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Solutions

U.S. Army Edgewood Chemical Biological Center

2015 | Annual Review

Message from the Director

Welcome to *Solutions*, Edgewood Chemical Biological Center's Annual Review — a comprehensive look at the people, projects and programs that define ECBC's service to our nation. Looking back at 2015, I am extremely proud of ECBC's performance in working with the most dangerous materials known to humankind in order to provide our nation with innovative chemical and biological defense solutions. A clear indication of the excellence we have demonstrated is reflected in the number of safety awards we have received over the past year, including the Army's highest award for safety and risk management.

Over the past year, laboratories across the nation engaged in work with biological agents have faced tremendous scrutiny from a number of oversight agencies regarding the safe and secure handling of these materials. ECBC is uniquely positioned to lead our nation's bio-defense efforts. We have a strong, professional, safety-conscious workforce, and the rigorous scrutiny from oversight agencies over the past year is making us even stronger.

That program-wide scrutiny has led us to take a good look at ourselves, and I have made the following goals priorities for myself and for every leader within ECBC. We will focus on these goals wherever ECBC employees are engaged in work around the world.

Grow and Support the Workforce. A trained and ready workforce is the top priority to the success of our Center's national security mission. ECBC will enhance its human capital planning processes with the goal of recruiting, challenging, and retaining a diverse community of world-class employees.

Sustain and Modernize Infrastructure. Modern facilities and specialized equipment are necessary to enable our work force to perform their jobs. Through an infrastructure planning process, ECBC leadership will ensure that the workforce has the required world-class facilities and equipment to safely and successfully perform their mission.

Cultivate Innovation. To address the enduring challenges represented by legacy and emerging chemical and biological threats, we must cultivate innovation to drive the development of new products and services to protect our forces and citizens.

Collaborate. ECBC will strive to foster collaboration both internally and across the entire Chemical and Biological Defense Enterprise. Good ideas are found throughout the Enterprise, and we want to leverage those ideas to ensure mission success.

Deliver Quality Products and Services. ECBC will leverage its institutional excellence to enable each customer's success. The Center will achieve this end by successfully executing programs and delivering quality products and services.

Joseph L. Corriveau, Ph.D.
ECBC Director

ECBC is a unique national asset providing innovative and cost-effective technology solutions through its scientific and engineering expertise, coupled with its unique facilities and collaboration with partners. We will continue to leverage the incredible depth and breadth of talent, expertise, and innovation resident in our workforce to safely develop solutions focused on protecting our nation from weapons of mass destruction.

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ECBC's History

In 1917, the first crew of workers reports to Edgewood Arsenal Chemical Laboratory.

ECBC's science and technology expertise has protected the United States from the threat of chemical weapons since 1917 when President Woodrow Wilson issued a proclamation that designated Gunpowder Neck, Maryland, as the site for the first chemical shell filling plant in the United States. Since that time, the Center has expanded its mission to include biological materials to become the nation's premier authority on chemical and biological defense.

With the approach of ECBC's 100-year anniversary in 2017, everyone at the Center takes pride in its long legacy of innovation. In that time, ECBC has taken chemical biological protection, detection, decontamination, and elimination operations from its primitive beginnings through two world wars, into the modern era of digital communication and nanotechnology.

Protection

From World War I to today, ECBC has played a central role in the maturation and improvement of protective masks, one of the most essential pieces of equipment for the warfighter.

After the Germans first used chlorine gas as a chemical weapon early in World War I, the Allies responded by issuing Soldiers cotton pads that they soaked in urine. With each passing decade, protective masks have become more comfortable to wear, easier to see out of, and easier to put on and take off. Today, Soldiers have the M50

1918 • R.F.K. Mask
The Army developed the Richardson Floy Kops mask, which was as an improved version of the widely used British mask. The face piece was cotton fabric coated with rubber. The canister was smaller to create less breathing resistance. In addition to being more comfortable, the mask was also much easier to manufacture. Approximately three million of these were produced during World War I.

Joint Service General Purpose Mask complete with a wrap-around visor, a silicon butyl blend facepiece, and an upgraded valve design which makes breathing 50 percent easier than its most recent predecessor.

ECBC already has technologies for the next generation respirator under design. Researchers are working to make it lighter and less bulky. The new design will also feature upgrades that allow a flow of air into the nose cup and eye cavity of the mask to keep users cooler. They are also developing physiological monitors and sensors that will control fan speeds for the air based on the breathing demands of the user. The next generation respirator will also integrate the most advanced communications technology inside the mask.

Detection

During World War I, the U.S. Army possessed no technology for remotely sensing chemical agent and relied on human "gas scouts." They were positioned just beyond the main trench line and if they smelled the garlicy scent of mustard agent or felt the nasal and throat irritation of chlorine, they ran back and warned the other Soldiers. After a chemical agent attack, Soldiers determined if the agent had dispersed by taking off their masks and performing the "sniff test." Recognizing the danger of using Soldiers as the canary in the coal mine, Army researchers experimented with animals; including dogs, pigeons and canaries.

In the decades that followed, ECBC developed hand-held detectors for chemical and biological agents that became continuously more accurate, more reliable, and more transportable.

Today, ECBC scientists and engineers continue to extend the boundaries of chemical and biological detection to make it ever faster, lighter, less expensive and more

reliable. Currently, ECBC is developing new methods to send detection instrument data to commercial smartphones held by a Soldier standing at a safe location nearby. The Soldier can then send the results to the unit commander, allowing hot zones to be quickly marked and communicated to other units. ECBC is also developing on-the-move detection at speeds of up to 30 mph, allowing a vehicle to remotely detect a chemical on the ground that cannot be seen by the naked eye.

Since the early 1990s, ECBC has been on the front lines of confronting emerging threats. By merging its world-renowned chemical biological expertise with intelligence assessments from national security agencies, ECBC is developing a new generation of technologies to counter homemade explosives, biological aerosols, and non-traditional chemical hazards. ECBC is without peer in its ability to research and understand emerging chemical and biological threats for which no established methods of detection, protection and decontamination may exist. ECBC researchers can characterize the chemical or biological properties of an emergent chemical or biological material to determine its impact on people and the environment. Researchers can then identify the capability gaps in existing response methods and procedures in close collaboration with intelligence and law enforcement agencies.

ECBC will continue to pursue these and many more promising technologies and research efforts to keep the warfighter and the nation safe from ever-changing emerging threats in what has proven to be a challenging modern world.

The M18 Series Chemical Agent Detector Kit was a lightweight, more sensitive, and easier use detector kit designed in 1957 to confirm the continuing presence of a chemical agent to determine when Soldiers could remove their masks.

Decontamination

The U.S. Army's chemical warfare agent decontamination methods during World War I were no more sophisticated than its protection or detection methods. Over 27,000 trench fans made up of a cane frame and canvas fan area were sent to the Soldiers in the trenches as a means of fanning away approaching clouds of agent. A good airing out was the solution to contaminated clothing and equipment. Soldiers exposed to agent were advised to clean themselves thoroughly with soap and water. After the shower, the Soldier was given a drink of bicarbonate of soda water and then had his eyes, ears, mouth, and nose washed with the soda water.

Today, ECBC is developing self-decontaminating uniforms and vehicle surfaces using revolutionary new materials and nano-manufactured molecules. ECBC scientists can predict the performance of these new kinds of decontaminants based on variables as diverse as contamination age, decontaminant dwell time and temperature.

Operations

ECBC's history of performing chemical munitions demilitarization and disposal extends as far back as 1946 when, as part of the Army Chemical Corps, it disposed of captured German chemical munitions brought back to Aberdeen Proving Ground from Europe. Today, ECBC's Chemical Biological Applications and Risk Reduction Business Unit, popularly known as CBARR, has earned a reputation as the world's premier chemical biological weapons material field response team.

CBARR is unique both for the highly specialized training and expertise of its personnel, and for the one-of-a-kind equipment it can mobilize and operate anywhere in the world. Over the years, CBARR has performed missions in all corners of the United States and the world. Most recently, it made international headlines by destroying Syria's declared chemical weapons stockpile onboard a ship in international waters using the Field Deployable Hydrolysis System, which ECBC uniquely configured to fit into the hold of the ship.

The Syrian stockpile destruction was only one of many successful field operations CBARR has performed since it was established. They include support to the United Nations Special Commission performing WMD inspections in Iraq, destroying recovered munitions at Dover Air Force Base, and destroying chemical agent onsite in places as remote as Tirana, Albania and Columboola, Australia.

Innovation

The Center's human and physical research and development infrastructure is only part of the ECBC story. As the nation's adversaries constantly innovate, using existing and emerging chemical biological threats in new ways, the men and women at ECBC stay a step ahead in a dangerous world.

It starts with ECBC's laboratory culture that moves beyond technology development and extends to process innovations that improve how we develop the technology. It includes rewarding researchers' promising out-of-the-box ideas with seed money, and working with industry partners to get smaller, better, faster chemical biological defense technologies into the hands of warfighters sooner. It also includes collaborating with the nation's leading research universities to push the envelope of chemical biological defense scientific knowledge.

