2014 Annual Report

Solutions

U.S. Army Edgewood Chemical Biological Center

Approved for Public Release

Message from Director

Joseph L. Corriveau, Ph.D.
ECBC Director

It was a banner year for more than 1,400 world class scientists, engineers and support personnel of the U.S. Army Edgewood Chemical Biological Center (ECBC). The Center made international news by fielding and operating an innovative mobile destruction technology it designed and built to destroy more than 600 metric tons of Syrian declared chemical warefare material aboard a ship in international waters. However, this was only one of many outstanding projects that ECBC's scientists and engineers worked on this year to counter chemical and biological (CB) threats to our Warfighters and the homeland.

In this year's edition of Solutions, we present ECBC's accomplishments under our core technical competencies. These competencies enable the Center to fulfill it's unique role in providing value and peace of mind to the nation. ECBC provides the full range of the technology development – from basic and applied research to engineering development to full production, fielding and sustainment of CB Equipment. What these accomplishments have in common is the application of innovative solutions to counter existing and expanding chemical and biological threats. This innovation is made possible by ECBC's agile workforce, our most valuable and enduring resource. This issue of Solutions will introduce you to some of those employees who have made 2014 a highly successful year for ECBC.

> "[ECBC's] **cutting edge infrastructure** helps us to meet **existing** and **emerging threats** throughout the **world**"

You will also learn how our cutting edge infrastructure helps us to counter existing and emerging threats throughout the world. Included in our infrastructure is a recently completed wing of our Advanced Chemistry Laboratory (ACL), where some of the critical work to characterize the most toxic compounds known to man is performed on a daily basis.

In 2014, ECBC also made important contributions to the community and invested in the future workforce of our nation. We continued to send our scientists and engineers into classrooms to engage students in science, technology, engineering and math (STEM) education activities. ECBC also entered into a Cooperative Agreement with the Minority Serving Institutions STEM Consortium to provide historically black colleges and universities with opportunities to participate in national security projects with ECBC.

It is our great honor and privilege to serve the Warfighters who keep our nation safe. They are the ultimate consumers for all of the knowledge we discover and the equipment we develop. That has been our benchmark since 1917, when we first opened our doors as Edgewood Arsenal, and it continues to guide us into the future. ○

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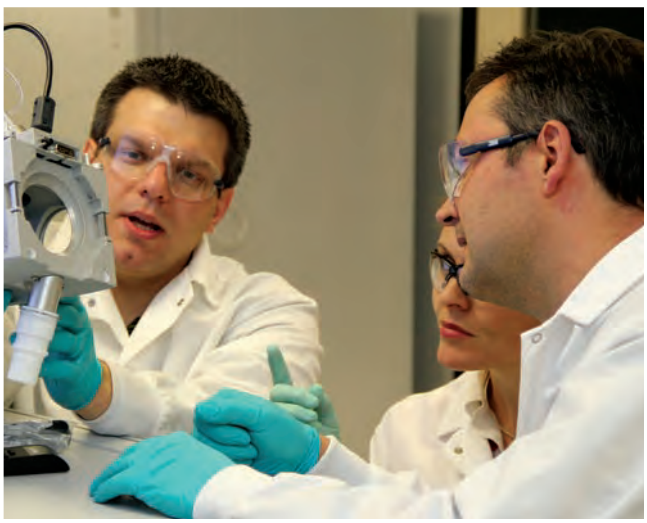

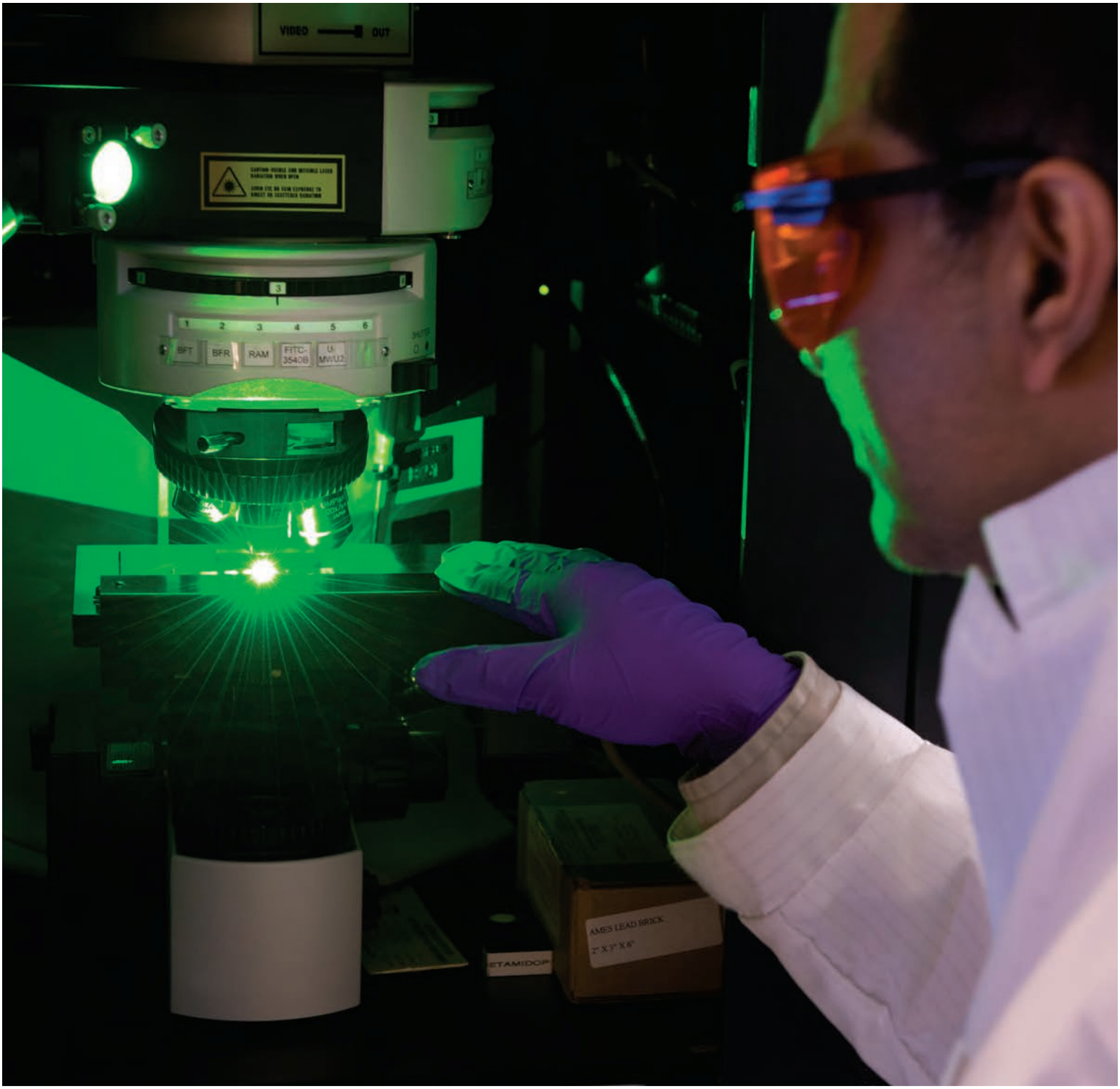
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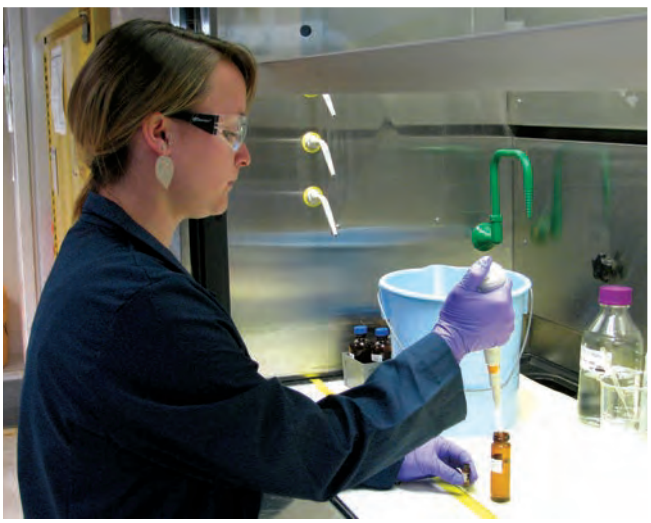



POPCORN

Introduction

ECBC is one of a handful of government organizations working with additive manufacturing to provide concept-to-product Warfighter solutions faster and more cost effectively.

ECBC is a National Resource with a Unique Research Role

The Edgewood Chemical Biological Center (ECBC) began its mission in 1917 when it was established on Maryland's Gunpowder Neck to counter chemical weapons (CW) used during World War I. Today, ECBC possesses an unrivaled chemical biological (CB) research and development infrastructure at Aberdeen Proving Ground (APG). ECBC is one of seven research laboratories subordinate to the U.S. Army Research, Development and Engineering Command (RDECOM).

ECBC has more than $1.8 billion in facilities and equipment, and more than 1.2 million square feet of laboratories and test chambers. These advanced facilities are used by a multidisciplinary team of more than 1,400 scientists, engineers, technicians and specialists. ECBC has a unique role in technology development that cannot be duplicated by private industry or research universities.

ECBC's Impact on the World

From non-state armies in the Middle East to the Ebola virus in East Africa, Americans have watched the world become a more dangerous place in 2014. The technologies ECBC develops and implements have addressed the threats the world faces and the evolving nature of national security. In the summer of 2014, ECBC field technicians destroyed Syria's declared stockpile of chemical weapons on board a ship in international waters, after having adapted a land-based technology to operate in the 700 foot by 100 foot hold of a ship.

