "People can tell us about their coping mechanisms, but we are also interested in what is going on in their brains. To do this, we are running an electroencephalography (EEG) study in collaboration with the Translational Neuroscience Branch at ARL-HRED. We outfit the Soldiers with an EEG cap and some other sensors that measure physiological responses to emotional stimuli, such as changes in breathing patterns, sweat responses and facial muscle activity."

"We are also looking at the way that personality traits, such as impulsivity or emotion-regulation style, interact with an individual's biological stress response to promote resilience," said Davis.

Finding ways for Soldiers to become more cognitively resilient may help increase Soldier performance and possibly improve decision-making, effectiveness and survivability.

"We have a unique ability to impact the Soldier," said Davis. "I am excited to be entering this rapidly growing field that has recently started to attract a lot of attention, and I think that we have real potential to improve life for the Soldier."

"It's rewarding to interact with Soldiers and see that they are excited about what we are doing," said Eddy.



# Nobody's Foil

## Natick investigates materials for food packaging

**By Jane Benson, NSRDEC Public Affairs / NATICK, Mass. (July 28, 2015)**

Scientists at the U.S. Army Natick Soldier Research, Development and Engineering Center, or NSRDEC, are investigating high-barrier, non-foil materials, which have the potential to be lighter in weight, less expensive, and more environmentally friendly than foil-based packaging.

The non-foil materials – which are based on nanotechnology – could be used for military ration packaging and for food packaging that supports deep space missions for NASA. The Advanced Materials Engineering Team, or AMET, part of NSRDEC's Combat Feeding Directorate, or CFD, is working on the nanocomposite materials, which are an ideal packaging choice for shelf-stable processed foods.

Nanocomposite films can improve the barrier, mechanical and thermal properties of non-foil food packaging films.

"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 materials engineer in NSRDEC's CFD.

Nanocomposite packaging can be lighter in weight and less expensive than foil pouches and can potentially reduce the amount of solid waste, enhance the quality of the rations and reduce the warfighter's logistical burden.

The technology is based on the incorporation of nano-clay particles into thermoplastic resins. These materials are 1,000 times smaller than conventional composite material fillers.

The high-barrier, non-foil material will decrease the permeation of oxygen and water molecules through packaging materials, thus better preserving food freshness and better ensuring safety. The packaging will comply with the meal, ready to eat, or MRE, requirement of maintaining a three-year shelf life. The packaging will maintain up to a five-year shelf life for space applications.

Food sterilization techniques, in combination with proper packaging, play an important role in providing this extended shelf-life protection. Retorting is the food industry's most common commercial sterilization process for pre-packaged, low-acid foods.

This process exposes food packages to high moisture and high temperature conditions. In some cases, the long retort process causes severe thermal impact to the food and the package, leading to a reduction in food quality and limiting the types of packaging materials that can be used.

Dr. Jo Ann Ratto, team leader, AMET, NSRDEC CFD, said that the implementation of a non-foil structure into food packaging will provide the ability to consider novel sterilization methods, such as microwave-assisted thermal sterilization, or MATS, and pressure-assisted thermal sterilization, or PATS.

MATS and PATS are desirable alternatives to retort sterilization as these methods reduce the time needed to raise the product temperature to that required for the thermal lethality of target bacteria. A shorter process time can improve food quality and nutrient retention, 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 & Technology Team. The two teams are also studying the effect of the various processing methods on vitamin stability, in an effort to not only preserve freshness and food safety, but also 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," Ratto said.

**Nanocomposite packaging can be lighter in weight and less expensive than foil pouches and can potentially reduce the amount of solid waste, enhance the quality of the rations and reduce the warfighter's logistical burden.**

Photo: Sgt. Simbha Rosario

# Down Under

## NSRDEC, USARIEM advisers travel to exercise in Australia

Photo: Sgt. Sinthia Rosario

# As nearly 30,000 U.S. and Australian Service members convened for Talisman Sabre 15, Army officials said the two-week exercise was a prime opportunity to address technological concerns.

U.S. Army science and technology advisors traveled across Australia July 7-20 to discuss issues with operational units during the joint, biennial exercise.