Leaders in their Fields

ECBC workforce members are also leaders in their technical fields. In 2015, ECBC researchers published a total of 65 scholarly articles in peer-reviewed science and professional journals. These journals ranged from microbiology to physical chemistry to nanotechnology to toxicology and pharmacology.

Also in 2015, 34 ECBC researchers presented papers at 24 conferences around the country and around the world.

Enrolled in the Personnel Reliability Program

ECBC personnel are thoroughly trained to safely work with the most lethal chemical and biological materials in the world. A major component of maintaining this safety is the Personnel Reliability Program – a Department of Defense program designed to permit only the most trustworthy and medically fit individuals to have access to nuclear, chemical and biological materials. ECBC has more than 350 personnel in the Army's Personnel Reliability Program. Prior to gaining access to chemical and biological agents, they must complete training in the safety of chemical and biological agent handling, CPR, first aid, use of engineering controls, and the use of respiratory protection.

A Diverse Workforce

ECBC owes its ability to consistently deliver innovative chemical biological defense to the diversity, specialized training, and dedication of its workforce. High-performing organizations are made up of high-performing people, and people are the sum of their experiences. ECBC embraces the Army's core belief that we can sustain our high-performing organization by taking advantage of the diverse talents, skills, and attributes that derive from varied ethnic and cultural backgrounds and experiences. Our workforce serves our nation and is a reflection of our nation -- men, women, African Americans, Latinos, Asian Americans and Native Americans. They truly make ECBC the nation's brain trust for chemical biological defense technology.

Highly Educated, Highly Trained

ECBC employs more than 1,100 civilian employees and about 300 contractors. Workforce members have approximately 500 Bachelor's degrees, more than 200 Master's degrees and more than 90 Doctorate degrees in a wide range of fields – including mechanical engineering, chemistry, mathematics, molecular biology, toxicology, and more.

Their experience ranges from recently graduated engineers, chemists and biologists to 30- and 40-year ECBC veterans with deep subject matter knowledge. The workforce also includes military veterans from all branches with many different specialties.

A Selection of 2015 Scientific Journals Publishing ECBC Researchers

Analytical Chemistry

Applied Soil Ecology

Army Chemical Review

Journal of Analytical Toxicology

Journal of Biomolecular Screening

Journal of Clinical Microbiology

Journal of Materials Chemistry

Journal of Medical Virology

Journal of Physical Chemistry

Industrial & Engineering Chemistry Research

Infection Genetics and Evolution

Microscopy Research and Technique

Nature Materials

Journal Of Microbiological Methods

Polymer Chemistry

ECBC IDEAS Program

ECBC meets 90 percent of its costs through customer reimbursement. Other government agencies come to ECBC with highly specific and very challenging chemical and biological protection needs, and ECBC creates the technology that best meets those needs. But sometimes these customers have needs that they are not yet aware of, or there is a better mousetrap by which to meet their needs.

ECBC's Innovative Development of Employee Advanced Solutions (IDEAS) Program was designed to give researchers with promising new ideas the opportunity to harness them and turn them into that better mousetrap, providing exactly the fix the customer needs.

Open to All at ECBC

Proposals addressing any CBRNE defense solution can be submitted by any ECBC employee. An ECBC Innovation Goal Team manages and oversees the proposal review process. They select a group of diverse subject matter experts to review each submission for its creativity, value to the warfighter, potential to advance ECBC's CBRNE mission, and business potential. When a proposal is selected by the committee, the project is provided a funding amount between $10,000 and $100,000, and the researchers are given eight months to conduct their study and compile results. The researchers then brief the Innovation Goal Team on the project's performance; the most successful projects become formal ECBC research efforts.

A Proven Ideas Incubator

Many IDEAS Program funded concepts have transitioned into well-known and highly regarded ECBC projects.

ECBC researchers of all levels of experience and areas of expertise are eligible to receive seed money to develop promising new concepts through the IDEAS program.

These include the VOCkit which uses stamp-sized volatile organic compound colorimetric assay strips to identify chemical biological threats.

Another winner, the Integrated Respiratory and Eye Protection Scarf, is a protective face scarf that provides protection against riot control agents and low-level chemical agent threat agents. It can be stored in the cargo pocket of a Soldier's uniform and donned quickly without needing to take off other pieces of equipment.

Yet another winner, the Selectable Color Single Canister Smoke Hand Grenade, provides warfighters with a single grenade capable of providing six distinct colors through the use separate dye chambers, reducing the warfighter's weight burden.

Winners for 2015

Fiscal Year 2015 saw many strong ideas that received funding. The highlights are:

Ebola Virus Detection and Characterization Using Nanopore Sequencing

Portable molecular epidemiology techniques for detecting and managing outbreaks are badly needed for better outbreak response. This has been highlighted by the recent Ebola epidemic where very little sequence data has been collected in West Africa. This prevents the characterization and tracking of the virus as it mutates within humans, leaving public health officials in the dark as the virus continues to evolve. ECBC has partnered with a private technology company to determine if the hand-held MinION™ nanopore sequencer can act as a fieldable platform for deployment during an outbreak. Samples collected from West Africa will be sequenced using the MinION™. These experiments are testing nanopore sequencing

technology to see of it can be used to rapidly identify and characterize Ebola virus in samples that might be encountered in the field by forward-deployed personnel.

Development of a One-Handed Environmental Surface Sampling Device

This project aims to develop a device to make biological sampling by people in the field wearing bulking protective equipment easier. If they can use one hand instead of two, they have the advantage of a free hand to meet other field demands. This device acts as the actual sampler as well as the transport packaging, thereby speeding up sampling times with higher throughput and reducing waste. This design is a major step forward in biological sampling technology.

Unmanned Aerial Vehicle Non-Line of Sight Chemical Detection

This project explores using unmanned aerial vehicles as chemical biological samplers which can be flown at distances up to a mile away from warfighters to provide a completely novel early warning capability for the presence of threat agents. The modified UAV chemical samplers also have onboard cameras to provide improved situational awareness plus a new all-hazard sampling capability that can be coupled with current field laboratory assets. This represents an inherently safe process for sample collection that allows the warfighter to remain at safe distances, and which leverages field laboratories already under acquisition to provide timely identification of potential threat agents.

ECBC's drone can take images of the scene, maneuver into small spaces, and use sensors to take readings and collect samples. All the while, the warfighter or first responder sees everything the unmanned aircraft system sees.

Animal Respiratory System Replicate Models for Aerosol Deposition Studies

Animal research is a very important tool in determining the effect of CBRN exposure on humans and the effectiveness of vaccines. However, animal research is inexact due to the many assumptions made in the deposition of particles inside of the animal's respiratory system. Over the course of this two-year project, the team will construct anatomically correct upper respiratory system replicates of commonly used animals to experimentally determine the location and amount of particle deposition in the model's respiratory system. That allows them to then precisely quantify the dose received by animals. The dose information will be used to validate the mathematical models and to extrapolate from animals to humans. During year one, five monkey upper respiratory system replicates were constructed, and both total and regional particle depositions were determined. In year two, upper respiratory systems of rats and rabbits will be constructed to determine the amount and location of particle deposition.

Going Forward

The IDEAS Program has proven its value to ECBC, the warfighter and the nation since it was established in 2012 by turning the good ideas of researchers in the laboratory into actual technologies in the field. ECBC will continue the program, providing more win-wins for all concerned.

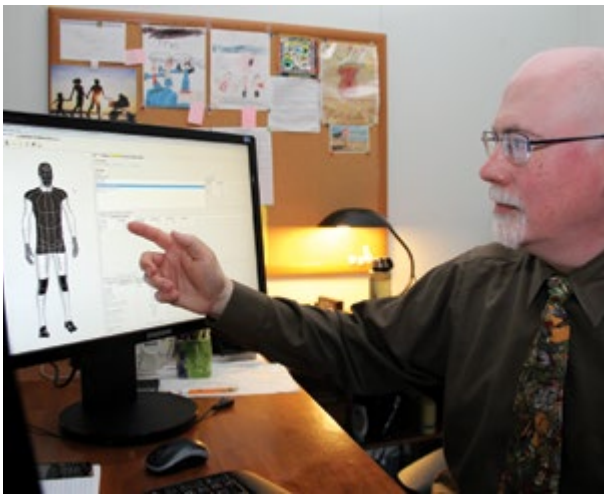
Projects

ECBC's projects to advance chemical biological defense technology cover four broad areas; protection, detection, decontamination, and elimination through field operations. These project highlights demonstrate ECBC's crucial national security role as the nation's principal research and development resource for non-medical chemical biological defense. They reveal the breadth of its scientists' and engineers' expertise in supporting all phases of the acquisition lifecycle—from basic and applied research through technology development, engineering design, equipment evaluation, product support, sustainment, field operations and demilitarization—to address ECBC customers' unique requirements.