ECBC scientists helped develop an Aeromedical Biological Containment System (ABCS) in 2010 to isolate infected patients during transport by aircraft without endangering the flight crew. In 2014, ABCS was successfully used to safely transport two Americans infected with Ebola from Africa to the United States. Also this year, ECBC had a major role in the largest-ever DoD Advanced Technology Demonstration on the Korean Peninsula. ECBC introduced the Republic of Korea to new biosurveillance technologies and enhanced the ability of Korean laboratories to detect and respond to both engineered and natural biological threats faster and more effectively.

ECBC's Excellence is Widely Recognized

In 2014, as in past years, ECBC received several awards in recognition of its excellence in research, engineering and technology transfer. Prior to his retirement, then-ECBC Director Joe Wienand received the Laboratory Director of the Year Award from the 2014 Federal Laboratory Consortium for "ECBC's many outstanding contributions to support technology transfer activities, including internal accomplishments, industry involvement and community services." Wienand also received the 2014 Presidential Rank Award.

Near the beginning of the year, the Center received the George Linsteadt Technology Transfer Achievement Award for its contributions to the DoD Technology Transfer Program. In addition, a team of researchers from the ECBC received the United States Department of Agriculture (USDA) Secretary's Honor Award. The team was recognized for partnering with the USDA to conduct critical chemical threat agent research to ensure that the nation's food supply is safe and reliable. Seven scientists and engineers from ECBC were awarded the prestigious 2014 U.S. Army Research and Development Achievement (RDA) Award for pioneering work and dedication in basic research and technology development.

ECBC's science and technology expertise originated with President Woodrow Wilson's 1917 proclamation that designated Gunpowder Neck, Maryland as the site for the first chemical shell filling plant in the United States. It was named Edgewood Arsenal and became a key part of the new Chemical Warfare Service (CWS). After World War I, the CWS's Research Division moved from American University to Edgewood Arsenal, along with several other divisions of the CWS from other locations. Edgewood became the center of chemical warfare research and development, training, testing, and production. Following World War II, the CWS was renamed the Army Chemical Corps.

1917

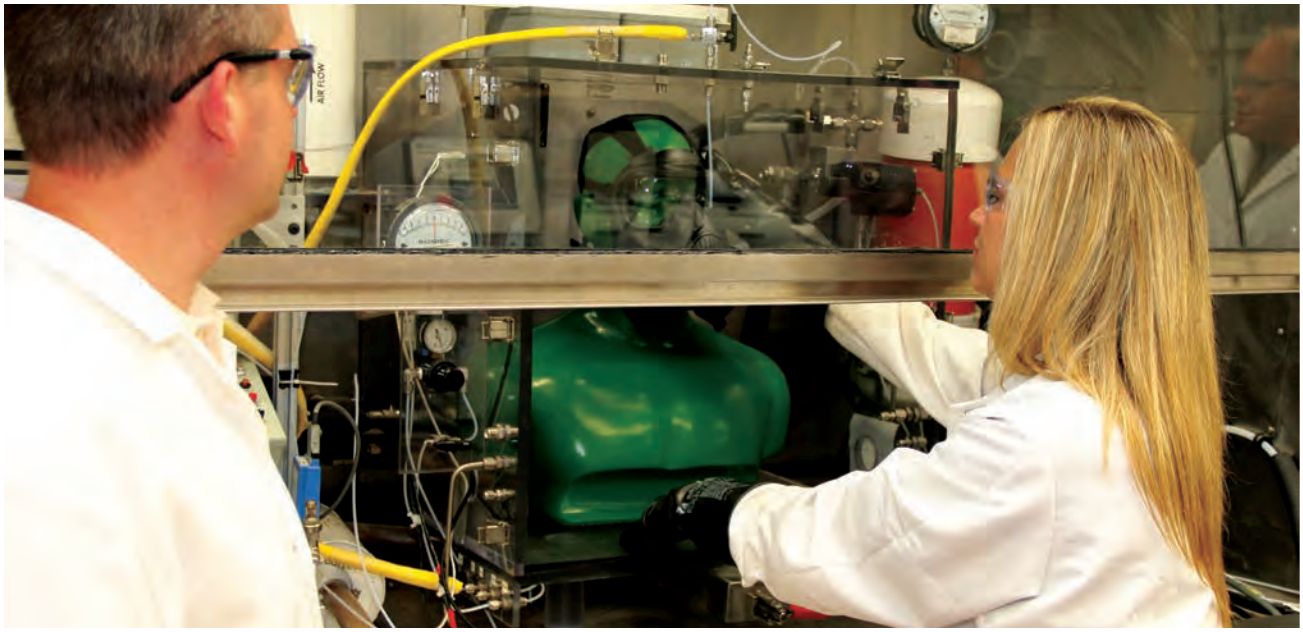
The four recognized projects, a) Raman Chemical Imaging of Explosive-Contaminated Fingerprints for Forensic Attribution, b) Biological Detection Using Mass Spectrometry-based Proteomics, c) Novel Zirconium Hydroxide Based Sorbent and Filter for Enhanced Toxic Chemical Protection and d) Agent Collection/On-board Detection Assembly (ANACONDA), are all ECBC research projects to introduce new or enhanced Chemical and Biological Defense solutions to the Nation's warfighters. The Center also passed the Organisation for the Prohibition of Chemical Weapon's (OPCW) international chemical identification proficiency test for the eighth time in a row, making it one of only a handful of laboratories in the world to receive an OPCW 'A' rating. ECBC was also part of the DoD team that was recognized by CBRN-UK, a British chemical, biological, radiological and nuclear industry organization that presented the group with its CBRN Innovator of the Year award.

Finally, in 2014 the ECBC project team that designed and operated ECBC's Field Deployable Hydrolysis System (FDHS) to safely destroy Syria's declared chemical weapons stockpile received the Secretary of Defense Group Achievement Award. The individual members of that team received federal service awards, including the Army Achievement Medal for Civilian Service, Meritorious Civilian Service Award, the Commander's Award for Civilian Service, and the Superior Civilian Service Award (see page 43). These members were also awarded the Navy Meritorious Unit Commendation during a Pentagon ceremony on Nov. 12. Consequently, the FDHS mission also resulted in the Center being awarded the Director of Army Safety Risk Management Award for their contribution to the vital mission of protecting the Warfighter and the nation against the growing global threat of chemical and biological warfare. This award which recognized safety as a critical component of the mission, which was completed in just 42 days without any reportable accidents or releases to the environment.

1969

In November 1969, President Richard Nixon ordered the United States to unilaterally discontinue its biological weapons program, thus ending further research into their development. These actions effectively stopped the research and production of biological weapons in the United States. This led to Edgewood Arsenal, then called the Chemical Research and Development Laboratories (CRDL), changing the focus of its mission from retaliatory chemical weapons to defensive systems to protect U.S. military forces. This included developing the proper equipment, knowledge, and materiel to survive and perform a military mission in a chemically contaminated environment, although a small chemical retaliatory weapons research and development program remained.

ECBC Simulant Agent Resistant Test Manikin (SMARTMAN) agent testing enables the laboratory to simulate human breathing, and provide a more realistic respirator system challenge.



ECBC's Core Technical Competencies

ECBC's unique success in working safely with chemical and biological agents in research, engineering and operations is a product of its six core technical competencies to address Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) threats. They span many scientific and engineering disciplines and have been developed over the course of nearly 100 years:

Chemistry and Biological Sciences

- Toxicology
- Aerosol Physics
- Filtration Sciences
- Spectral Analysis & Algorithm Development
- Spectroscopy and Algorithm Development for CBRNE Detection
- Decontamination
- Smoke, Obscuration and Pyrotechnics

CB Agent Handling and Surety

- Single Small Scale Facility
- Risk Management/CB Surety Program

CBRNE Materiel Acquisition

- CBRNE Program Development (Detection, Protection, Decontamination & Smoke)
- Systems Engineering
- Life Cycle Engineering (Concept Development, Rapid Prototyping, Manufacturing Support)

CBRNE Analysis and Testing

- Forensics
- Screening of Unknown Samples
- Full Service CBRNE Testing
- Sampling & Analysis Development
- Environmental Monitoring

CBRNE Munitions and Field Operations

- Chemical Destruction
- Mobile Laboratories and Test Kit Development
- Field Operations Training

Science and Technology for Emerging Threats

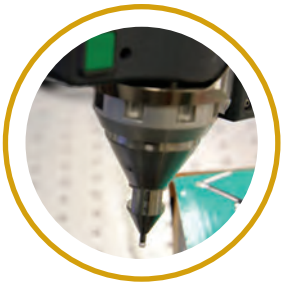
- Chemical Synthesis
- Homemade Explosives Synthesis and Analysis
- Synthetic Biology
- Molecular Engineering
- Modeling and Simulation
- Equipment Testing
- Threat and Vulnerability Analysis

1977

Edgewood Arsenal ceased being a command and its chemical research mission was subsumed under the Chemical Systems Laboratory (CSL).

CSL was renamed the Chemical Research, Development and Engineering Center (CRDEC).

1980s



1991

CRDEC designed defensive equipment to protect troops deployed to Kuwait and Iraq.

ECBC Offers Value to the Nation

ECBC is a customer-funded science, engineering, research and development center that provides a unique value to the Warfighter, first responders, and the U.S. national security community:

The National Security Community

ECBC also develops safer and more efficient means to eliminate chemical and biological materials once they are discovered. Most recently, ECBC received world recognition as the leader in innovative chemical agent destruction technology for the FDHS system which was used to destroy Syria's chemical weapons stockpile at sea (see page 30). ECBC's Chemical Transfer Facility (CTF) handles unknown chemical, biological, radiological or explosively configured samples from anywhere in the world (see page 26). ECBC's Forensic Analytic Center (FAC) continues to be a pioneer in the area of forensic analysis. In addition to maintaining state-of-the-art on-site analytical expertise, ECBC has designed and fielded mobile laboratory systems supporting on-going client operations for over a decade. ECBC works closely with customers to determine needs, recommend specific equipment and integrate and fabricate unique configurations using industry standards and equipment.