"Soldiers are happy to talk with you about their equipment," said Lt. Col. Tom Bentzel, director of the U.S. Army International Technology Center Australia. "We got good feedback about boots, packs, vehicles, logistics supply chain, and command and control issues with communications connectivity and interoperability.

"Hopefully we'll be able to turn those into ideas that become research projects or contribute to ongoing projects and bring more relevance to them."

The ITC in Australia is part of the U.S. Army Research, Development and Engineering Command. The ITC mission is to work cooperatively between countries on research and development projects that bridge gaps and achieve common goals.

Bentzel, along with Capt. Scott Pegan of U.S. Army Reserve Sustainment Command Detachment 8, were based at Camp Rocky, Queensland, during the exercise. They traveled to several exercise locations to meet with American and Australian operational units.

They submitted 35 requests for information to RDECOM headquarters on behalf of Soldiers. The RFIs are forwarded to the appropriate U.S. Army research and development center, and six requests were answered during the exercise. Four RDECOM centers received RFIs.

"Commanders in the field welcomed our presence," Bentzel said. "They recognize they won't see resolutions in six months, but it's achieving that RDECOM objective of being relevant to Soldiers in operational units and serving their needs.

"Sometimes it takes a bit of imagination to see beyond the daily common everyday problems that Soldiers have and see how science can influence those. Look beyond acquisition to look to the science. We were looking for ways that we could improve their comfort, effectiveness and efficiency in the field."

Mission command interoperability and communications connectivity was the greatest issue for Soldiers, Bentzel said. Some American systems did not interact well with Australian ones or were not able to be configured properly because of the complexity of the networks.

"RDECOM is supporting each of the Pacific Pathways exercises as part of its commitment to being warfighter focused," Bentzel said.

In addition to RDECOM's team on the ground in Australia, the command also provided technical expertise to U.S. Army paratroopers flying from Joint Base Elmendorf-Richardson, Alaska.

About 400 Soldiers parachuted onto Kapyong Drop Zone at Williamson Airfield in Australia. The 4th Infantry Brigade Combat Team (Airborne), 25th Infantry Division, jumped from seven C-17 Globemasters, two of which belonged to the Royal Australian Air Force. The 19-hour journey was their longest infiltration direct flight.

Andy Margules, RDECOM's Field Assistance in Science and Technology advisor assigned to U.S. Army Alaska, said three Army organizations worked together on the Soldier readiness issues of proper nutrition, heat-related injuries, dehydration and sleep cycles.

"With 4/25 being active and able to engage in its objectives immediately after landing, it gives confidence to the Australian forces that the U.S. is ready and prepared to execute such a mission in the future," Margules said.

Scientists from RDECOM's Natick Soldier Research, Development and Engineering Center gave advice on nutrition. They provided more than 800 First Strike rations and explained the nutritional benefits compared with commercial alternatives. In addition, they explained how Soldiers could change their eating habits before the exercise to prevent lethargy after landing in Australia.

The U.S. Army Research Institute of Environmental Medicine discussed how to prevent heat-related injuries upon landing based on thermal loading predictions and equipment requirements. USARIEM also provided information on the amount of water needed prevent dehydration during flight and once on the ground.

Finally, Walter Reed National Military Medical Center sleep specialists presented the optimal sleep plan for the flight. The plan detailed when Soldiers should be sleeping (with and without the use of sleep aids), the difference in sleep cycling for Soldiers landing to refuel in Hawaii versus those flying non-stop, and how Soldiers should change their sleep cycles to match Australian time.

Photo: 1st Lt. Timothy Golden

Photo: Sgt. Sinthia Rosario

Photo: Sgt. Sinthia Rosario

**Scientists from RDECOM's Natick Soldier Research, Development and Engineering Center gave advice on nutrition. The U.S. Army Research Institute of Environmental Medicine discussed how to prevent heat-related injuries upon landing based on thermal loading predictions and equipment requirements.**

"The gaps addressed by RDECOM were not technological in nature but show that the research and engineering at RDECOM can address non-technological or 'soft gaps' when challenged," Margules said.