Protection

Improving Protection Modeling

With ongoing conflicts in Iraq and Afghanistan, Department of Defense planners wanted to get the best chemical biological protection possible into the warfighters' hands. ECBC responded by developing Generation 2 Individual Protection System Performance Model which uses cutting edge software to bring individual protection ensembles to a new level of sophistication. The system has proved that it both saves money and gets improved protection into the warfighters' hands faster.



Michael Kierzewski, Branch Chief for Modeling, Simulation, and Analysis, shows how ECBC's Generation 2 Individual Protection System Performance Model gets better protection to the warfighter faster and at less cost.

The ECBC design team achieved this by modernizing their method of performance modeling to better determine the protective value of warfighters' individual protection ensembles.

"The Defense Threat Reduction Agency told us that they wanted software that could evaluate new suits while still in the design phase instead of taking the time and going to the expense of producing prototypes to test," said Michael Kierzewski, team lead and branch chief for modeling, simulation, and analysis at ECBC. "The idea was to save both time and money by narrowing down several garment designs to just the few most promising ones, as demonstrated by the software, for production and testing. It was time for the days of just testing a swatch of material and going straight to producing an IPE prototype to end."

Teamwork Made the Difference

Kierzewski pulled together a team of ECBC toxicological modelers and experimenters plus an expert in mass and flow calculation from the private sector. "What the team came up with is a software code that is much like an airflow model. It can evaluate the protective value of the materials used in a suit, plus the value of how it is tailored such as integrated cuffs and hood," he said.

"But what makes this an entirely new generation of modeling is that it can model where agent will collect in the suit over a given amount of exposure time and predict the toxicological effect of that concentration of agent on the person wearing the suit," Kierzewski said. "It also determines the amount of heat and moisture that will collect in the suit over time and predict how that will degrade the wearer's performance."

Pulling together just the right people with the right areas of expertise involved networking and collaboration-forming, and a little serendipity. "The primary investigator on the project, Christy Hoppe, had met a researcher who was also working on individual protection ensemble design and production at a technical meeting in 2013. He worked at one of our sister laboratories in the development and engineering centers network; the Natick Soldier Research, Development, and Engineering Center in Natick, Massachusetts," Kierzewski recalled.

Natick had its own DTRA project to develop an integrated protective fabric system using commercially available materials, and they had a team busy figuring how to maximize the protection value of individual protection ensembles while minimizing the wearer's heat burden. When they learned about the ECBC team's modeling capability, they immediately realized its usefulness to them.

"We got DTRA's approval to work together, and we agreed to use our model to help them better design their suits, and they agreed to perform their testing in a way that would give us better validation of our model" Kierzewski said. "It worked out well; we were pleased to find out from their data that our base model was very accurate coming out of the chute. We had to do very little tweaking to bring our model into agreement with their data."

A Four-Way Win

The exchanges turned out to be a four-way win. Natick was able to make decisions about design changes very efficiently because ECBC's model told them whether or not a particular design was likely to work before they even had to test it. That meant fewer, more focused tests. ECBC received very valuable real-world validation of the model, and the warfighter was able to get better designs fielded faster. Finally, the American taxpayer got a vital chemical biological defense product at far less expense.

Protection

Scarf-Mask Provides Immediate Protection

A prime example of a successful IDEAS Program project is the Respiratory and Eye Protection Scarf, or IREPS program. A team of ECBC researchers used the one year of funding to develop a comfortable, wrap-style respiratory protective mask for protection against riot control agents. Its big benefit is that it is as simple to put on as a surgical mask.

ECBC researchers developed the idea for the solution from special operations Soldiers. They expressed a need for a protective mask to protect against riot control agents such as 2-chlorobenzalmalononitrile, also known as CS, or tear gas. They also wanted a mask that could protect users who have beards, or must operate with other unique head-borne equipment.

Currently, users wear a traditional full general protective mask when disseminating riot agents. This mask is a hard material and the user must remove any existing equipment on their face to put it on. This process can take time that operators might not have during emergency situations.

The Integrated Respiratory and Eye Protection Scarf protects warfighters from riot-control agent, and can be stored in a pocket and donned quickly without needing to take off any other pieces of equipment.

Many Applications

"The solution we envisioned would easily integrate with the user's helmet, communications headphones and protective eyewear, so that it could provide a simple solution for all users," said Dave Caretti, an ECBC researcher assigned to the project.

The team began by researching to understand more about CS. The team then partnered with commercial vendors to get donations of materials that protect against particulates and vapors. Next, the team partnered with the ECBC engineers, and another engineering design shop experienced in making soft-good items for sportswear applications, to develop several different IREPS models that the team shared with the user community.

Simplicity of Design

The final design is a simple, comfortable wrap that can be donned without removing any head-borne gear. The wrap includes a material with one-way stretch and it can be pulled around the user's headphone ear cups, as well as the back of the protective helmet for full protection.

The filter component passed the National Institute for Occupational Safety and Health, or NIOSH, standards for protection from a CS riot control agent and demonstrated a filtration capacity of up to 140 minutes.

Protection

New Molecule Absorbs, Neutralizes Toxic Chemicals

ECBC scientists, working with Northwestern University, have developed a new molecule that can not only absorb large volumes of chemical warfare agents and toxic industrial chemicals, but also neutralize them as they are absorbed.

Like an Erector Set

This new molecule, NU-1000, is a recently created member of the metal-organic frameworks family of constructed materials. What all metal-organic frameworks have in common is that they combine organic struts such as oxygen, hydrogen and carbon; and metals, commonly copper, zinc, or zirconium, acting as nodes. The results is much like an erector set, these rods and nodes form lattice-shaped structures with large void spaces, called pores. The pores are readily filled by whatever liquid or gas flows through them, giving metal-organic frameworks phenomenal adsorption capacity.

NU-1000's improvements over prior versions of metal-organic frameworks do not end with just neutralizing what enters the molecule. It absorbs 20 times more chemical agent than its predecessors. And, it neutralizes chemical agent 80 times faster than any other molecularly designed neutralization agent created thus far. NU-1000,

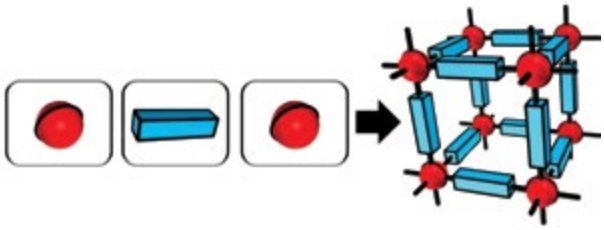
therefore, holds the potential to perform as the active ingredient in applications as varied as protective filters, decontamination powders and wipes, protective suits, and potentially elimination technologies.

With the addition of water to flush the void spaces out, these molecules do not get saturated and can keep on working. Once neutralized, the agent breakdown material can be flushed out with water – even water that the molecules themselves pull out of the air – so that the individual NU-1000 molecules can keep neutralizing more chemical agent as it enters the void spaces.

The Minds Behind the Molecules

Leading the effort to realize the full potential of metal-organic frameworks for chemical agent protection at ECBC are scientists Greg Peterson and Jared DeCoste, Ph.D. When they describe the chemical characteristics of NU-1000, the revolutionary nature of the technology become apparent.

“These modular building blocks are organic and inorganic molecular hybrids that take on the advantages of each type of compound,” said DeCoste. “The inorganic characteristics give metal-organic frameworks a very stable compartmentalized structure while the organic component gives them the dynamic quality of interacting with molecules that come into contact with them. Both the organic and inorganic components can be interchanged to create an incredible variety of structures and properties designed to absorb gases as desired for destruction or storage.”



Metal-organic frameworks are metal oxide clusters connected by organic linkers, resulting in formation of 3-dimensional, highly porous, crystalline structures – similar to polymers with repeating units.

”What makes NU-1000 different is that these crystalline structures have a larger organic linker making the void spaces larger, trapping vastly more chemical agent combined with its ability to flush and keep working.”

Fruits of a Long Research Effort

Peterson’s and DeCoste’s initial interest in metal-organic frameworks was in creating a molecule that will vastly improve upon the carbon mask filters that Soldiers and first responders have relied on since World War I.

However, in the highly technical world of chemical agent defense research, new technologies are typically developed incrementally and are a highly specific response to a particular type of chemical agent threat. Research on metal-organic frameworks is changing all that. Because of the unique chemical characteristics of metal-organic

Greg Peterson holds metal-organic frameworks in powder form as Jared DeCoste holds models of metal-organic frameworks.

frameworks generally, and NU-1000 in particular, whole new vistas of research have opened up, spanning protection, decontamination and detection of a wide range of chemical warfare agents and toxic industrial chemicals, and biological aerosols.

“Metal-organic interactions have been known for decades; however, only in the late 1990s and early 2000s did research on metal-organic frameworks boom because of the energy industry’s interest in their potential for capturing and storing hydrogen gas,” said Peterson.