Warfighters and First Responders

ECBC continuously works to improve threat detection, personal protection and decontamination technologies to respond to CB threats. ECBC scientists and engineers drive these technological innovations through basic and applied research, engineering design, equipment evaluation, product support, and by sustaining field operations. ECBC is currently developing better ways to remotely detect these chemical and biological materials – before the Warfighter or first responder ever enters a threat zone. Breakthrough technologies such as Raman spectroscopy can detect CB threats from a safe distance (see page 36). ECBC is also developing a next-generation mask that will be lighter, cooler and provide better visibility and have improved charcoal filter technology.

An ECBC biologist prepares a liquid sample for analysis using Raman Spectroscopy.

1993

CRDEC, renamed the Edgewood Research, Development, and Engineering Center (ERDEC), was assigned to the new Chemical and Biological Defense Command (CBDCOM) under the Army Materiel Command to reflect its expanded mission of addressing chemical and biological threats.

1998

CBDCOM merged with the Soldiers Systems Command to form the Soldier and Biological Chemical Command (SBCCOM) and ERDEC was renamed the Edgewood Chemical Biological Center (ECBC).

2004

The Research, Development and Engineering Command (RDECOM) was established and ECBC was placed under its command.

TODAY

ECBC works closely with the other CB Defense organizations at APG to form Team CBRNE (Chemical, Biological, Radiological, Nuclear, Explosives). These organizations include the Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD), the U.S. Army Chemical Materials Activity (CMA), the U.S. Army 20th CBRNE Command, the U.S. Army Public Health Command (PHC), the U.S. Army Medical Research Institute of Chemical Defense (MRICD), Defense Threat Reduction Agency (DTRA) and the U.S. Army Program Executive Office Assembled Chemical Weapons Alternatives (PEO ACWA).

ECBC Partners with Industry, Universities and Other Federal Agencies

ECBC actively partners with private industry and universities on research and development through Cooperative Research and Development Agreements (CRADAs) and Technology Support Agreements (TSAs). ECBC currently has 69 ongoing CRADAS and 84 ongoing TSAs with private companies around the Nation.

In addition, ECBC is currently collaborating on research projects with the Massachusetts Institute of Technology, Harvard University, the University of Maryland, Baltimore County, and many other leading research universities across the nation. These collaborations have resulted in technological innovations that no single member of the partnership could have produced alone.

For example, ECBC is working with a team at the University of California, Los Angeles, to develop a technology using smartphones to report the analysis of CB samples and geotag the location of the sample on Google Maps.

Most recently, ECBC has entered into a Cooperative Agreement with the Minority Serving Institute STEM Consortium to provide minority serving institutions with opportunities to participate in research and technology advancement projects with ECBC.

ECBC is an Engine of Private Sector Job Growth

Many of the technologies that ECBC and its partners develop lend themselves to commercialization, stimulating the economy at the same time they make the nation safer. Through Patent License Agreements (PLAs) and a variety of other mechanisms, ECBC forms active partnerships to advance and commercialize new technologies. In 2014, ECBC partnerships with private businesses contributed to civilian job growth in the Mid-Atlantic Region. ECBC anticipates that these numbers will increase in 2015 as its novel advancements in additive manufacturing 3-D printing expand their commercial availability (see page 24).

An ECBC biologist removes a cryogenically preserved biological sample from a liquid nitrogen dewar.

2014 Project Highlights

Field Deployable Hydrolysis System (FDHS)

ECBC responded to a critical diplomatic need to develop and field a means of destroying Syria's 600 metric ton declared stockpile of chemical weapons at sea in international waters. ECBC scientists and engineers miniaturized an existing neutralization technology that uses hot water and sodium hydroxide to convert chemical agent to a conventional industrial waste product. Through innovative design, ECBC engineers re-designed the capabilities of an 18-acre factory facility into a 700 by 100 foot system that could fit in the hold of a ship. The system was further modified to operate while the ship was deployed at sea. These modifications were designed and the system completed in an unprecedented six months. An ECBC team of field operators then destroyed the Syrian chemical weapons at sea completely and safely in July and August in just 42 days, 20 days ahead of schedule.

Sen. Barbara Mikulski receives a tour and an explanation of the Field Deployable Hydrolysis System.

Project JUPITR is a collaborative effort between the U.S. and the Republic of Korea to identify and ultimately field the world's best bio-threat detection technology.

Project Joint U.S. Forces in Korea Portal and Integrated Threat Recognition (JUPITR)

The JUPITR is a project led by the JPEO-CBD. It is a three-year advanced technology demonstration (ATD) of biosurveillance technology for deployment on the Korean Peninsula. The ATD consists of four legs. First is the development of a web-based information portal with a cloud library that tracks biological events, pools the latest research on biological threats, connects subject matter experts, and provides response commanders with information fusion and decision support. The second leg upgrades and expands Republic of Korea laboratory facilities, so that biological samples can be collected and analyzed in-country and within hours instead of days. The third leg is an assessment of 10 different biological agent detection technologies in the field to determine their speed, accuracy and suitability for a field environment. The fourth is the development of multi-functional, all-seeing sensor combining multiple detection technologies to rapidly sense biological threats along a defensive perimeter. It is the largest ATD ever undertaken by the DoD, and many other countries beyond the Republic of Korea have expressed interest in adopting the technologies under development for their national security.

Chemical Reconnaissance and Explosives Screening Set (CRESS) Kits

The CRESS is a screening kit ECBC developed to enable Warfighters and first responders to detect traces of homemade explosives in-theater in less than a minute. ECBC developed the kit using a rapid prototype process developed by ECBC's Advance Design and Manufacturing Division and using 3-D printing technology within the Center. The kit uses an innovative configuration of its component parts and added colorimetric chemistry to make the kit compact enough for easy use in the field and can distinguish between a safe fertilizer and a powerful home made explosion (HME). The kit has been successfully used by U.S. Warfighters in Afghanistan to provide evidence to detain suspects who would otherwise go free.

Currently ECBC scientists are working on broadening the range of HME precursors it can detect and enable it to detect narcotics. They are also working to develop an Android app to digitalize reporting (see page 35).

Tactical Biological (TAC-BIO) Detector, Generation II

The TAC-BIO Detector is a biological agent sensor developed at ECBC that is lower cost, more advanced and less burdensome for end users to carry than its predecessor. It is designed to rapidly detect the presence of an airborne biological threat and to provide early warning to minimize exposure and casualties to our Armed Forces. The device exploits the scientific principle that biological aerosols will fluoresce and scatter light when exposed to ultraviolet (UV) light. These signals can be used to detect the existence of a threat. Prior to the TAC-BIO, most biological agent detectors used large, costly and bulky UV lasers to extract optical signals from threat aerosols. The TAC-BIO program resulted in five ECBC patents addressing state-of-the-art optics and optical interrogation techniques. It also provides a biological agent detector that costs as much as 80 percent less than Generation I, is 50 percent smaller, weighs 80 percent less, and uses only four percent of the energy. TAC-BIO won the Federal Laboratory Consortium award for Excellence (see page 34).

M50 Mask

ECBC continues to support JPEO-CBD and the Joint Project Manager – Protection in managing the production of the current generation Joint Service General Purpose Mask known as the M50. The M50 was designed to provide better visibility, easier breathing and greater comfort for users. It features a wrap-around visor rather than goggles for increased peripheral vision. It has a silicon and butyl face piece that is flexible enough to fit face sizes from the second to the 98th percentile of the adult population. Its upgraded valve design makes breathing 50 percent easier. In addition, it is cheaper than its predecessor. To make it truly inter-service, the system was designed accommodate the differences in service uniforms – including hoods, gloves and helmets – and each service's internal communications gear. Thus far, the Air Force has received 345,448 M50 masks; the Marines 131,289, and the Navy 274,333. When fielding to the Army is completed in 2019, the Army will have received 1,245,978 masks. Meanwhile, the Joint Service General Purpose Mask Team is busy developing a Special Operations version of the M50, known as the M53.

3-D Printing

3-D printing, also known as additive manufacturing, is the process of making a three-dimensional solid object of virtually any shape from a digital model. This capability has enabled ECBC to rapidly produce prototypes of a host of innovative new CB products while still in the concept design phase. This allows designers the flexibility to make design changes during the preproduction cycle of a product, before fully investing critical resources into the mass-production of that item. This capability has been instrumental in accelerating many ECBC projects vital to national security and Warfighter safety, such as the manufacturing of key components of the CRESS Kit, FDHS, TAC-BIO and the M50 mask.