"While the soft gaps raised by 4/25 for this exercise are unique to their role as the Airborne response force in the Pacific area, they can be applied to any other long duration mission by U.S. forces."

# Gift for Doriot

## Massachusetts gives $900K for chambers upgrade

**By Jeffrey Sisto, NSRDEC Public Affairs / NATICK, Mass. (Aug. 3, 2015)**

The Secretary of the Army has accepted a $900,000 gift from the Commonwealth of Massachusetts' Development Finance Agency, or MassDevelopment, to perform infrastructure upgrades to the Doriot Climatic Chambers at the U.S. Army's Natick Soldier Systems Center.

"On behalf of the United States Army, I am pleased to formally accept the gift of funds to enhance existing facilities within the Doriot Climatic Chambers at U.S. Army Natick Soldier Systems Center," said the Honorable John McHugh in an official acceptance letter to MassDevelopment in March. "Please accept my deepest appreciation for this generous and thoughtful gift."

Now, the commonwealth is demonstrating a renewed commitment to its only remaining active-duty Army installation by funding renovations to one of NSSC's signature research facilities.

"I am proud of the collaboration among industry, academia, and the Department of Defense that will be enabled by these upgrades," said Massachusetts Governor Charlie Baker. "The great work done at Natick's first-class facilities is a vital component to the research needed to fully serve the needs of a modern military and our national security interests."

The chambers is a unique testing facility capable of producing extreme environmental conditions for the Army's equipment and human-performance-related research and technology development. The facility consists of two large, main chambers that simulate tropical and arctic environments by replicating the temperature, humidity, wind, rainfall and solar radiation conditions found anywhere in the world.

"The expansion of systems capabilities in two of the smaller temperature conditioning rooms will give Army personnel a more energy-efficient, cost-effective and adaptive capability to conduct research," said McHugh.

While the chambers primarily support military research, their specialized capabilities can also benefit nearby academic institutions and commercial industry.

MassDevelopment — whose mission includes stimulating economic and industrial growth, increasing employment, promoting prosperity and building communities throughout the commonwealth — is supporting the opportunity to foster cross-sector, collaborative research partnerships that will advance science and technology innovation.

"Upgrading this Natick Soldier Systems Center facility is critical to promoting federal, industry, and academic collaboration in the Center's work," said MassDevelopment President and Chief Executive Officer Marty Jones. "The Commonwealth's military installations play a major role in the Massachusetts economy, and MassDevelopment is pleased to support Natick Soldier Systems and encourage further innovation."

Potential partners include any organization within the Department of Defense, industry, or academia that conducts research and development-based testing on clothing, tent shelters, sporting equipment, cold-weather gear, eyewear, food, food equipment, personal electronics, or humans in extreme climates. Under appropriate arrangements, the chambers can be used by non-federal entities interested in conducting similar research and development.

The chambers are operated by technicians from the Natick Soldier Research Development and Engineering Center. The chambers serve as a joint-use facility with the U.S. Army Research Institute of Environmental Medicine, also a NSSC tenant organization, responsible for the Army's medical research and development aimed at optimizing servicemen and women's health and performance during training and on the battlefield. The NSRDEC-USARIEM partnership ensures a comprehensive approach to human performance-related research and development efforts conducted in the chambers.

The two smaller conditioning rooms receiving the system upgrades were originally designed to be used when specific testing does not require use of the larger chambers or wind tunnel. However, the mechanical systems were never implemented, causing considerable energy usage. In a single year, the NSSC often spends more than $125,000 just to power the chambers.

The gift from MassDevelopment will fund the installation of new mechanical and electrical systems, reducing the chambers' annual operating costs by more than $71,000 and energy use by 85 percent.

The simpler mechanical controls and smaller room sizes will allow for minimal operator oversight, significantly reduce energy costs, and consume smaller amounts of non-HCFC refrigerant, resulting in a smaller carbon footprint. The implementation of modern, automated systems will also enable researchers more frequent, longer-running tests, creating a faster response to emerging test requirements without risk to the equipment and personnel.

The design phase of the upgrades will take an estimated three months, while the construction and startup phases are projected to take approximately six months.