“It’s been a seven-year undertaking,” said DeCoste. “We started working with milligram quantities of metal-organic frameworks — testing them for their ability to remove toxic industrial chemicals such as ammonia and sulfur dioxide. Then, working with researchers at Northwestern University, we developed theoretical calculations to model the adsorption of gases on a variety of metal-organic frameworks, allowing us to determine the theoretical loading of thousands of metal-organic frameworks for various chemicals, reducing the number of experiments we actually need to run. This effort ultimately led to the creation of NU-1000.”

But first, the metal-organic frameworks powder they created had to be rendered into granules or pellets, part science and part art, a task which Peterson and DeCoste mastered. With that breakthrough, Peterson and DeCoste were able to use NU-1000 as a component in prototypes of more advanced protective masks. They are also working with North Carolina State University to grow NU-1000 in fibers that can be used in both protective suits and as a next generation filter that can be worn like as scarf.

Decontamination Research

As Peterson and DeCoste, and their research collaborators at Northwestern University, gained more knowledge of NU-1000, applications for decontamination starting becoming apparent. They saw that it could actually decompose entire classes of chemical and toxic organic compounds on contact and in bulk, especially in the presence of moisture. But to fully exploit this characteristic, they have to find the metal-organic framework’s sweet spot.

"We are working with our university partners to design an improved version of NU-1000 with both the best pore structure for agents to enter, and the most reaction sites where the decomposition occurs. This is hard because while big pores take in large molecules, they also place the reactive sites farther apart. We're working on getting the right balance," Peterson said.

Ultimately, Peterson and DeCoste hope to develop a decontamination powder that can be used to neutralize chemical agents found in the field, and even an aerosol version that can be sprayed on a chemical agent-exposed surface such as an armored personnel carrier.

Personal protective equipment manufacturing companies have already expressed an active interest in the technology according to Peterson and DeCoste, and it is an aspect of metal-organic framework technology that could become commercially available for both the chemical biological and the medical community relatively soon.

Detection

New Self-Test Kit Provides Automated Alerts

An infantry unit goes into an area recently held by insurgents and finds evidence of a biological agent laboratory. Chemical biological experts arrive on the scene in protective suits and determine that they were weaponizing ricin. The warfighters in the unit need to know if they have been exposed, and fast. ECBC's newly developed biological self-test kit can quickly get that answer and automatically send it in to the warfighter and his commander.

Rapid Results Save Lives

Known as the Smart Colorimetric Assay Reader, or SmartCAR, the device uses a colorimetric assay, very much like a home pregnancy test strip, to identify the presence of a biological toxin or agent of concern such as ricin, anthrax or plague. The warfighter or a field medic can take a saliva or stool sample, place it in a small vial containing a reagent that will bind the pathogen of concern, then place a drop of the solution on the strip. The strip is placed inside the handheld SmartCAR which then reads whether there is one line on the strip, meaning no exposure, or two lines on the strip, indicating the presence of an agent.

ECBC's newly developed biological self-test kit, known as SmartCAR, fits into the palm of the hand, is rugged enough for the battlefield, and automatically calls in test results to the warfighter and his commander over Nett Warrior.

The SmartCAR then transmits the results over Nett Warrior, a combat operations communications system that displays tactical data on a smartphone. Information passes through Nett Warrior up the chain of command. If positive, the warfighter and field medic know to immediately begin treatment, and the information is automatically entered into the warfighter's medical record. The commander immediately knows about this individual warfighter, and if more are exposed, knows how many and where they are located. This provides the commander with vital situational awareness to cordon off the area and notify the chain of command.

"Although much of the technology in SmartCAR is commercial off-the-shelf, it is a real innovation because it is a handheld field-ready device that not only determines exposure, but provides its own data management and distribution," said Patricia Buckley, Ph.D., an ECBC research scientist on the SmartCAR development team.

Other Applications

SmartCAR is only limited by the strip assays available. It can also capture data from environmental sampling for field reconnaissance. An advance chemical biological team can take swab samples of suspicious surfaces and analyze them. By adding a device known as an impinger, an instrument for collecting samples of suspended particles by forcing them into a liquid stream, the team can also analyze air samples. This provides vital information to commanders who must decide whether or not to send units into suspect areas.

SmartCAR has important civilian applications, too. It can be brought to austere and forbidding environments to test drinking wells for water quality. A test strip that identifies the presence of Ebola could be used by medical personnel sent to control an outbreak. Its data management and distribution capabilities make it ideal for humanitarian relief mission personnel to establish restricted areas and determine resource needs.

From Requirement to Prototype

ECBC developed SmartCAR for the U.S. Army Telemedicine and Advanced Technology Research Center, known as TATRC. TATRC seeks to automate information technology for medics and sought out ECBC to develop a prototype for laboratory and field testing.

ECBC's Advanced Design and Manufacturing team used its rapid development process to manufacture the housing and contents and the software that identifies and communicates the presence of one line or two lines on the test strip. Buckley and her team have since been increasing the variety of pathogen-specific immunoassay strips that the SmartCAR can read.

Potential Synergies

Buckley hopes to ultimately combine the biological sensor capabilities of SmartCAR with another advanced ECBC technology, the VOCkit -- a handheld, field-ready chemical agent detector which also uses colorimetric assay technology. However, the VOCkit does not analyze the data itself as does SmartCAR. Rather, it automatically sends the data to a software system that uses an algorithm to compare the unknown compound to a library of known compounds.

"A combined chemical biological detection device that small, that automated, and that wide-ranging could put an incredible amount of chemical biological data literally in the palm of your hand," said Buckley. "The applications for military and civilian organizations safeguarding the public would be nearly limitless."

SmartCar interfaces with Nett Warrior to provide biological agent exposure data to warfighters rapidly.

Detection

Castle Laboratory Increases Detection Testing Distance

CASTLE, which stands for CBRNE Assessment, Science and Technology Lab at ECBC, is the Center's newest laboratory. It is designed for long-distance surface detection testing in a surety setting. Most laboratories that deal with chemical and biological testing can only test detectors from just a few inches away. In the CASTLE, researchers can test chemical and biological detectors from up to 24 meters away. This new capability will provide better assessment of detection equipment before it gets into the hands of warfighters.

In the CASTLE lab, detection systems under development can be challenged against low-volatility materials laying on surfaces, including powder, dust and liquids in various scenarios at these long distances. If a company creates a prototype that is supposed to detect the presence of chemical warfare agent from 15 meters away, CASTLE can be used to safely test that prototype against actual chemical warfare agent at various distances.

The ability to detect contaminated areas at a distance is a critical need of U.S. armed forces and first responders. It helps them evaluate whether or not a potentially contaminated area is safe without having to come in direct contact with it and risk exposure. Most detectors require the user to get close to the potentially contaminated scene. There are several detectors and methods designed for long-range detection in the works. However, in order for these to make it into the hands of the end users, the devices need to be challenged and tested in a laboratory setting like CASTLE.

CASTLE is yet another product of ECBC's IDEAS Program. A team of ECBC researchers submitted the idea for CASTLE and earned funding to stand up the CASTLE lab within three years. The CASTLE team exceeded expectations by developing the laboratory in less than a year. Currently, ECBC is using CASTLE to perform tests for the Republic of Korea, the Defense Threat Reduction Agency and the Joint Program Executive Office for Chemical and Biological Defense.

Detection

Are There Bugs in There?

Invasive insect species pose a considerable threat to the nation's agriculture and natural resources, so the stakes are high for detecting them as they travel global trade pathways. ECBC has stepped up to the challenge with advanced technology developed in the course its chemical biological defense research.

Stopping Shipments Dead on Arrival

Smaller than a grain of rice (three millimeters or less than an eighth inch long), the Khapra beetle is difficult to control and can survive nearly anywhere they are protected from cold temperatures. Preferring low-moisture foods, Khapra beetle larvae can destroy a significant proportion of unprotected grain stores due to their "dirty eating" behavior – a feeding habit where the beetle eats only a little of a single grain before moving on to others. In addition, the larvae and their byproducts are potential allergens and respiratory hazards, particularly for young children. That has made them the only product pest with quarantine status in the U.S. The discovery of even non-living life stages or other body parts of the insect automatically triggers rejection of import shipments.

A Needle in a Haystack

Current inspection methods involve targeting imports from countries where Khapra beetles are known to live, and visually examining high risk commodities. The Department of Homeland Security Customs and Border Protection Agriculture Specialists are currently required to open shipping containers in order to look for evidence of Khapra infestation. Detection of the Khapra beetle is particularly

The Khapra beetle is an invasive insect species that poses a serious threat to U.S. agriculture; ECBC is developing an inexpensive disposable sensor that can detect even trace amounts of vapors that reveal their presence in a shipping container.

challenging as the beetle is capable of living for years without food and can be found in non-food commodities such as textiles or packaging materials.

Colorimetric Sensors Replace the Naked Eye

In a project funded by the Department of Homeland Security Seedling Program, ECBC researchers in partnership with a private company are currently studying the use of colorimetric sensor arrays to detect this invasive species in shipping containers. These inexpensive, disposable sensors are approximately one square inch in size (about the size of a postage stamp) and spotted with 73 dyes which change color in response to vapor given off by Khapra beetles.