Barcoded Spores

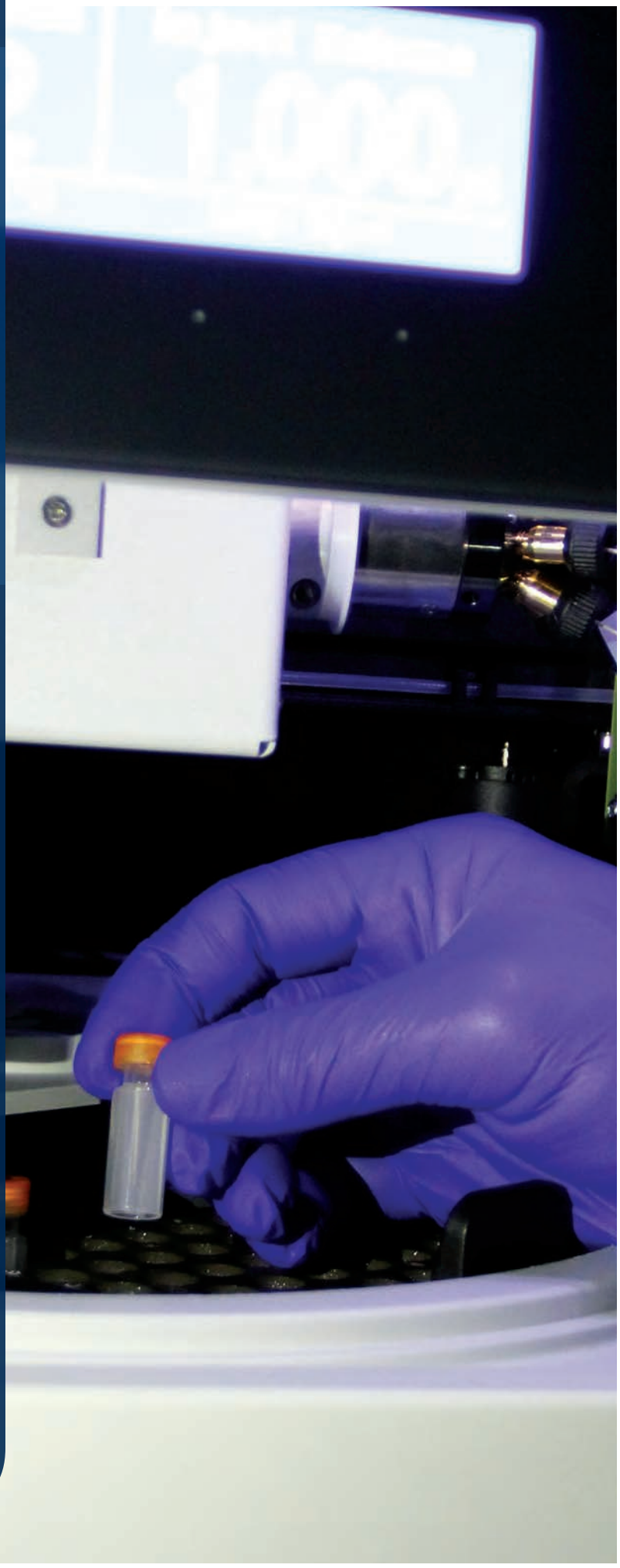
ECBC scientists found the solution to a longstanding problem encountered when testing with bacterial spores. After repeated operational testing in the same test chamber or range, the spores can accumulate, making it difficult for scientists to identify the spores that were released in the current test versus spores from previous tests. ECBC developed "barcoded" spores to help scientists differentiate between different test lots of bacteria spores. Barcoded spores are tagged biological spores that allow scientists to tell one bacterium apart from another by implanting a specific code into the spore's DNA. Those codes give each spore a unique identity, allowing researchers to discern which spores belong to which test. This saves valuable time by allowing multiple tests on the same day.
After three years of testing, ECBC is transitioning this technology to Dugway Proving Ground for use in DHS's Scientific Program on Reaerosolization and Exposure (SPORE) program. ○

Chemical and Biological Sciences

ECBC performs the applied research necessary to expand scientific understanding of chemical agents, toxins and biological organisms. ECBC scientists, as well as academic and industry scientists around the world, build upon this research to develop and implement technologies that protect Warfighters and first responders and protect the nation from current and emerging CB threats. This research includes better means of detection; better personal protective equipment (PPE); material development and design; more effective decontamination; and better CB destruction technology.

ECBC's breadth of expertise and facilities for conducting novel work in chemical and biological defense research sets it apart from other government agencies, research universities and commercial laboratories. ECBC's staff includes some of the world's pre-eminent scientists and engineers in the field, as is evidenced by the methodologies they have pioneered, and their extensive publications documenting the results of their work.

In 2014, working for two of its primary customers – the U.S. Army and the Defense Threat Reduction Agency Joint Science and Technology Office – ECBC advanced CB science and technology research resulting in several key breakthroughs.



ECBC improved chemical formulations for smoke grenades that enabled it to field lower toxicity dyes in the M18 Colored Smoke Grenade series.

HX Smoke

The ability to use a smoke screen to conceal movements on the battlefield is an essential tactical asset. However, the hexachloroethane/zinc (HC) smoke that was used during the World War I and II can act as an irritant to the Warfighters enshrouded by it, and can be toxic to the environment. It was also expensive to produce and had an uncertain shelf life. The DoD is always looking for smoke that conceals longer and is resistant to wind dispersion, particle fallout, and degradation through reaction to sunlight. ECBC rose to the challenge by developing a new generation of battlefield smoke.

ECBC used its expertise in the fundamentals of chemistry combined with state-of-the-art technology, such as high-speed digital cameras, electron microscopes and chemical analysis equipment to observe potential advantages and shortcomings of trial mixtures. ECBC's staff of pyrotechnicians has developed HX, a zinc-free composition similar to HC. HX smoke is both less toxic and less of an irritant as well as longer lasting and more resistant to fallout and reaction with sunlight. HX smoke is less expensive to produce and has a longer shelf life than HC.

These improved chemical formulations enabled ECBC to field new and innovative obscurant devices: the M83 Low Toxicity Screening Smoke Grenade, the M106 Smoke Obscurant Device, the lower toxicity dyes in the M18 Colored Smoke Grenade series, and even the improved low-toxicity, environmentally friendly Thermate composition used in the new production of the M14 Thermate Grenade.

Bispectral Smoke

The nature of concealment has changed in modern warfare. Smoke must also be able to defeat modern thermal enhancing and thermal intensifying devices, thermal-guided munitions and microwave seekers and radars. That means extending the electromagnetic spectrum that the smoke blocks.

HX smoke creates a cloud that disperses better, stays suspended longer, and more effectively conceals Warfighters from the visual and infrared spectra.

In 2014, ECBC researchers tested an array of commercially available metal flakes and graphite flakes in an aerosol chamber for their precise obscurant properties. Based on this research, ECBC was able to design a 'bursting' obscurant grenade that more effectively disperses these particles. The team then added another dimension to its testing by innovating a new technique for field trials. By using infrared sensors and mounting infrared sources on grid poles, the team was able to precisely

measure the size of the cloud created, how long it took to disperse, the cloud's duration, and the concealment value of the cloud in the visual and infrared spectra. The team was then able to definitively identify the best compound to use in the development of the Bispectral Grenade which conceals Warfighters from enemy sensors that operate from the visual through the far infrared portion of the electromagnetic spectrum.

Ultra High Vacuum Studies

Working with scientists at Virginia Tech and the private corporation, Excet, ECBC has developed the nation's first chemical agent-permitted Ultra High Vacuum (UHV) system to advance the understanding of chemical warfare agent interactions with a material's surface at the molecular level. This allows scientists to directly study how chemical warfare agents such as sarin interact with surfaces of environmental materials and coatings designed for protection as well as decontamination materials.

Using the UHV, researchers can monitor reactions in real time with infrared spectroscopy and mass spectrometry and take before-and-after images of surfaces using photoelectron spectroscopy.

Working with scientists at Virginia Tech and private industry, ECBC has developed the nation's first chemical agent-permitted UHV system to advance the understanding of chemical warfare agent interactions with a material's surface at the molecular level.

ECBC scientists built the built the surface science instrument which can safely perform ultra high vacuum studies with CWAs.

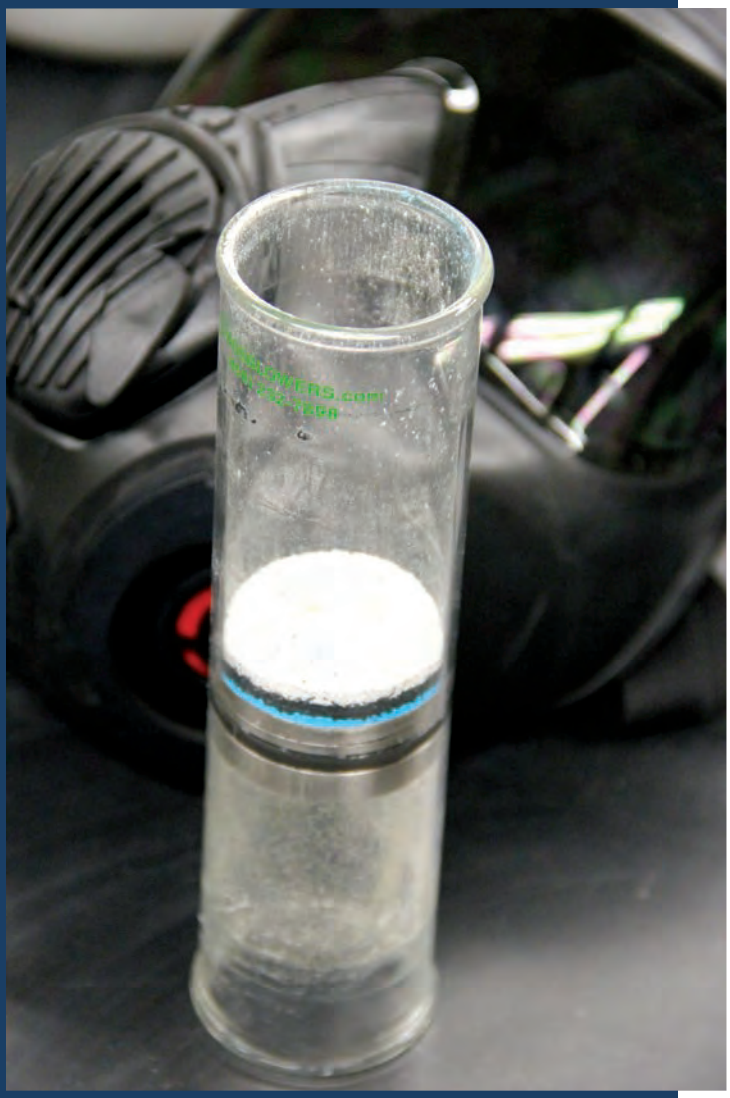
In addition to combining three detection technologies that can be used simultaneously, the UHV's safety design allows researchers to work closely with highly lethal chemical agents as the live agent is sealed in a chamber inside a laboratory. The UHV has all metal seals instead of polymeric ones to reduce the likelihood of a leak. In addition, all backing pumps are located within engineering controls, and it has a custom ventilation system.

