

FLC Northeast Region Newsletter – Fall 2007

Homeland Security Technology Focus of NE Region Meeting

The Northeast Region held its latest meeting September 24-26 in Natick, Massachusetts. Themed "Homeland Security Technologies from Northeast Labs," the three-day meeting was attended by technology transfer professionals from government, industry, and academia.

Following a reception on the evening of September 24 to kick off the event, the meeting began in earnest the next day at the Soldier Systems Center (SSC) in Natick. In keeping with the meeting theme, representatives from several Northeast regional laboratories, including the Transportation Safety Laboratory of Atlantic City International Airport, New Jersey; the Army - Armament Research, Development, and Engineering Command of Picatinny Arsenal, New Jersey; and the Naval Undersea Warfare Center, Division Newport of Rhode Island made presentations highlighting technologies that have become key elements in the nation's homeland security effort. Another highlight of the first full day of the meeting was a tour of the SSC facilities, where attendees saw some of the technology transfer projects taking place there.

The third and final day of the meeting included an update on procedural matters regarding the region, as well as an award ceremony honoring the 2007 Northeast regional award winners.

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2007 Northeast Regional Award Winners Honored

The Northeast Region recently presented its annual awards honoring individuals and laboratories for outstanding achievements in technology transfer. The award winners were recognized at a ceremony during the 2007 regional meeting in Natick, Massachusetts. Among the winners were:

Princeton Plasma Physics Laboratory of Princeton, New Jersey, received the Excellence in Technology Transfer Award for its successful transfer of the Miniature Integrated Nuclear Detection System (MINDS). An anti-terrorism technology, MINDS was developed to detect the radiation emitted from a nuclear threat such as a dirty bomb or from dangerous nuclear material. This technology employs a conventional off-the-shelf hardware approach to detecting the nuclear radiation spectrum, coupled with an innovative detection scheme. Using a sodium iodide scintillating crystal to detect x-ray and gamma radiation, the emitted signal is then coupled to a multi-channel analyzer (MCA) with appropriate amplification. The output of the MCA is analyzed by the proprietary software developed by PPPL for the identification of specific sources of radiation that may be associated with the threat of nuclear terrorism. The analysis is generally done on a laptop or other conventional computing environment.

The **Naval Undersea Warfare Center (NUWC), Division Newport**, located in Newport, Rhode Island, received the Regional Laboratory Award for its outstanding technology transfer efforts. Among NUWC's accomplishments was the creation of a Technology Partnership Enterprise Office (TPEO); the establishment of an annual Diversity Summit to encourage an inclusive work environment where scientists and engineers are free to explore ideas that may lead to patented inventions and solutions for the Navy; development of relationships with Rhode Island nonprofit economic development organizations to foster potential military and commercial partnerships; and maintaining a Cooperative Research and Development Agreement (CRADA) and patent licensing program that has been recognized with a number of FLC awards.

The Northeast Region congratulates the winners on a job well done.

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Governor Patrick visits SSC

On June 15, Massachusetts Governor Deval Patrick visited the U.S. Army Natick Soldier Systems Center (SSC) to receive an overview and learn about the work done there. The governor was briefed on a number of topics, including body armor advances; uniform design and collaboration between the Army, Marines, Navy, Coast Guard and Special Operation Forces; Department of Defense combat feeding; and the collaboration with Massachusetts State Police on the Law Enforcement Advanced Protection System.

While viewing the displays and listening to the briefings, Patrick asked questions, made comments, and occasionally joked with the presenters. At the conclusion of his visit, Patrick said he appreciated the invitation to visit SSC.

Secretary Daniel O'Connell, Secretary of Housing and Economic Development for Massachusetts, and State Senator Karen Spilka were among various other public officials who accompanied Gov. Patrick on the visit.

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Zinc Transporter Protein Structure Deciphered

Scientists at Brookhaven National Laboratory have deciphered the atomic-level structure of a cell-membrane protein that regulates the movement of zinc ions into and out of cells. Details of the structure may help scientists better understand the crucial role zinc plays in many biological processes, from nerve cell communication to insulin regulation. The research was published online by the journal *Science* on August 23, 2007.

Brookhaven scientists Dax Fu and Min Lu studied a zinc transporter protein taken from the common bacterium *Escherichia coli*. "This protein is structurally and functionally related to zinc transporter proteins found on human cells, and will therefore provide insight into the role of zinc and these transporter proteins in a variety of human conditions," said Fu. The findings may also have implications for improving microbial cells' ability to modify or remove metal contaminants from the environment.

Zinc is essential for cellular growth and differentiation, and is often a structural or catalytic component of proteins and enzymes. It is involved in myriad processes, from gene expression to immune function. Zinc also modulates the activity of chemical messengers in the brain, and helps to regulate the release of insulin from pancreatic cells in response to changing blood sugar levels.