Samples are identified not by any single spot changing color, but instead by the combination of color changes across multiple spots forming a "fingerprint" that can be used to identify compounds found in a sample. The colorimetric sensor array's color changes are sensitive enough to detect even trace amounts of some vapors, allowing for a broad spectrum detection, even at vapor levels well below concentration levels attributable to health risks.

During an assay, colorimetric sensor array sensors are exposed to odors emitted into the headspace above bulk grain infested with beetles. Over time, changes in the colored spot patterns emerge, and by using special software designed specifically for this project, unique color fingerprints are revealed and included in a reference library. The goal of the project is the development of unique and individual spot patterns capable of differentiating between invasive, quarantined Khapra beetle infestation and other non-invasive species.

Remote Detection

Since detection of infestation is based on vapor signatures within a closed container, this method has the potential of allowing infested cargo to be sequestered prior to being opened. Ultimately, this technology could transition into a self-contained sampling and detection unit that could wirelessly transmit results to a smart phone for analysis.

ECBC envisions a solution where an inexpensive, disposable reader could be placed within a crate prior to shipment, then later queried by a smart phone to allow inspectors at the port of destination to assess food security and quality without ever having to open the container.

Detection

ECBC Seeks to Identify Chemicals in Fingerprints

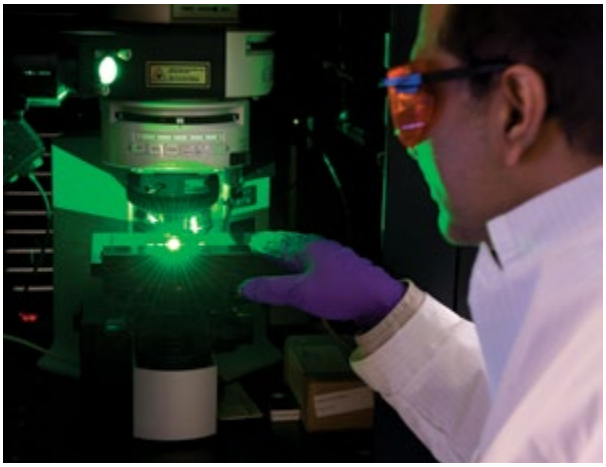
ECBC is on the forefront of chemical detection and is currently developing a new detection system with an industry partner that will specifically detect and identify traces of dangerous materials within fingerprints. Over four years, ECBC established a unique library of fingerprint algorithms that can identify chemical materials within a fingerprint. Now, ECBC has a vendor building two prototypes for a first-of-its-kind Chemical Fingerprint Imaging System for ECBC to begin testing upon delivery.

Filling a Critical Gap

ECBC anticipates that the device will fill a critical gap in fixed and portable laboratory detection technology, as there is currently no stand-alone equipment that can both detect and identify chemical materials and collect fingerprints.

Fingerprints can be a difficult surface from which to collect evidence, but can also be rich in information based on the substances found in them. These include perspiration and residue from non-harmful chemicals such as hand soaps and lotions. In order to design a fingerprint imaging system that will detect and identify chemicals, the system needs to have all of the right optics for this type of complex deciphering.

"In many other types of fingerprint detectors, the fingerprints can be destroyed in the detection process," said Augustus W. Fountain III, Ph.D., ECBC's senior research scientist and the system's program lead. "We wanted the system to



ECBC is using Raman chemical imaging technology to develop a device that can be used by warfighters to identify explosives by type without compromising the fingerprints at the scene of the event.

be able to perform the detection without the sample being altered or destroyed."

A Battlefield View

ECBC began investigating the concept of sophisticated chemical fingerprint imaging in 2010 as a part of an Army Technology Objective. The project began shortly after Fountain returned to the U.S. after serving in Iraq as the combined explosives exploitation cell chief scientist. While in Iraq, Fountain worked closely with counter improvised explosive device programs, and saw the need for better methods to identify and detect the presence of any illicit material in the field.

Through the Army Technology Objective and follow-up funding, ECBC collaborated with the U.S. Army Criminal Investigation Laboratory (USACIL) located at Fort Gillem, Ga. to begin research. The key to this type of chemical identification was to not only be able to get a biometric match of the chemical image, but also to be able to identify chemicals collocated in a fingerprint to unambiguously identify that a bad actor had been building a bomb or handling illicit materials such as drugs, explosives or any chemicals of interest.

"We look forward to receiving and testing the two prototypes," Fountain said. "With them, we can see this concept become something we can hold and test, and eventually be transitioned into the hands of our law enforcement customers and warfighters."

Detection

Decoding DNA in the Palm Of Your Hand

ECBC is researching the use of a palm-sized nanopore-based genetic sequencer that could be used as a mobile diagnostic tool. Ultimately, warfighters could use this highly portable capability to perform biological analysis of a threat area in near real time. This is yet another successful IDEAS Program project.

A team made up of researchers from ECBC and private industry discovered this promising new field deployable detection and surveillance capability after just six months of research, coming up with the MinION™ Nanopore sequencer.

Going Mobile

The research team saw that it had the capacity to accurately identify a range of closely-related bacteria and viruses within six hours. And, they demonstrated the potential for this technology to be used as a mobile diagnostic kit during bacterial and viral outbreaks. The team's findings were published in the March 2015 edition of the journal Gigascience.

"Being able to accurately identify and characterize strains of viruses and bacteria using a mobile platform is attractive to anyone collecting biological samples in the field," said the ECBC team lead, Andrew Kilianski. "And we expect that as the technology improves, the sequencing will generally become cheaper, faster and more accurate, and could have further clinical applications"

The low-cost palm-sized sequencing device is powered and operated through a USB connection plugged into a laptop, which means that it could potentially be used for on-site clinical analyses in remote locations.

ECBC is working with a revolutionary new DNA sequencer, known as the MinION™ which fits into the palm of the hand and is perfect for use in remote locations to characterize strains of viruses and bacteria by determining their genetic fingerprint.

Passing the Test

The researchers were able to use the MinION™ to accurately identify and differentiate viral and bacterial species from samples. Within six hours, the device generated sufficient data to identify an E. coli sample down to species level, and three poxviruses (cowpox, vaccinia-MVA, and vaccinia- Lister) down to strain level. The device was able to distinguish between the two vaccinia strains despite them being closely related and over 98 percent similar to each other.

The technology relies on protein 'nanopores' to determine the sequence of a strand of DNA. At the core of the protein is a hollow tube only a few nanometres in diameter, through which a single DNA strands can pass. As the DNA strand passes through the nanopore, it causes characteristic electrical signatures, from which bases can be identified, and the sequence of the strand determined.

A Bright Future

The next phase of its development is being funded by ECBC's IDEAS program. The ECBC team and its private industry partners will determine if the hand-held MinION™ nanopore sequencer can act as a fieldable platform for deployment during an outbreak.

In collaboration with the Broad Institute, the Public Health Agency of Canada, NIH NIAID, and USAMRIID, samples collected from W. Africa will be sequenced using the MinION™. These experiments will test if the current and future versions of nanopore sequencing technology can

be used to rapidly identify and characterize Ebola virus in samples that might be encountered in the field by forward deployed personnel.

Detection

Drone to Support Sampling, Detection

When it comes to investigating a chemical, biological, radiological, nuclear, or explosive (CBRNE) threat, the more distance from it the better for the warfighters and first responders whose job it is to observe and assess these threats. So for those personnel, the customized unmanned aircraft systems ECBC is developing to get the job done remotely can be a lifesaver.

The systems have the capability to transmit images of the scene, maneuver into small spaces, use sensors to take readings, and collect samples.

“This has been an ongoing effort for the past two years,” said Mark Colgan, leader of ECBC’s Unmanned Systems Team. “We’ve made a lot of advances in the last year with modular payloads, sensors, and detectors, and we are continuing to expand the platform and payload capabilities.”

ECBC's Unmanned Systems Team researched and evaluated commercial off-the-shelf (COTS) unmanned aircraft systems, and then made its own version, including the innovation of using a circuit board to act as the structural frame.

Building a Better Drone

Internal development of the latest ECBC unmanned aircraft system, or drone, began when DTRA had a requirement to transport and remotely deliver a five-pound payload. An initial evaluation found that existing commercial unmanned aircraft systems were insufficient—they either couldn’t lift enough weight, or they were too large for the mission space and logistical constraints. The customer was looking for a system that was man-portable and quick to deploy.

“We started by researching and evaluating commercial off-the-shelf (COTS) unmanned aircraft systems, and then made our own version,” explained John Sparks, leader of the ECBC Electrical Integration Team. “We discovered that we could use a circuit board to act as the structural frame. Using the circuit board made the assembly easier and helped with the overall weight of the prototype. Traditional unmanned aircraft systems are made with wires that can get tangled and create electrical interference. Circuit boards make it a lot cleaner.”

In addition to developing the airframe, ECBC engineers, technicians, and machinists developed an electro-mechanical device to remotely release the payload once the unmanned aircraft system had completed a precision landing. This payload release mechanism has been adapted and used as an interface for modular CBRNE sensors and collectors.