Ultimately, the system will help scientists and engineers help to develop technologies to protect Warfighters and first responders in the event chemical agents are used on a battlefield or in a terrorist attack.

Metal Organic Frameworks

ECBC scientists are working on an entirely new material that will vastly improve upon the carbon filters that Warfighters and first responders have relied upon since World War I. They are constructing Metal Organic Frameworks (MOFs), which are molecules ECBC scientists constructed using organic struts consisting of oxygen, hydrogen and carbon, with metals-commonly copper, zinc, or zirconium-acting as nodes. Much like an erector set, these rods and nodes form lattice-shaped structures with large pores. The pores are readily filled by whatever liquid or gas flows through it, giving MOFs an adsorption capacity many times that of passive carbon filters. In addition, they can be designed to remove specific chemicals by changing the mix of organics and metals used in their construction.

ECBC scientists have been working with academic and industrial labs for the past seven years to refine their methods for constructing and customizing MOFs.



Metal Organic Frameworks are an entirely new type of material that will vastly improve upon the carbon filters that Soldiers and first responders have relied on since World War I.

In 2014, they succeeded in creating a production system for ammonia-absorbing granulated MOFs to place in gas masks and stand-alone filters for outdoor use. Their next goal is developing zirconium-based MOFs targeted at G-type nerve agents, such as sarin. In addition to placing MOFs in masks and filters, they envision using MOFs as an aerosol spray that can quickly decontaminate surfaces that have been contaminated by a nerve agent.

CoZZAT

As an extension of their success with the molecular design of MOFs, ECBC scientists, working with private industry, have designed a non-combustible filter material made of cobalt, zinc, zirconium, silver and triethylenediamine (TEDA), called CoZZAT. Rather than relying only on adsorption, as carbon filters do, CoZZAT also reacts with toxic chemicals. Essentially, ECBC scientists made the carbon more porous by removing some of the metals in the material, creating a highly active surface. When CoZZAT is combined with traditional carbon in a layered configuration, the filter provides double the protection of traditional filters.

The material has the ability to filter toxic industrial chemicals (TICs) in addition to chemical warfare agents (CWAs). CoZZAT increases reactivity against acid and acid-forming gases such as cyanogen chloride, hydrogen cyanide, hydrogen chloride, hydrogen sulfide, nitrogen dioxide, and sulfur dioxide, among others. The material also detoxifies nerve and blister agents, unlike activated carbon, which simply physically bonds to these agents. CoZZAT also exhibits greater resistance to battlefield contaminants and weathering, allowing for extended filter service life. All this greatly increases the effectiveness of the protective filter and overall protection for Warfighters.

In August, a team of ECBC and the Naval Surface Warfare Center (NSWC) scientists and engineers, installed CoZZAT-based filters on a U.S. Navy destroyer to evaluate its usefulness as a protective guard bed, a pre-filter for

ECBC scientists, working with private industry, have learned to design a metal oxyhydroxide composite the cobalt-zinc-zirconium-silver, and TEDA, known as CoZZAT, which reacts with toxic chemicals as they enter a filter containing it.

the ship's carbon-based filters. In addition to providing longer life, CoZZAT-based filters are designed to bond to contaminants the Navy routinely encounters onboard its ships, such as nitrogen oxides and sulfur oxides, hydrogen chloride, and heavy organics such as petroleum, oils, and lubricants. Data on the tests will be available after several months of constant use.

The potential of CoZZAT has led ECBC scientists to explore its use in several new areas including protective clothing, decontaminats and sensors.

Close-up view of a painted sample (green colored stub held by tweezers) of a Chemical Agent Resistant Coating (CARC) being scanned using electron microscopy (SEM) and energy dispersive spectroscopy (EDS).

Chemical Agent Resistant Coating

The current generation of airtight combat vehicles works well for protecting Warfighters from direct contact with a CWA. However, the risk of a CWA penetrating the surface coatings of vehicles remains. ECBC is meeting this challenge by studying, at the molecular level, exactly how paint on vehicle surfaces is penetrated by CWAs; and they are bringing state-of-the-art detection technologies – scanning electron microscopy and energy dispersive spectroscopy – to bear. As they carry the science of agent penetration of painted surfaces forward, ECBC scientists will be able to develop better chemical agent resistant coatings.

In 2014, ECBC scientists conducted a series of experiments using Scanning Electron Microscopy (SEM) and energy dispersive spectroscopy to measure where within the thin coating of a combat vehicle CWA goes. They applied CWA to surfaces under engineering controls to ensure that the agent was fully contained, and then bisected samples so that the SEM and energy dispersive spectroscopy could analyze cross sections. This allowed the scientists to examine the topographical, spectral, and elemental mapping of the contaminant-material systems to one-millionth of a meter.

By exposing various coatings for differing periods of time, ECBC scientists were able to better understand the properties of individual coatings and see precisely how different types of CWAs interact with them over time. Thus, ECBC was able to dramatically advance the science of agent penetration. ECBC is currently working with the Army Research Laboratory to study paint formulations using the results of this research.

Self-Detoxifying Protective Suit

PPE currently used by the Warfighter in the field fully protects against direct skin or inhalation exposure to a CWA. However, CWA can still be absorbed by the PPE fabric, creating a lingering threat to the Warfighter and anyone else that comes into contact with the suit. In response to this threat, ECBC, DTRA, the U.S. Army Natick Soldier Research, Development and Engineering Center (NSRDEC), and the Air Force Civil Engineer Center (AFCEC) have designed and tested new fabrics for a Self-Detoxifying Protective Suit to replace Warfighter uniforms.

The suit is made up of four materials – air impermeable, cover fabric, semi-permeable membrane and knit comfort liner – strategically placed within a CB garment that reacts with and decontaminates CWAs on contact. In addition to using reactive materials to meet the contact hazard, the suit decreases thermal burden to allow Warfighters to remain combat effective while it is being worn.

While testing materials, ECBC scientists developed new analytical methods for a solid state Nuclear Magnetic Resonance (NMR) spectrometer. In this method, researchers could add live CWA to the fabric, seal it inside of a ceramic rotor, then repeatedly observe the sample over time without disturbing the sample. Using previous methods, the fabric sample would have to be destroyed during the analysis. The previous methods required the making of multiple samples in order to observe different reaction times, which increased the possibility of errors. In other cases, simulant was used instead of live agent, leading to less accurate results.

In September, the project hosted an Army operational demonstration of the Self-Detoxifying Suit for the Joint Project Manager Protection (JPM-P). Warfighters from

The Self Detoxifying Protective Suit is made up of four materials – air impermeable concept, cover fabric, semi-permeable membrane and knit comfort liner – strategically placed within a CB garment that reacts with and decontaminates CWAs on contact.

the 7th Infantry Division, Ft. Lewis, Washington, and instructors from the 3rd Chemical Brigade at the U.S. Army Chemical School, Ft. Leonard Wood, Missouri, went through obstacle courses, firing ranges, a two-mile march, and mounted and dismounted vehicles comparing the self-detoxifying suit to the standard Joint Service suits that are currently fielded. The Self-Detoxifying Protective Suit will next undergo an Operational Demonstration with the Air Force during which Airmen will wear the self-detoxifying suits while performing Air Force-specific tasks such as refueling a plane. ○

Warfighters from the 7th Infantry Division, Ft. Lewis, Washington go through obstacle courses, firing ranges, a two-mile march, and mounted and dismounted vehicles comparing the self-detoxifying suit to the standard Joint Service suits that are currently fielded.

CB Agent Handling and Surety

Central to ECBC's unique role in safeguarding the nation from CB threats is the maintenance of stocks of the world's most deadly CB agents for research purposes. The infrastructure ECBC maintains to do this has two parts; state-of the-art laboratories and personnel with the most advanced training. Central to this capability is the Advanced Chemistry Laboratory. It was designed and built to safely isolate and contain the most toxic compounds known to man. ECBC also has a biosafety level 3 laboratory (BSL-3) that allows scientists to safely conduct research using highly pathogenic bacterial and viral microorganisms. ECBC forensic and safety experts are on the forefront of developing new methods of monitoring and detecting CB-laced mail.

A third element of this capability is performing field operations in support of the U.S. Army Corps of Engineers mission to clean up Formerly Used Defense Sites (FUDS) and active installations. ECBC's Chemical Biological Application and Risk Reduction (CBARR) field team provides onsite near-real-time monitoring of chemical contaminants and their breakdown products for the duration of response operations.

A biologist dons a protective suit before entering ECBC's biosafety level 3 laboratory.

Advanced Chemistry Laboratory

In 2014, ECBC completed construction on the final phase of its 91,582-square-foot Advanced Chemistry Laboratory (ACL), a unique facility designed for working with the most toxic compounds known to man. Highly instrumented and adaptable, the ACL is designed for flexibility, so that it can conform to the rapidly-changing requirements of scientific advancement. Engineering controls such as comprehensive ventilation and filtration systems protect the scientists inside the lab as well as the surrounding community and environment.