However, too much zinc can be toxic. For instance, excessive zinc may cause seizures and play a role in the deposition of amyloid protein plaques in Alzheimer's disease.

Zinc transporter proteins are one of the major regulators of zinc levels. These proteins lie partially within the cellular membrane, moving zinc ions across this otherwise impermeable barrier to maintain an optimal balance, or homeostasis.

Sometimes the transporter proteins push zinc out of cells or lock it up in vesicles within the cells. In the brain, the transporter proteins reabsorb excess zinc from extracellular spaces called synapses. Failure of this reuptake mechanism has been identified as one of the leading causes of seizures. Another human zinc transporter involved in regulating insulin release has recently been identified as a major risk factor for Type 2 diabetes—and is now a hot target for drug development.

While the location of transporter proteins within the membrane makes them ideally situated for their diverse functions, it also makes them particularly difficult to study. This is because, chemically, membrane proteins are similar to grease molecules; they tend to clump together in an aqueous solution. The challenge is to keep individual zinc transporter proteins isolated from one another as well as from other proteins. The purified proteins then have to be put back together in an orderly manner into a three-dimensional crystal lattice for structural analysis.

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Zinc Transporter (continued)

"After more than seven years of intensive efforts, we have finally learned how to crystallize the zinc transporter," said Fu.

Another critical barrier to determining the human zinc transporter protein structure is the lack of a way to produce large-scale quantities. Most mammalian membrane proteins can only be obtained from their native sources; but despite its ubiquitous functions, the zinc transporter is extremely limited in human tissues. The scientists circumvented this hurdle by using a homologous zinc transporter that can be abundantly obtained from *E. coli*.

At the structural level, many bacterial proteins look just like their human counterparts. In fact, Brookhaven Science Associates, manager of Brookhaven Laboratory, has filed a patent application for models of mammalian zinc transporters and their use based on the Brookhaven scientists' newly derived structure.

Using *E. coli* proteins has the added benefit of contributing to a better understanding of how microbes maintain a proper balance of metals, and may suggest new ways to use this knowledge to improve microbes' ability to remove or sequester heavy-metal contaminants in the environment.

The Brookhaven scientists obtained crystals of an *E. coli* zinc transporter protein known as YiiP bound with zinc ions. They then deciphered the protein structure using a technique called x-ray diffraction at Brookhaven's National Synchrotron Light Source (NSLS). By studying how an intensely bright beam of x-rays diffracts and bounces off the crystal, the scientists can determine the positions of, and distances and angles between, the individual atoms that make up the protein. They then use computers to generate 3-D models.

Since YiiP crystals are unusually small (the size of a needle tip) and fragile, even the brightest x-ray beam at NSLS is only marginally adequate to produce useful diffraction data. The scientists therefore had to manually position each of thousands of YiiP crystals in the center of the x-ray beam to maximize exposure.

"This project would have been impossible without the help of the beamline scientists at the NSLS and the easy access to this remarkable scientific facility," said Fu.

The crystal structure of YiiP reveals an unusual Y-shaped architecture made of a pair of identical protein chains. They juxtapose each other in the cell's cytoplasm to form the base of the Y where the protein chains swing out and insert into the membrane.

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Zinc Transporter (continued)

The cytoplasmic domain adopts a structural fold similar to a family of small soluble proteins involved in intracellular metal ion trafficking. The transmembrane domain is characterized by two cavities, which collectively penetrate more than half of the membrane thickness from opposite membrane surfaces.

"The YiiP structure suggests that the cytoplasmic domains may receive zinc ions inside the cell and deliver them to a water-filled cavity where the ions are then transported across the membrane barrier via a protein conformational change," Fu said.

"In addition to providing information about the specific function of a zinc transporter protein, our structure provides a more general conceptual framework for understanding the selective binding and energized movement of metal ions across membranes," said Lu.

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Volpe Continues Railroad Tank Car Structural Integrity Research

The Volpe Center, Dow Chemical Company, Union Pacific Railroad, and the Union Tank Car Company are collaborating on a high priority, fast-track effort to improve the safety of railroad tank cars carrying hazardous materials (HAZMAT). The objective of this joint government/industry effort, called the Next-Generation Rail Tank Car (NGRTC) Project, is to design a rail tank car that will meet or exceed performance requirements while improving safety and security. This includes full-scale impact tests to evaluate the crashworthiness of rail tank cars under accident loading conditions.

The results from the tests will be used to support a Notice for Proposed Rulemaking (NPRM) developed by the Pipeline and Hazardous Materials Safety Administration (PHMSA) and the Federal Railroad Administration (FRA) in the creation of the new regulations and by the NGRTC project team as it continues to construct a new tank car design. In January 2007 the FRA signed a Memorandum of Cooperation with the sponsors of the NGRTC project to share research information.