Help from Additive Manufacturing

An integrated project team was formed including employees from several teams, branches, and divisions at ECBC. They used ECBC’s rapid engineering design and additive manufacturing (3-D printing) capabilities to fabricate the unmanned aircraft system.

“Initially we were just using 3-D printing for prototyping, and then we realized the 3-D arms we created worked really well, and it was convenient because we could print them on demand,” said Harold Wylie, an ECBC industrial designer. Wylie noted that the ability to quickly create replacement parts or make adjustments to the design in real time, while keeping costs down, is invaluable to the customer, which is why the team started using 3-D printing for fabrication of the system.

This unmanned aircraft system is a “quad-copter” design which uses four propellers to achieve vertical take-off and landing. ECBC’s system consists of two stacked printed circuit boards which serve as the core frame, power distribution, and component mounting structure. One-piece arms fasten to the core frame, providing the separation distance necessary for each motor and propeller. A variety of autopilot control systems can be mounted and configured for this platform; the current flight configuration uses a low-cost COTS system which is easily adapted for different missions. A rigid shell provides protection and contains the electrical systems and COTS lithium polymer batteries.

This emerging capability is encouraging different methods and ways of thinking, according to Corey Piepenburg, a mechanical engineer on the project. “A good example is that you can attach a surveying instrument to the unmanned aircraft systems we’re developing. Currently, surveying instruments are mounted on a pole and carried around by a Soldier who surveys the area. By using the unmanned aircraft system to do it, not only are you not putting anyone in harm’s way, you can also survey a larger area at one time.”

Different Interfaces for Different Payloads

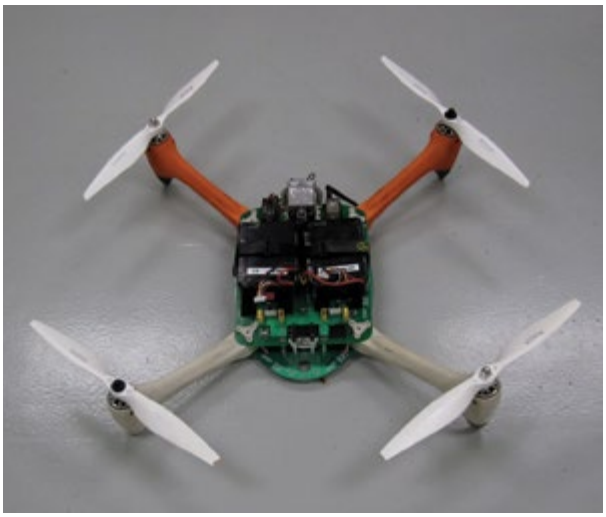
After they built the initial unmanned aircraft system to meet the payload lifting requirement, the team created and adapted a modular payload interface that would allow a variety of payloads to integrate with it. Another type of a payload is a solid sample collection device carried by the unmanned aircraft system directly to the CBRNE threat where a sample can be collected and flown back for testing.

Yet another type of payload is using the unmanned aircraft system to quickly fly needed supplies in an emergency situation. “We can integrate payloads to satisfy a broad range of mission needs,” said Sparks. “The possibilities are endless.”

Now the team regularly conducts flight evaluations of new vehicles and payloads, and hosts unmanned aircraft system demonstrations for current and potential customers at ECBC facilities.

On the Horizon

Next steps include increasing both the unmanned aircraft system’s payload carrying capacity and flight time. The team also plans to make some design changes to improve portability and transportability, and reduce set-up time. Ultimately, the team would like to see the system become as regular a part of CBRNE responders’ toolkits as their personal protective suit and communications gear.



ECBC used its rapid engineering design and additive manufacturing (3-D printing) capabilities to fabricate the unmanned aircraft system.

Decontamination

Researchers Modify Standard Cleaning Compound

When it comes to the chemical warfare agent decontamination of military vehicles, the deeper the clean the better. To do that, ECBC researchers first had to develop a better understanding of exactly how VX nerve agent is absorbed by the rubbery silicon-like polymer coated on military vehicles for their protection.

“Liquid agent doesn’t just sit on the surface of a material, some of it gets absorbed into the material by undergoing molecular diffusion into the inside or bulk of the material,” said Brent Mantooth,Ph.D., an ECBC research chemist and principal investigator for this project. “And, no matter how fast a decontaminant may work on an exposed liquid, the real challenge is getting to and removing the agent that was absorbed into the material. If there’s agent inside the material, there’s no interaction between the agent and the decontaminant, and the material will not get decontaminated.”

Adding Methanol to the Standard Decon Formula

To study how decontaminants can best come into contact with agent absorbed in materials, Mantooth and his team started with a decontaminant solution of sodium hydroxide and added various amounts of methanol to it. Methanol is a solvent that VX agent is partially soluble in, and methanol also absorbs into materials like silicone, allowing part of the decontaminant solution to access the agent absorbed in the material.

As it turns out, methanol’s presence slows down the decontamination reaction, which occurs only with the sodium hydroxide in the liquid phase on the material’s surface. However, as it absorbs into the silicone solid, methanol increases the diffusion rate of VX out of the material, moving the agent from the material up to the decontaminant, allowing the reaction to occur in the liquid on the surface.

A Slower Reaction Rate Turns Out to Be Better

“For a long time, researchers have focused on increasing the liquid reaction rate of a decontaminant to improve performance. By modeling what a drop of VX does on a silicone surface, we realized that the liquid phase on the surface is only one piece of a larger picture,” Mantooth said.

This solves a long-time conundrum in decontamination research. After a contaminated surface gets decontaminated, the remaining chemical warfare agent still inside the material will gradually migrate to the surface where it is emitted from the material, generating the inhalation and contact hazards that were present prior to decontamination. Sacrificing a little speed in the decontamination reaction rate is well worth the benefit of pulling the absorbed agent to the surface faster, leading to a more efficient and more complete decontamination of the material.

“We’ve been modeling what happens with the diffusion of VX on silicone, and we’ve been trying different decontamination blends to maximize performance,” said Mantooth. “We build computational models to simulate the process of agent absorption and diffusion to the surface which we further refine using data from experiments in the lab.”

Delving Into the ‘Why’

Mantooth and his colleagues believe that it is not enough just to know that adding methanol to a decontaminant makes it work better, it is essential to know why. This leap from research centered upon reaction rates in the liquid phase to a holistic view of agent dynamics and transport is just the start. They are on a long-term quest to understand

exactly what chemistries work best on different kinds of surfaces and materials. They do this by modeling the entire process to help identify the chemistries that would improve decontamination methods.

“Currently warfighters are using the same hot, soapy water or bleach to decontaminate surfaces that has been used since World War II. The efforts of our team to develop a real understanding of agent transport dynamics on the molecular level will bring decontamination technology into the 21st Century,” Mantooth concluded.

Operations

ECBC Supports Pueblo Stockpile Destruction

ECBC’s CBARR Business Unit spent much of 2015 at the Pueblo Chemical Depot in Pueblo, Colorado. The field operators CBARR sent there provided support to the Program Executive Office Assembled Chemical Weapons Alternatives, or PEO ACWA, chemical agent destruction pilot plant known as the Pueblo Chemical Agent-Destruction Pilot Plant or PCAPP.

ECBC was there to safely destroy 560 “overpacked” chemical weapons and steel cylinders containing mustard agent using the Explosive Destruction System. These weapons and cylinders had been previously sampled or leaked in the past, rendering them unsuitable for destruction using the main plant’s automated processing systems. PCAPP is in the process of destroying the remainder of the 2,600 tons of weaponized mustard agent stored there.

The Obvious Choice

When PEO ACWA needed outside help to handle the unsuitable munitions, the U.S. Army Chemical Materials Activity's Explosive Destruction System operated by ECBC was the obvious choice. “We looked closely at cost, schedule and technical factors,” said the program’s executive officer, Conrad F. Whyne. “We found that the Explosive Destruction System is fully capable of doing the work we need it to do, while offering the best overall value to the taxpayer.”

The Explosive Destruction System, known as the EDS, seals munitions inside a steel chamber, then uses explosives to access the contents of the munition, expose the chemical agent and destroy the burster. Chemicals are then added to the chamber to neutralize the munition’s fill of chemical agent. The blast, vapor and fragments are all contained inside the stainless steel chamber, where destruction of the chemical agent is confirmed by CBARR operators who provide onsite sampling and analysis of the residual liquid and air inside.

A Collaborative Effort

Arranging for ECBC’s support was a collaboration from the start. The Chemical Materials Activity engaged ECBC technical operators throughout the design process of the neutralization technology to gain the critical insights necessary for how best to use the EDS.

“Instead of waiting until the end to bring in ECBC operators, we invited them in early on in design meetings,” said Allan Caplan, lead research and development specialist for the Joint Project Manager for Elimination. “They’ve tested out prototypes and provided direct feedback that has influenced the modifications we’ve made to the Explosive Destruction System. There was a good exchange of ideas and a lot of compromise, but in the end we had a faster design process and a safer product that is more intuitive to use.”