Primary facilities within the ACL include advanced toxic agent laboratories, environmental chambers and secure work spaces for classified materials. Chemical agent operations in this building include analytical chemistry, Chemical Weapons Convention (CWC) treaty support, filtration, decontamination and evaluation of chemical agent detectors. In addition to supporting ECBC's Warfighter mission, the ACL allows ECBC to continue to serve the Homeland Security community as well many other federal agencies, including the intelligence community and the Departments of Justice and State.

Risk Management/CB Surety Program

ECBC attracts some of the most talented scientists in the world because of the opportunity afforded them to conduct research in ECBC facilities. ECBC not only provides mentorship from more senior scientists, but also extensive safety and health training to protect scientists while working with highly dangerous CB materials. All ECBC personnel allowed direct access to these highly lethal chemical and biological agents are certified in a Personnel Reliability Program (PRP). The PRP is an integral part of the overall ECBC surety program that includes extensive background checks, random drug testing, intensive security and safety training, and regular medical surveillance.

The expertise of ECBC's risk management professionals is sought out by other organizations. They are retained to provide these organizations with guidance on how to manage their own CB surety, safety and security programs. ECBC supplies chemical agent and provides surety oversight for four contractor-owned, contractor-operated chemical agent laboratory programs. In addition, ECBC provides surety guidance and oversight to two contractor-owned, contractor-operated biological surety laboratories on behalf of the JPEO-CBD. ECBC also provides safety, security and surety support to the DHS Chemical, Ordnance, Biological, and Radiological Training Facility in Anniston, Alabama.

An ECBC chemist prepares chemical agent standards with known amounts of agents for testing detection equipment.

CBRNE Materiel Acquisition

ECBC is a unique organization possessing expertise across the entire material acquisition lifecycle. ECBC can take a CBRNE technology concept from basic and applied research, and engineer it into an operational, sustained capability in the hands of Warfighters and first responders.

Materiel Acquisition has four components – technology development, systems engineering, testing and evaluation. Throughout the development of a new technology, design, engineering, production and sustainment are a unified and carefully controlled process that ensures affordability and sustainability, and meets customer requirements. To accomplish this, ECBC maintains a cadre of certified acquisition professionals trained in systems engineering, logistics; testing and evaluation; and program management to achieve CBRNE solutions for program offices in JPEO-CBD, U.S. Army and other agency partners.

M50 Mask

An example of the Materiel Acquisition team taking a new technology from concept to fielding is the M50 protective mask. It was designed for JPEO-CBD to be a successor to the M40 mask and MCU 2/P, with basic research and design on the M50 beginning in 1998. Design improvements included a wrap-around visor rather than separate lenses for increased peripheral vision, a silicon butyl blend facepiece that is flexible enough to fit all face sizes from the second to the 98th percentile of adults, and an upgraded valve design which makes breathing 50 percent easier. It is also less expensive than its predecessor.

The ECBC team overcame formidable design challenges such as producing a M50 mask usable by all the services. That required ECBC designers to accommodate each service's unique uniform configuration, helmets, weapons and communications gear. As the mask progressed through the acquisition cycle moving from design to production, the team was involved with every step of the design – validation, the testing and modification process as well as addressing product quality and deficiency reports. ECBC took full advantage of its reach-back capability within the Center, including it test facilities and specialty teams – Advanced Design and Manufacturing, Packaging, Acquisition Logistics, and Sustainment Engineering – to advance the development and sustainment of the product and to solve technical issues.

The silicon and butyl face piece of the M50 mask is flexible enough to fit all face sizes from the second to the 98th percentile of the adult population.

A soldier wearing an M50 mask with night vision goggles.

Over a million masks have been fielded to Warfighters of all four services thus far. However, ECBC's Materiel Acquisition team continues to make improvements to upgrade the mask's capabilities. For example, when the mask's self-sealing valve started failing after one year, the team worked with the contractor to quickly design, produce and field an improved version. The team also discovered that a single-piece drink tube worked better than the original three-piece tube, so again, they quickly redesigned, produced and distributed it to the Warfighters.

Joint Service Aircrew Mask for Strategic Aircraft

The ideal protective aircrew mask is one that achieves a high level of protection while still being easy to put on and is comfortable while still offering a wide field of view. Meeting all these requirements has been a challenge to designers for decades. ECBC engineers, under the auspices of the JPEO-CBD leadership, are working to meet this challenge by adapting a ground mask that was designed for the Special Forces to meet aircrews' needs.

Known as the Modified M53 (MM53) or Joint Service Aircrew Mask for Strategic Aircraft (JSAM), it is a variant of the M53 mask which is used by Special Operations personnel in shipboard, fixed sites and ground applications. The JSAM SA team integrated a pressure-compensated exhalation valve and a Valsalva device that pinches the nose in order to normalize middle ear pressure when changing altitude. In 2014, the team began a battery of design verification tests using 85 masks manufactured by a commercial vendor. The tests included blowing sand, dust and salt fog in test chambers. It also includes rough handling, 12 weeks of cyclic storage at extreme temperatures, altitude testing and protection factor testing to ensure the mask provides protection during normal aircrew operations.

Mass Casualty Decontamination System

Following the same concept of the pre-packaged, ready-to-go detection and sampling kit that DR SKO represents, the Mass Casualty Decontamination (MCD) System is a pre-packaged, ready-to-go response kit for a CBRNE mass casualty incident response.

ECBC collaborated with the Joint Project Manager for Consequence Management (JPM-CM) to design and field modularized sets of response equipment including detection equipment, personal protection equipment, tents, decontamination and clean up equipment plus communications gear, hazardous materials reference guides, cameras, power and lighting. Combinations of equipment were configured to respond to a variety of CBRNE incidents in a modular design concept. These sets are stored in industry standard containers with interiors that ECBC customized to precisely match the storage requirements of each specific equipment ensemble. ECBC designers made the placement of individual items of equipment as intuitive as possible, applying what they learned during interviews with end users.

ECBC was able to benefit from its manufacturing capability to create easily adaptable brackets and shelving that safely secures the commercial off-the-shelf (COTS) equipment making up the ensembles. ECBC also developed an inventory tracking system to ensure that after a response, all the equipment used is properly repacked in its correct location. In addition, ECBC verified the COTS equipment for their suitability to go in the containers.

In 2014, ECBC produced its 19th MCD system, consisting of 15 ISO containers, and delivered it to an Army National Guard unit. Ultimately, MCD systems will serve as a valuable asset to federal and state agencies responsible for CBRNE incident response and for local first responders.

The Mass Casualty Decontamination (MCD) System provides first responders with a pre-packaged, ready-to-go response kit for a CBRNE mass casualty incident response.

A Special operations soldier wears the Joint Service Aircrew Mask for Strategic Aircraft. It was tested in chambers that subject it to blowing sand, dust and salt fog, extreme temperatures and simulated altitude changes to ensure the mask provides protection during normal aircrew operations.

In its testing, the team is also using a Simulant Agent Resistance Test Manikin, known as SMARTMAN. It is a test mannequin ECBC developed to simulate human breathing and provide a more realistic respirator system challenge in a contaminated environment.

Upon the successful completion of these tests, the MM53 program will conduct developmental and operational testing and ultimately field the mask to aircrews starting with the Air Force's E-3 Airborne Warning and Control System in 2016 and the Navy's P-3 Orion crews in 2017.

Dismounted Reconnaissance Sets, Kits and Outfits

Over the past decade, U.S. armed forces units have periodically needed to mount rapid responses to suspected CBRNE threats. It quickly became apparent that these responses could be performed sooner, faster and more safely if these units had a pre-packed set of equipment, including personal protection equipment; CBRNE detection equipment; decontamination equipment and supplies; and environmental sampling and marking kits.

ECBC engineers developed the required capability for dismounted reconnaissance of CBRNE threats, known as the Dismounted Reconnaissance Sets, Kits and

A hazardous material field response team approaches the hot zone in an ensemble selected from DR SKO to provide them with full protection.

Outfits (DR SKO). In addition to the necessary protection, detection and decontamination equipment, DR SKO includes communications gear, hazardous materials reference guides, power and lighting.

What makes DR SKO more than just a collection of the right equipment is the fact that it packages its 32 major components into any one of 20 different capability sets and five separate configurations to match the specific type of CBRNE threat encountered. The equipment is stored in industry-standard dry freight storage containers that can be delivered to a site by a High Mobility Multipurpose Wheeled Vehicle.

ECBC personnel developed the internal platform inside the cargo containers and are providing equipment training to U.S. Navy personnel, who were the first to receive DR SKO in September. In 2015, ECBC will deliver DR SKO to CBRNE teams in the U.S. Army, U.S. Army Reserve, and Army National Guard.

Additive Manufacturing

Additive manufacturing, commonly referred to as 3-D printing, has attracted a great deal of attention for its potential to revolutionize all forms of manufacturing in the 21st century. It is the process of layering plastics or metal to create a three-dimensional solid object of virtually any shape from a digital model. It holds the promise of ultimately extending to assembling materials as exotic as human tissue into organs. ECBC uses 3-D printing to provide concept-to-product Warfighter solutions faster and at less expense.

In 2014, additive manufacturing was used by project teams across the organization for proof-of-concept testing of items they have designed, including the CRESS kit and the M-50 mask. The prototypes are produced without committing to the expense of tooling up a conventional manufacturing process. Design teams are able to quickly and cheaply turn out a prototype, refine it based on test results and user feedback, and refine and retest the design before beginning full production.