"I am grateful for the Commonwealth's enduring support of our Soldier-focused mission," said Brig. Gen. William Cole, NSSC senior commander. "MassDevelopment's generous gift to upgrade the chambers will enhance our existing capability, as well as generate new collaboration opportunities with leading university and industry researchers who may also use the facility through Test Services Agreements.

"Most importantly, the increased capability will allow NSSC to more quickly and efficiently develop state-of-the-art equipment for our Soldiers."

Photo: Spc. Joshua Edwards

# Power Up

## Making base camps more energy efficient

**By Jeffrey Sisto, NSRDEC Public Affairs and Allison Barrow, CERDEC Public Affairs / ABERDEEN PROVING GROUND, Md. (Aug. 17, 2015)**

When you need to charge a cell phone or turn on the lights, the power is typically there. You most likely don't have to wonder how you'll get it or how long you'll have it.

But for Soldiers at small base camps in forward operational environments, being able to harness and maintain power is essential for operating effectively. The better they're able to manage available power and energy, the less they have to rely on resupply convoys to bring more fuel and batteries — driving up costs, taking Soldiers away from other missions, and risking lives in the process.

The Secretary of the Army, the Army Chief of Staff, and the Sergeant Major of the Army made effective energy solutions a top priority, and the Army has a number of initiatives to make base camps more energy efficient by enabling Soldiers to not only maintain power for longer, but to intelligently control power distribution. The aim is to decrease the power draw and more smartly manage the use of available power, limiting the number of resupply convoys needed.

The Army demonstrated a number of these integrated capabilities at the Base Camp Integration Lab at Fort Devens, Massachusetts, July 7-31, with the overall goal of reducing fuel, water and waste at small base camps.

This 300-person camp demonstration was the third in a series of demonstrations that are part of the Sustainability Logistics Basing — Science Technology Objective Demonstration, known as SLB-STO-D. The research effort to make base logistics more sustainable is led by the Research, Development and Engineering Command, and is being managed by the Natick Soldier Research, Development and Engineering Center, or NSRDEC, with collaboration from the Communications-Electronics Research, Development and Engineering Center, or CERDEC, for several fuel-saving technologies; the Tank Automotive Research, Development and Engineering Center to reduce water demand and waste water generated; and the Army Research Laboratory for basic research across each of the areas.

"These operational demonstrations provide an excellent opportunity to showcase how each of the fuel, water and waste technologies contributes to the overall objectives when integrated together. The data collected during the event allows the systems with the highest return on investment and those that have the biggest impact to be identified," said Gregg Gildea, NSRDEC's lead for the SLB-STO-D.

CERDEC's Command, Power and Integration Directorate, or CP&I, is leading several fuel-reduction technologies with the task to cut fuel consumption by 25 percent.

"Our job is to demonstrate our technologies and show how their improvements impact the issues — those being reduction of fuel consumption, operational efficiency and how it impacts mission flexibility," said Selma Matthews, CERDEC CP&I engineer, and fuel lead for the project.

One of CERDEC's initiatives for intelligent power management is the Energy Informed Operations project, which is developing a nonproprietary tactical microgrid architecture that allows integration and sharing of different power sources aimed at providing more efficient, more reliable power for a tactical base camp.

In this demonstration, the team constructed a large microgrid consisting of several generators that powered base camp equipment, including shelters and shower facilities, as well as air conditioners, called environmental control units, said Garrett Clarke, the CERDEC CP&I software lead for Energy Informed Operations.

Having the ECUs connected to the microgrid allowed for better power distribution and provided the microgrid with initial steps toward identifying what loads are connected to the grid, and allowed the grid to intelligently shed those loads to save power if necessary, Clarke said.

Soldiers could control the ECUs directly through the EIO software application. For example, Soldiers were able to turn off the cooling inside a specific tent to save power.

"The objective of the Energy Informed Operations architecture and standards will allow Soldiers to efficiently manage, monitor and control a microgrid," said Clarke. "This will provide Soldiers with real-time information about their power resources in situations where they may be constrained, may not be able to get resupply or have multiple generators or other power resources available to them. The microgrid will take into account these things and provide them with the best way to sustain their power as long as possible until that resupply can occur," Clarke said.