CBARR was selected by the U.S. Army Chemical Materials Activity to operate the Explosive Destruction System at the Pueblo Chemical Agent Pilot Plant near Pueblo, Colo.

Constant Modification and Improvement

One of the most time-consuming steps in using the EDS was opening and closing the steel vessel using a traditional two-piece clamp. Continuous monitoring of operators vitals showed this labor-intensive activity put the most stress on the operators, who are dressed in full personal protective equipment working in hot or cold environments, depending on the location.

“We took the most physical aspect of the operation and automated it,” Caplan said. “We came up with a new closing mechanism that cuts down on the stress of the crew, allowing them to have more energy throughout the day. It also takes a process that originally took 30 minutes, and cuts it in half.”

The modified EDS also uses larger pumps for faster addition of liquid and uses pressurization for faster draining once the chemical agent has been neutralized, and injection of chilled water for faster cooling. What used to take 12 hours overnight now takes about 30 minutes, returning the chamber to cooler temperatures so operators can safely prepare the system for the next round of munitions.

Ongoing Support

CBARR Operations Business Manager Tom Rosso said the campaign that recently concluded was just the first in a series designed to support the ACWA program's main plant. Future campaigns will follow each of the three munitions campaigns: 155-millimeter and 105-millimeter projectiles, 4.2-inch mortars, as well as any explosive components found to be agent contaminated. "We expect to be operating the EDS well after the last munition is processed in the main plant sometime in 2019," he said.

Operations

Training EPA Responders

The Environmental Protection Agency's (EPA) on-scene coordinators have a well-earned reputation of being highly skilled in responding to oil spills and hazardous substance releases. When the EPA planners began looking to expand their expertise to chemical and biological warfare agents, they turned to ECBC for the specialized training that only an organization with decades of real-world chemical and biological remediation experience can provide.

To get that training, a group of 38 on-scene coordinators from EPA Regions III and V participated in a three-day chemical and biological agent response and recovery course Oct. 6-8, 2015 at ECBC facilities in Aberdeen Proving Ground, Md. A day of classroom instruction was followed by two days of entries in Level A personal protective equipment, known as PPEs, into a mock chemical warfare agent laboratory inside of what looked like a typical single family home.

In reality, the home was constructed inside a warehouse, and was outfitted with cameras to allow instructors to monitor the students' actions. The instructors included biologist Carrie Poore, Ph.D., ECBC's Training Team leader, and members of the CBARR Business Unit.

Sharing Real-World Experience

"ECBC has done everything in the field that it taught to the class of EPA on-scene coordinators" said Brian O'Donnell, ECBC senior project manager and one of the organizers of the training. This experience includes closing several U.S. chemical stockpile sites, assessing and monitoring CWA storage sites on mountainsides in Albania, searching the ocean floor for chemical munitions off the coast of Hawaii, and most recently, destroying Syria's declared chemical weapons stockpile at sea in the hold of a ship.

ECBC instructors used this experience to customize their training to the EPA's specific needs. The classroom portion of the training covered the advanced instrumentation required to identify the presence of chemical or biological agent and then how to sample and characterize a site.

Planning is Critical

The true value of ECBC's real-world experience became apparent as the instructors addressed the one truth common to all complex undertakings; the devil is in the details, and it is best exorcized through very thorough planning. Seemingly little things can seriously impede a response and recovery, things as simple as not having enough polyethylene drums to contain contaminated materials, not having enough roll-offs to remove the waste, and overlooking advanced coordination with even one of the many jurisdictions through which waste-hauling trucks will have to pass to reach the waste disposal facility.

Making it Seem Real

The class spent the next two days responding to a realistic chemical warfare agent incident scenario that ECBC carefully planned with EPA Region III to address their specific training needs. The mock single family home constructed inside an APG warehouse was staged to look like a home laboratory in which terrorists were loading mustard agent into fire extinguishers for later use in a planned attack. However, in the scenario, they over-pressurized one of the fire extinguishers and it erupted, spraying mustard agent in the house. The scenario included one of the terrorists running out of the house carrying the leaking fire extinguisher and dropping it in the driveway.

The EPA on-scene coordinators planned and executed series of entries into the mock home wearing Level A PPE, while ECBC evaluators looked on. The entrants' tasks included an initial entry in which they surveyed the scene and identified the presence of chemical warfare agent. They delineated the contamination spots using hand-held monitors, communicated contaminated locations to the command post outside and marked them with tape. They then used the rest of their one-hour' worth of air to perform gross decontamination. Every entry was followed by medical monitoring of the entrants, duplicating standard practice in actual incident responses.

Building Win-Win Relationships

"This training offered us something we don't usually get — very specific instruction in chemical and biological agent response and recovery techniques taught by people who have done it all," said Charlie Fitzsimmons, an EPA on-scene coordinator posted at Fort Meade, Md. "Theory can't replace the ECBC instructors' on-the ground experience; they have tried and true methods we can adopt."

Two EPA on-scene coordinators enter a mock home chemical warfare agent laboratory in Level A PPE during the ECBC training.

Future

ECBC's Future Depends on its People

No matter how technologically advanced ECBC's current chemical and biological agent defense research may be, the Center always looks to the future by investing in people; both those people currently working at the Center and a new generation of well-trained researchers who will succeed them one day.

ECBC has established programs that invest in the scientific training of the next generation, from elementary school all the way through post-doctoral degrees. ECBC programs that invest in its own researchers include those that further their technological knowledge and those that promote cross-discipline awareness and collaboration.

STEM Outreach:
Creating a Sense of Awe

"Nothing warms your heart or measures the success of an activity more than a class full of third grade students gasping with excitement and disbelief the first time they look through a contraption they made out of everyday household items and see it magically transform white light into a rainbow," said Nicole McKew, an ECBC scientist and science, technology, engineering and math (STEM) outreach coordinator. In this case that everyday object was a cardboard paper towel tube that she had the students turn into a kaleidoscope using aluminum foil and prism paper.

Another example is teaching high school students to use a compact disc as a reflector shining light onto a webcam. The webcam sends the reflected light into a computer through the webcam's USB cable. Using a simple software program, the students can see that light on the computer screen translated into wavelength data which they can then calibrate into known chemical compounds.

"When presented with this odd collection of random components that could do something as powerful and precise as visible light spectrometry on a computer, they were truly awed," said Casey Weininger, ECBC scientist and STEM outreach specialist. "The experiment showed them that a little ingenuity can put real-life science in the hands of anyone who takes an interest in it."

In addition to performing scientist-in-the classroom activities, ECBC volunteers also help students with career exploration, help teachers with curriculum development, serve as guest lecturers and mentors, and serve as judges at school science fairs. They also help develop STEM learning modules, provide summer camp support, help teachers with their STEM professional development, and invite teachers to ECBC for hands-on tours of its facilities.

Reaching Thousands of Students

During the 2014-2015 school years ECBC planned, designed, and executed education initiatives that helped teachers meet the Maryland Common Core Curriculum requirements. ECBC volunteers implemented the "Engineering is Elementary" STEM curriculum. Elementary age students took part in hands on classroom activities to develop agricultural, chemical, electrical, environmental and material engineering skills.

In 2015, more than 50 ECBC volunteers reached more than 9,000 students in 20 schools and worked with nearly 300 teachers. Also in 2015, ECBC's STEM outreach team designed and implemented over a dozen new activities to complement the Next Generation Science Standards.

Sharing Knowledge:
Mentoring Minority Students

The men and women who perform research at ECBC also give back. They serve as mentors to undergraduate, graduate, and postgraduate students. Students from colleges and universities around the country come to ECBC through three separate internship programs; ECBC's ten-week summer Minority Undergraduate Student Internship Program, known as MUSIP; the Oak Ridge Institute of Science and Education Program, known as ORISE; and the National Research Council Associateships Postdoctoral and Senior Research Awards.

In 2015, 38 students from over two dozen colleges and universities worked one-on-one with ECBC scientists and engineers on projects as varied as designing the next generation chemical detector, development of a human 3D liver model for toxicity testing, and understanding the biological threat posed by suicide bombers.

"We are all grabbing onto this opportunity," said Imani Love, an environmental sciences major at Spelman College and a second-year MUSIP intern. "We see the importance of ECBC's mission, and we want to learn how to protect the warfighters who protect us.

Another MUSIP intern, Lauren Amrhein from the University of Maryland did not know the field she studied with her mentor, aerosol sciences, even existed before coming to ECBC. "It's a huge field, and it's important," she said. "It fits right in with my love for modeling how things flow by writing equations. However, I discovered at ECBC that you can learn all the theory you want, but you can't know what's really going on except through hands-on experimentation, it's often different than what you expect from just theory."

Recruiting the Best:
The Research Associate Program

The National Research Council Research Associate Program provides an opportunity for postdoctoral

students of unusual promise to work at sponsoring federal laboratories where they perform advanced research.