ECBC is also pursuing partnerships to transfer additive manufacturing/3D printing technology to the private sector. In 2014, the Governor of Maryland signed a bill into law to establish the Northeastern Maryland Additive Manufacturing Innovation Authority (NMAMIA), a consortium of private business, educational institutions, government agencies and APG representatives. NMAMIA's mission is to use this revolutionary technical asset to help U.S. industry gain a competitive advantage in the international marketplace.

ECBC is also introducing additive manufacturing to high school students to encourage STEM students to consider a career related to it. This summer, ECBC introduced students to additive manufacturing at a Communications-Electronics Research, Development and Engineering Center (CERDEC) summer camp. ECBC engineers and technicians worked with the Hollywood movie industry to learn additive manufacturing processes and techniques to produce special effects props such as the Iron Man suit. They brought that concept back and created the Future Soldier model at the camp. ○

An ECBC technician scans a piece of a building in order to perform a 3-D blast reconstruction.

Full Service CBRNE Analysis and Testing

ECBC, through its full service analysis and testing capability, is helping to lead the Nation's fight against chemical agent threats, both emerging and existing. As adversaries develop new compounds (emerging threats), or as they are anticipated by the intelligence community as a possible threat, response agencies turn to ECBC for its expertise. ECBC uses its full service CBRNE analysis and testing to do the following:

- Synthesize and characterize new threat compounds
- Determine the spectroscopic and physical properties of new threat compounds
- Develop test methods and the fixtures used in detector testing
- Assess the capability of current detection equipment to detect these compounds

The analytical methodologies ECBC develops through this process often become accepted as the test standard in the chemical agent laboratory community.

In addition, the ECBC Forensic Analytical Center is one of two OPCW designated laboratories in the United States. These labs specialize in analysis of

An ECBC chemist prepares sample aliquots for chemical analysis in the Chemical Transfer Facility.

samples for chemical warfare agents, byproducts, precursors, and other compounds of interest. ECBC also confirms that U.S. laboratories used by stockpile sites comply with all analytical protocols specified by the CWC. At these stockpile sites, ECBC personnel challenge individual detectors to confirm that they are accurately detecting CW agents at precise concentrations.

Commercial vendors regularly retain ECBC to test detectors they have under development before they release them commercially. Finally, ECBC's analysis and testing capability is used to develop the fixtures that will be used to safely challenge detectors and protective materials, such as custom glove boxes or aerosol dispensers.

Chemical Detector Testing for Maryland Transit Administration's Baltimore Transit System

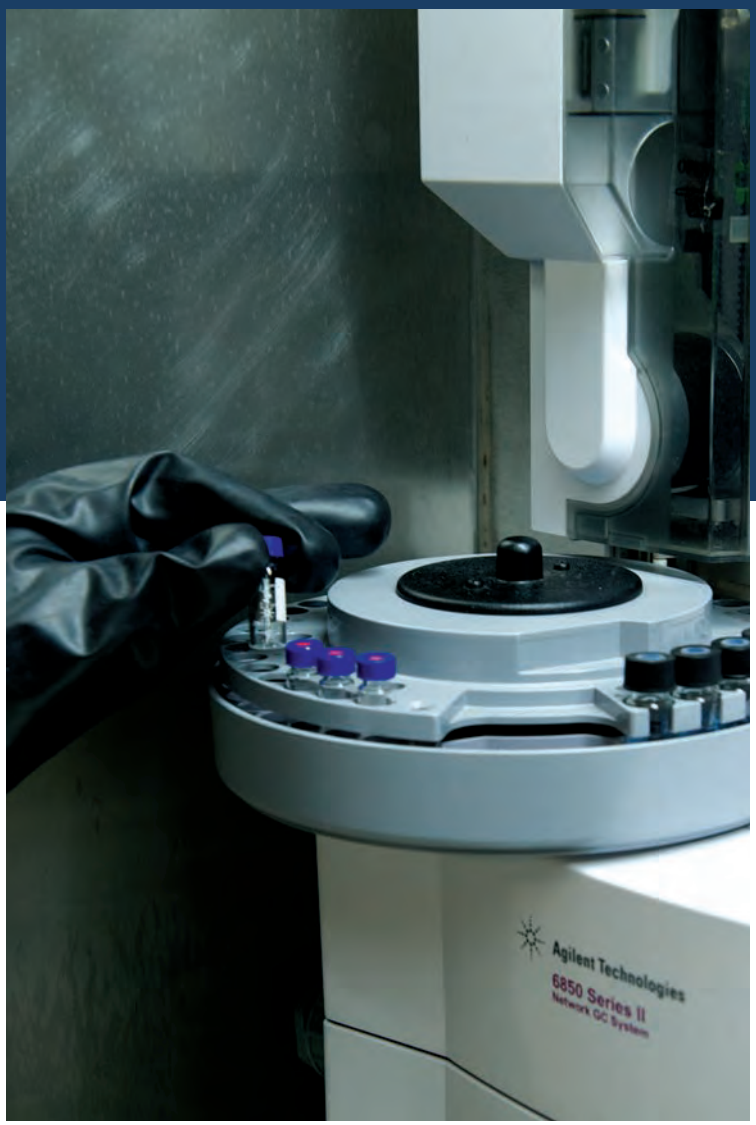
In 2014, ECBC performed extensive testing of the Maryland Transit Administration's (MTA) detectors. ECBC finished the testing in March, ahead of schedule, and provided a test report that provided MTA an awareness of the detectors' capabilities and limitations for the CW agents and toxic industrial chemicals tested. In cooperation with the Army Materiel Systems Analysis Activity (AMSAA), these capabilities and limitations will be integrated into MTA's concept of operations. MTA will then be able to determine how they, working with local first responders, can best respond to a chemical threat and protect the public.

The testing ECBC performed was based on a methodology for testing commercial chemical vapor detectors that ECBC developed in 2012. The methodology tests the ability of commercial detectors to identify select CWA and toxic industrial chemicals as required to meet the Transit Security Grant Program specifications for underground transit systems. ECBC developed this test standard to be used by any qualified laboratory in its testing of chemical detectors to determine if those detectors meet the Transit Security Grant Program requirements.

Chemical Transfer Facility

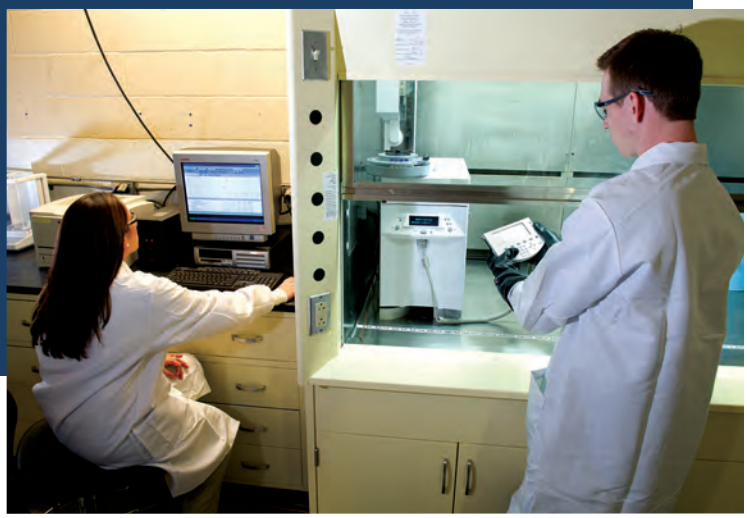
The Chemical Transfer Facility (CTF) serves a unique role in the nation's chemical weapons defense and elimination efforts. Under the CWC, the CTF is one of two designated U.S. facilities for production of chemical agents in quantities greater than 100 milliliters per year. The agent stored and produced by the CTF is used to

An ECBC chemist performs a reaction in a secure CTF laboratory.



An ECBC chemist loads a gas chromatograph with an unknown chemical sample in preparation for positive identification.

An ECBC chemist performs data reduction on an unknown liquid sample to derive a positive identification.



conduct defensive research and development throughout the DoD and is imperative to maintaining an effective defensive posture against chemical threats.

In addition, the agent produced in the CTF is used at U.S. facilities which specialize in developing CWA defenses such as respirators and protective clothing and in confirmation testing for new CW material decontamination and elimination technologies. Finally, CTF personnel are responsible for the safe packaging and shipment of neat and dilute agent to the U.S. stockpile and CW research locations authorized to receive it.

The CTF is also responsible for the receipt, triage and screening of “unknown” samples found worldwide. The CTF characterizes “unknowns” so that they can be properly routed for further analysis. CTF personnel are extensively trained in safety, health, proper use of PPE, hazardous materials packaging and transportation regulations, hazardous waste storage and handling procedures and regulations, CWC Treaty Compliance, surety, security management, and first aid with special attention to toxic exposure.

In 2014, CTF personnel were among those who went to sea with the FDHS to destroy the Syrian chemical weapons stockpile. CTF personnel provided analytical confirmation that their ECBC teammates were effectively destroying the stockpile. Additionally, the CTF passed an extremely rigorous CWC inspection in which records and inventories were scrutinized to ensure compliance with all

An ECBC chemist performs sample preparation of a chemical agent in Level C protection.

CWC regulations. The CTF also purified large quantities of the mustard agent HD to support research and testing operations on the U.S. Army Chemical Material Activity's Explosive Destruction System (EDS) which is being used to destroy chemical munitions at the Pueblo Chemical Agent-Desctruction Pilot Plant (PCAPP). Finally, the CTF provided live agent training sessions to several National Guard Weapons of Mass Destruction Civil Support Teams (WMD-CSTs).