ECUs with improved efficiency was another capability CERDEC brought to the demonstration as part of its Innovative Cooling Equipment, or ICE, program. The ICE program aims to reduce the electrical energy required to produce cooling and heating for forward bases as well as brigade and below environmental requirements. This is done through advancements in thermodynamic cycles, electronics/digital controls, heating ventilation, air conditioning components, and waste heat recovery.

The Army Materiel Systems Analysis Activity and Project Manager Expeditionary Energy and Sustainment Systems have found that up to 60 percent of generator power goes to environmental control, said Bill Campbell, CERDEC CP&I ICE project manager.

The advanced ECUs benefit Soldiers through improved and sustained control of the environment, reduced noise, and humidity control, Campbell said.

"A 10-percent ECU efficiency improvement would translate to a savings of more than three million gallons of fuel. This represents not only a potentially significant cost savings, but a major reduction in the number of fuel convoys required to sustain the operations," Campbell said. "The ICE program has built prototypes which have shown that the 10-percent efficiency reduction is achievable. We are looking to continue our efforts with an ultimate goal of as much as a 30-percent efficiency improvement in all ECUs."

The Army demonstrated a number of these integrated capabilities at the Base Camp Integration Lab at Fort Devens, Massachusetts, July 7-31, with the overall goal of reducing fuel, water and waste at small base camps.

NSRDEC's Energy Efficient, or E2, Optimization program also reduces fuel consumption in combat outposts and platoon base shelters through enhanced energy-control management, battery storage, improved electrical component design and energy-efficient shelters.

E2 Optimization's improved shelter systems feature thermal insulation, solar shade, passive ventilation and LED lighting, while two ECUs improve the heating, cooling and dehumidification capabilities. A Microgrid Storage and Distribution Unit battery storage distribution system coupled with power monitoring software minimize the running time and logistical burden of generators.

Additional power technologies demonstrated were Man-Portable Generator Sets for Power Generation for Expeditionary Small Unit Operations, or MANGEN, and the Onsite Automatic Chiller for Individual Sustainment, or OACIS. MANGEN addresses the Army's power gap between large batteries and small generator sets. The program provides a lightweight, man-portable conversion kit that adapts gasoline engines to be able to run on JP-8 fuel, the main fuel found in the field.

"The OACIS leverages high-efficiency refrigeration technology to reduce the energy and power needed to chill up to 500 liters of bottled beverages at base camps. OACIS reduces the fuel draw and encourages Soldier hydration via easy access to cold beverages," said Gildea.

Soldier perspective is an important part of becoming a more energy-efficient force, and Soldiers from the 542nd Quartermaster Forcer Provider Company were on hand throughout the demonstration to provide feedback on the applicability of the technologies and to test their ease of use, Matthews said.

"The EIO microgrid went above and beyond what we expected to see," said a Soldier with the 542nd Force Provider Company during the demonstration. "Everything that it could possibly do would make our job even easier."