The benefits of this program go both ways. According to Christopher Karwacki, Ph.D., an ECBC scientist who mentored two National Research Council postdoctoral scientists in 2015, “The researchers we work with through this program have significantly improved our ability to pursue new research initiatives in nanostructured materials. Their contributions are critical to development of improved capabilities for the warfighter."

ECBC's School of Choice Program: Opportunities for Employee Growth

ECBC invests in the professional growth of its personnel. The ECBC offers its employees a chance to participate in the Section 219 School of Choice program. It is a competitive program that provides members of the ECBC workforce an opportunity to enhance their knowledge and skills by funding Bachelor's, Master's, and Ph.D. level academic training courses at nationally accredited colleges and universities. Academic courses are directly related to the performance of official duties and must contribute to meeting the goals of ECBC’s strategic plan.

ECBC's Employee Mentoring Program

ECBC also provides professional growth opportunities within the organization. From February through June 2015 a group of 16 employees selected from across the Center participated in ECBC’s Mentor Program. The program paired experienced ECBC leaders and managers with mentees. The mentees were given further insight into the mission, functions, policies and people of ECBC, and taught to foster collaboration and teamwork through networking opportunities among mentors and other mentees. The mentees were purposely paired with mentors from another of ECBC’s three directorates to expand networks and knowledge across the Center. The program consisted of an orientation plus five sessions on specific topics, such as self-awareness, leadership potential, generational differences, and entrepreneurship. Mentors and mentees were encouraged to meet regularly in between sessions to discuss the program, grow their relationship and develop paths toward personal and professional growth.

“The Mentoring Program promoted growth towards my career path,” said Catherine Sabol, a biologist in the Research and Technology Directorate who was assigned to a mentor in the Engineering Directorate. “I was able to shadow my mentor and gain insights into a directorate I wasn't too familiar with even though I’ve worked here for ten years. I also participated in several group activities with peers from all over the organization and made a lot of new contacts. But most important, I have remained close to my mentor now that the program ended, and I regularly turn to him for career advance.”

Engaging Minority College Students in STEM Research

In 2015, the ECBC was proud to award $2 million in research grants to minority serving institutions to pursue promising new areas of chemical biological weapons defense research. ECBC provided this money with two goals in mind; adding to national security through advanced chemical and biological defense research and engaging a largely untapped pool of college-level minority students in defense-related science and technology.

Minority STEM students are an important resource for developing new chemical biological defense technology.

To create a structure for funding these research opportunities, ECBC worked with the United Negro College Fund Special Programs Corporation over four years and together they established the MSI STEM Research & Development Consortium. The initiative has attracted membership from institutions across the country that have traditionally served minority students, including African Americans, Latinos, Native Americans, and Alaskan natives.

A technical committee of ECBC scientific experts, faculty from participating schools, and experts from private industry solicit white papers from member institutions based on established technology requirements for chemical biological research that the committee develops. The committee then reviews the white papers and the most promising ones lead to requests for specific proposals to perform the research described in the white paper.

In May 2015 the technical committee sent out its first call for white papers. By now the consortium had 23 members, including such well known schools as Howard University, Morehouse College and Tuskegee University. The call for white papers received 27 responses in research areas including chemical and biological sensing, chemical and biological protection, predictive toxicology, and smoke and obscuration.

ECBC secured $1 million in funding from the Assistant Secretary of Defense for Nuclear, Chemical and Biological Defense Programs and another $1 million from DTRA. With that funding, the committee selected four papers on chemical biological sensing and four papers on chemical biological protection for follow-on proposals.

ECBC awarded six one-year projects in September 2015. The research grants ranged from $80 thousand to $280 thousand. ECBC scientists provide guidance and mentoring to the student researchers over the course of the year, and the teams will provide ECBC with quarterly progress reports. At the end of the year, each team provides ECBC with a knowledge product such as a technical paper, a laboratory presentation, or a newly developed chemical or biological protection material.

Safety

ECBC Serves as DoD's Biosafety Experts

ECBC has quietly but effectively established and managed safety and surety protocols for biological agent defense research ever since it began performing research on these deadly agents after World War II. It was no surprise then, when after another DoD laboratory inadvertently shipped low concentration samples of live anthrax to laboratories in the United States and several foreign countries, DoD leaders turned to ECBC for help.

A Call for Leadership

When DoD senior leaders learned of the error they promptly established a Biosafety Task Force to ensure the long-term safety and security of all biological agents at DoD laboratories. The task force established four working groups. ECBC Director Joseph Corriveau, Ph.D., was placed in charge of the working group responsible for developing and testing a methodology for effectively killing anthrax spores by gamma irradiation. He is being closely supported Henry Gibbons, Ph.D., an ECBC research microbiologist.

Corriveau and Gibbons are collaborating with subject matter experts from other DoD laboratories that have biosafety missions, learning about the best practices that each has to offer and combining them into a single standardized methodology for the certain inactivation of the spores through irradiation plus a validation method that ensures that all the spores are killed every time.

“It is an honor to be able to get to have a meaningful role in improving the nation’s biological defense,” said Gibbons. “Everyone at ECBC works so hard every day at having the best biological agent safety and surety practices possible, it feels great to have that acknowledged by the highest levels of the DoD in giving us this role.”

Off to a Running Start

Since the working group was set up in the summer of 2015, they have established standard procedures for calibrating the equipment used to irradiate the spores, they have developed criteria for evaluating an organization’s capability to perform the task, they have written guidance for generating the documentation to accompany the shipment of irradiated spores, and they have established protocols for surface sampling inside laboratories that handle anthrax.

In 2016, working with their partner organizations, the United States Army Medical Research Institute of Infectious Diseases and Naval Surface Warfare Center - Dahlgren, Va, ECBC will conduct extensive tests on the working group’s proposed standardized anthrax spore irradiation and validation protocol in preparation for DoD-wide implementation.

A Dream Team of Experts

“All the experts I work with at our sister agencies as we develop this protocol are among the best biological agent researchers in the world,” said Corriveau. “It’s a thrill to manage a team with that much brain power. When we’re done, we’re going to have a protocol that everyone can be proud of, and one that will raise the bar for researchers around the world.”

The other three Task Force working groups have important tasks, too, and ECBC researchers are represented on each of them. There is a working group stood up to understand biological agent user requirements, another to take a fresh look at DoD’s overall biological agent research and development infrastructure, and still another that is establishing the U.S. Army Office of the Surgeon General to act as the Army’s executive agent for biological agent safety and surety.

Finally, DoD senior leaders are standing up a Biosafety Peer Review Panel to closely examine the standard operating procedures of each of the DoD laboratories engaged in biological agent research, development, and testing to ensure consistency across their length and breadth. ECBC will have both a research scientist and a risk management expert on the panel.

“This is an enormous undertaking,” said Corriveau, “and I am proud to say that ECBC is at the forefront of the analysis and decision making for this vital effort.”

2015 ECBC Safety Awards

Industrial Operations Safety Award
Presented to ECBC by U.S. Army Materiel Command for outstanding achievement in demonstrating a strong commitment to improving their safety culture.

Exceptional Organization Safety Award
Presented to ECBC by U.S. Army Materiel Command for exceptional achievement in leading a joint mission to safely destroy Syria's declared stockpile of chemicals.

2015 Director of the Army Safety Risk Management Award
Presented to ECBC by the U.S. Army in recognition of a significant contribution to Army readiness in maintaining a perfect safety record while installing its land-based Field Deployment Hydrolysis System inside the limited hold of a cargo ship, and then successfully destroying the chemical agent at sea in just 42 days.

Agility

Innovation, Agility Key to ECBC's Future

In the ever-changing arena of chemical and biological defense, innovation and agility are the keys to preparing for the future. Our nation's enemies are constantly devising new ways to harm us, and we must remain agile in order to stay ahead of them in a rapidly evolving and complex world.

An agile organization has the ability to adapt to a changing environment, and we've seen tremendous change in the bio-safety environment over the past year. Of the changes recommended by the Army's Bio-Safety Task Force, one of the most dramatic is the realignment of the Life Sciences Division of Dugway Proving Ground's West Desert Test Center from the U.S. Army Test and Evaluation Command to the U.S. Army Research and Development Command's Edgewood Chemical Biological Center.

The Life Sciences Division has an amazing infrastructure supporting a complex mission serving government agencies involved in biological defense. I'm honored to have the opportunity to lead the people of the Life Sciences Division. We will spend 2016 and beyond working to integrate the Life Sciences Division into ECBC.

Our innovation and agility lie within our people. The ECBC workforce at Aberdeen Proving Ground, Rock Island Arsenal, Pine Bluff Arsenal and Dugway Proving Ground is focused on advancing the frontiers of chemical and biological defense research in order to bring innovative solutions to bear against the threat of chemical and biological weapons. Our workforce is agile and able to respond to current and future threats with quality products and services delivered in time to make a difference.

I'm proud of the work that's been accomplished across all of our campuses nationwide. We have a lot more work to do, as we continue developing technologies to protect our warfighters and homeland from chemical and biological threats. We'll accomplish that work safely. We'll accomplish that work as a team.

Joseph L. Corriveau

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