In April 2007, a full-scale shell-impact test was conducted on a rail tank car donated by Dow at the Transportation Technology Center (TTC) in Pueblo, Colorado. In this context, shell impact means that the rail tank car is impacted at the side by another rail car. The test was conducted at an impact speed of 14 miles per hour and resulted in a 9-inch deep dent.

In July, another full-scale shell impact test on a railroad tank car designed to carry chlorine was successfully completed at the TTC. This test resulted in rupture of the tank car shell.

Detailed data will be analyzed by the FRA, Volpe Center staff, and contractors, not only to improve tank cars but also to verify and validate analysis tools under development for the project. With the assistance of this ongoing research, FRA, in conjunction with PHMSA, is working to develop new hazardous material tank car safety standards. The target date for a prototype next-generation tank car is April 2008, with the first cars entering service in 2010.

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USARIEM Researchers Test WPSM Capabilities During Training Exercises

Researchers from the U.S. Army Research Institute of Environmental Medicine (USARIEM) in Natick, Massachusetts, recently got a chance to test one of the products they have been working on in an exercise scenario. The Warfighter Physiological Status Monitor (WPSM) lets an observer view heart rate, respiration and core temperature from a remote location. Although intended for medical personnel to monitor the critical vital signs of warfighters on the battlefield or in training, it also has other uses.

In June, USARIEM worked with the National Guard 1st Civil Support Team Weapons of Mass Destruction (CST-WMD) out of Wellesley, Massachusetts, during two training exercises. The mission of the CST-WMD Team is to support civilian authorities in the event of a WMD incident. Their tasks include advising local authorities and assisting with response.

Nationally, the CST-WMD has been looking for a medical monitoring telemetry system for a couple of years, said Mark Buller, USARIEM physiologist. Currently, when members of the CST-WMD are wearing chemical/biological personal protective equipment (PPE), they have to work using the buddy system and only have external physical signs to work with (e.g., their partner begins to stagger when walking or is unresponsive to verbal commands). "They wanted to ID a system that would let them monitor core temperature, heart rate and ECG traits," said Buller. "We have been working on WPSM systems for more than 10 years, and thought we had a system mature enough to be a good fit. The prototype of the system met most of their needs."

A partnership was created between the two organizations (USARIEM and the 1st CST-WMD Team), and USARIEM first traveled to a training exercise in North Truro, Massachusetts, to get a better understanding of the CST-WMD mission. Next they traveled to North Brookfield, Massachusetts, and outfitted members of the CST-WMD team who were performing first responder-type work with the WPSM system during actual training exercises.

"We want potential users of the WPSM system to try it out in a real environment to see if it will meet their needs," said Bill Tharion, USARIEM principal investigator. The first exercise in North Brookfield involved members of the CST-WMD performing first responder type work in their PPE in enclosed spaces, such as in a tight sewer system and septic tanks. Six individuals were equipped with the WPSM system with a strap that goes over their chest and shoulders. An electronics unit that snaps into the chest strap that gathers and processes the physiological information obtained from the strap sensors was also worn.

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USARIEM (continued)

"This system differs from the chest straps available on the sports market," Tharion emphasized. "Although those systems also have a chest band which sends your heart rate information back to a watch, the WPSM system provides a lot more information and also provides more reliable information. The WPSM is a system developed to detect vital signs," he said.

"The [WPSM] can even tell you if a device is broken or not on," Buller added. During the exercise, a physician's assistant from the 1st CST-WMD observed the information provided by the WPSM system, such as heart rate and respiration. "The system worked great," said Buller. "We were able to monitor the individuals reliably with no equipment failure and were able to get good data."

The second exercise was on a firefighters' training site with large containers that had restricted entry through only a manhole. The setup for testing the WPSM system was the same as the first exercise, but the day was warmer, with temperatures in the containers reaching between 80 and 90 degrees F. "This gave us a good opportunity to see how the item works in the field," Tharion said. "It also gave us the chance to ask if the item meets this group's needs and, if not, what else they would like to see."

The WPSM system was a useful tool for the CST-WMD. The medic is able to see where a problem might arise, such as heat stress, and send out a new individual to cover for the one who might be in danger. The WPSM is considered a device that would supplement a normal level of care, not replace it.

For the future, USARIEM is working on algorithms based on vital signs, such as core temperature, and types of exercise being done to predict work/rest cycles. "These will let us predict schedules with relative reliability," said Tharion. Regarding working with the 1st CST-WMD, both Buller and Tharion thought it was a success. "They have been great to work with," said Tharion. "It's truly become a partnership."