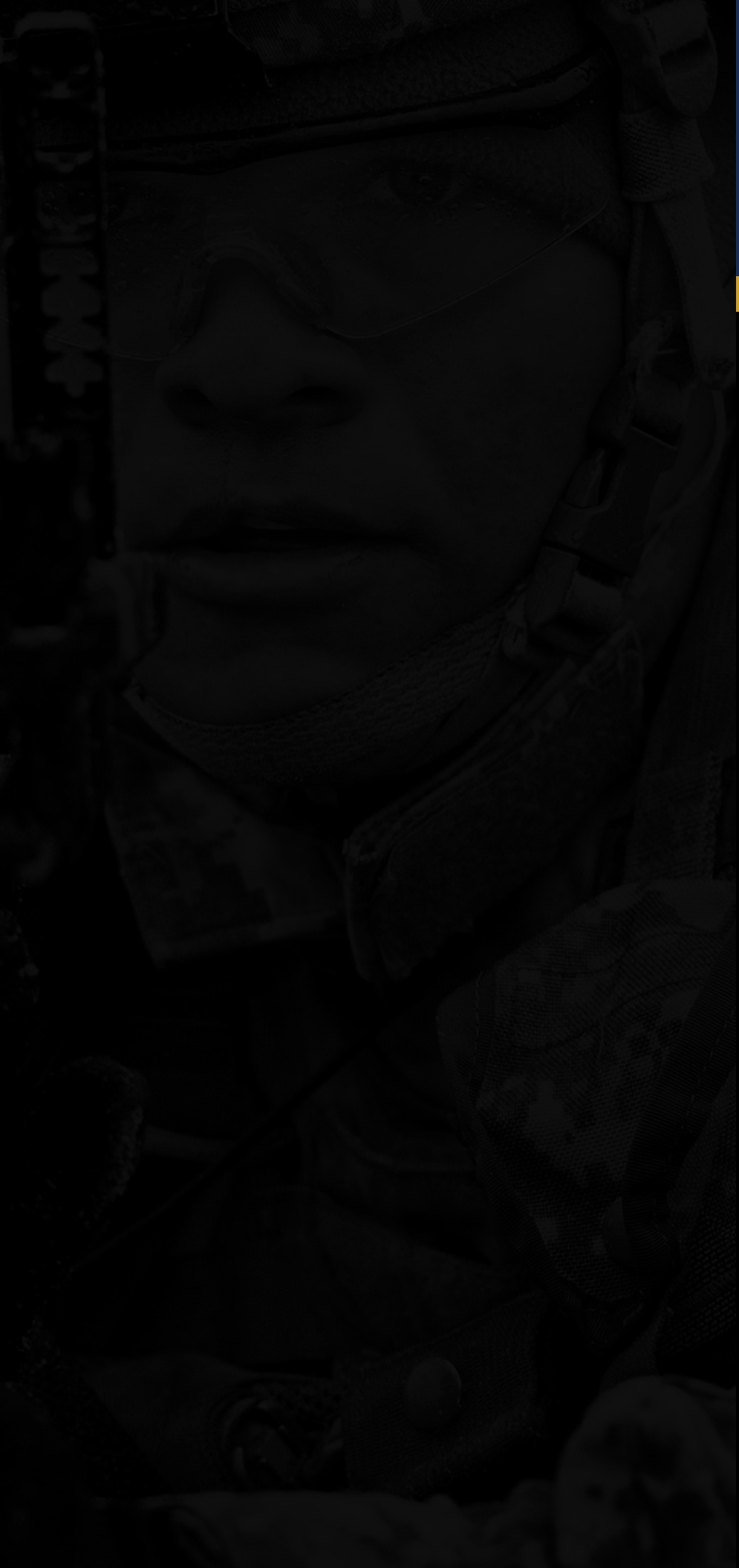
Planning is underway to demonstrate approximately 25 additional technologies to help make base camps more efficient during fiscal year 2016 at two venues: a 1,000-person camp demonstration at the Contingency Base Integrated Technology Evaluation Center at Fort Leonard Wood, Missouri, and a 300-person camp demonstration at the BCIL.

Additionally, a capstone integrated demonstration is being planned with acquisition partners to showcase technologies with the greatest impact to base camp efficiency and potential for transition to programs of record in fiscal year 2017.

# One step at a time

As researchers from the U.S. Army Research Institute of Environmental Medicine at Natick Soldier Systems Center continued their Physical Demands Study, two women Soldiers graduated Aug. 21 from Ranger School, becoming the first of their gender to do so. USARIEM is working with the U.S. Army Training and Doctrine Command to provide valid, reliable and accurate predictive tests to select Soldiers for physically demanding occupations. Capt. Kristen Griest, center, an MP with 716th Military Police Battalion, Fort Campbell, Kentucky, and 1st Lt. Shaye Haver, an Apache pilot with 4th Combat Aviation Brigade, 4th Infantry Division, Fort Carson, Colorado, started training with the first gender-integrated Ranger Course, Class 06-15, in April. Both Griest and Haver are graduates of the U.S. Military Academy, West Point, New York.

*Photo: Staff Sgt. Scott Brooks*



Soldier
Science & Engineering

## Soldier Science & Engineering

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