Aerosol Testing Facility

ECBC's Aerosol Test Facility (ATF) was fabricated and installed in ECBC's McNamara Life Sciences Research Facility in 2014. The ATF will provide the infrastructure required for critical toxicology studies. In addition, it provides a novel capability for temperature and humidity controlled aerosol full-immersion testing of new chemical detection, protection and decontamination products designed to protect Warfighters, first responders and the Nation from chemical agents. Starting in 2015, the ATF will be used to test these commodity items against the full range of chemical threats - chemical warfare agents, toxic industrial chemicals and emerging chemical threats. It will also be available for commercial manufacturers of chemical agent defense equipment to test products they have under development. ○

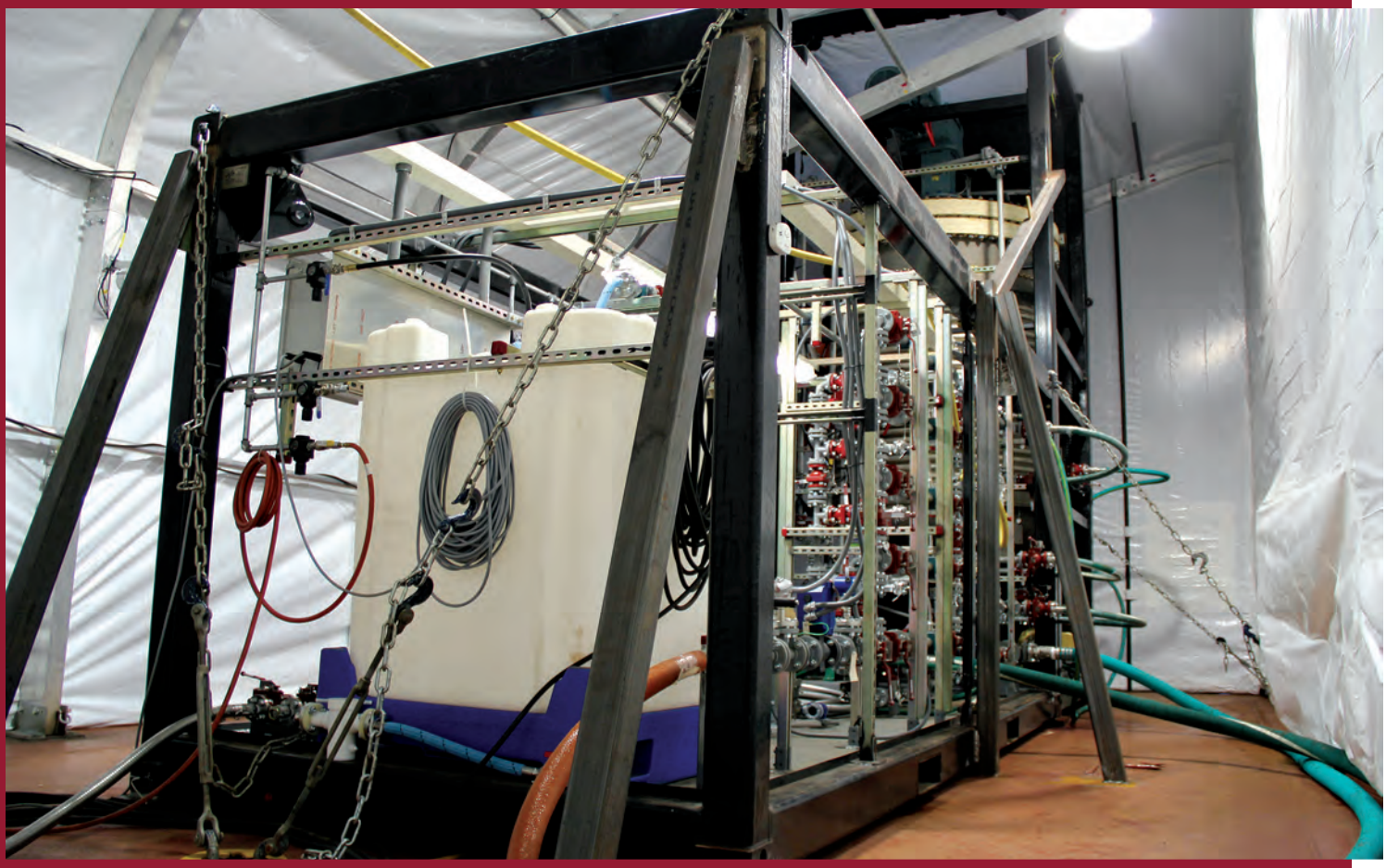
ECBC's Ambient Breeze Tunnel is one of only three in the U.S. Recent upgrades allow researchers to determine what happens after an agent is exposed to the air and then lands on a surface such as a car hood, or a window pane and then becomes airborne again.

Two ECBC scientists examine the data results from a recent aerosol test.

CBRNE Munitions and Field Operations

The cornerstone of ECBC's munitions and field operations capability to eliminate CB hazards is its Chemical Biological Application and Risk Reduction team. ECBC has more than 350 personnel in the Army's Chemical/Biological Personnel Reliability Program (PRP). PRP participants are certified, trained and vaccinated to deploy on field operations at a moment's notice. Their mission is to eliminate CB threats in the field where they are found. From Australia to Albania to international waters aboard a ship, this team has supported CB responses by deploying mobile labs, providing CBRNE training to other responders, supervising health and safety at response sites, and performing live agent operations.

ECBC's mobile labs can provide near real-time test results of air, soil and water samples to identify the presence of CB warfare agents and their breakdown products. ECBC can also install, operate and maintain a broad range of engineering-controlled vapor containment shelters. In addition, ECBC personnel can train local responders the proper selection and use of PPE, as well as how to isolate and secure a threat area, and how to fully decontaminate responders leaving the hot zone.



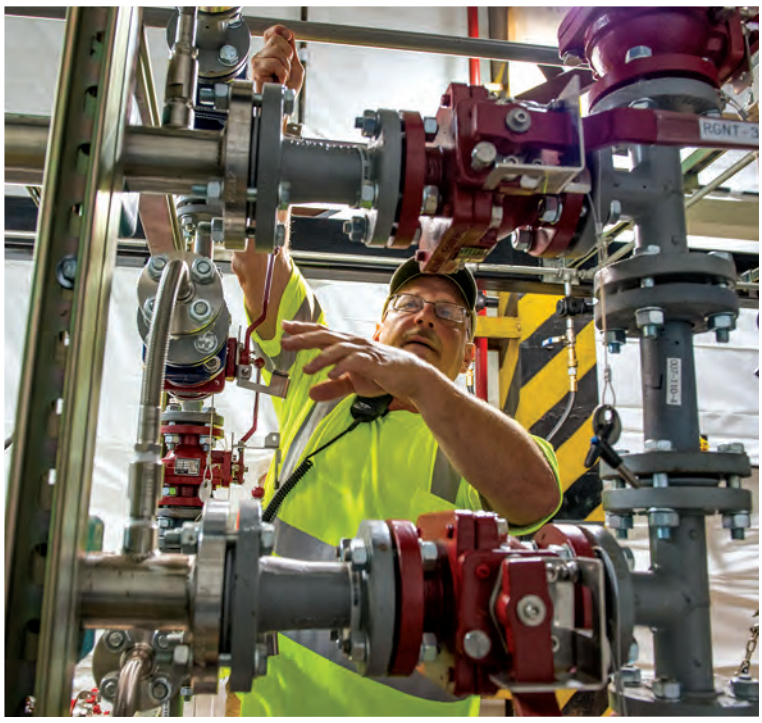
One of two FDHS units installed under engineering controls into the MV Cape Ray to destroy Syria's chemical weapons at sea.

Field Deployable Hydrolysis System

As noted in the introduction, ECBC made history in 2014 by developing, fielding and operating a mobile technology to destroy Syria's 600-metric-ton declared stockpile of chemical weapons at sea in international waters. The effort started in late 2012 when the international community and DoD recognized that chemical agent stockpiles in Syria posed an imminent international threat. ECBC teamed up with the Joint Project Manager for Elimination (JPM-E) and the U.S. Army Chemical Materials Activity (CMA) to develop a deployable chemical agent destruction system using the established nationalization technology of an existing land-based system.

The United States had used neutralization technologies to destroy U.S. stockpiles of bulk agent in two large scale factory-style facilities in Indiana and Maryland. The technology needed to be miniaturized to fit aboard a ship. In 2013, the team conceived, designed, fabricated and systemized the new system, known as the FDHS in just six months, an unprecedented accomplishment. The shipboard version of the land-based system was

Will Rowell, below, a chemical engineering technician for ECBC, opens a valve on the FDHS aboard the roll-on/roll-off and container ship MV Cape Ray.



fraught with complications and specialized engineering requirements. It meant converting the capabilities of an industrial complex covering an 18-acre factory facility to the 700 foot by 100 foot space available in the hold of a ship. The system was further modified to operate while the ship was pitched by waves, which could have caused enough vibration to imperil the ship and crew. In November 2013, two fully operational FDHS units were installed on the U.S. Maritime Vessel (MV) Cape Ray. In January 2014, the multi-agency team performed sea trials. The ship then sailed to the Mediterranean and in July the Syrian chemical weapons materials were loaded aboard. Once onboard, the destruction of 600 metric tons of Syrian bulk chemical agent was completed in just 42 days. This achievement received international acclaim and was prominently featured in national and international news media as an American contribution to world peace.

A MV Cape Ray crew member places a vibration sensor on FDHS equipment. ECBC engineers used vibration analysis to adapt the land-based FDHS for shipboard operations.

Hydrolysate containers being readied for use aboard the MV Cape Ray.

An ECBC field response team assists the Army Corps of Engineers with removal of chemical warfare material in the Washington D.C. neighborhood, Spring Valley.

Two ECBC field operators prepare a recovered chemical munition for destruction in the Explosive Destruction System at Dover Air Force Base.

ECBC Remediation Sites

Spring Valley, Washington, D.C.

During World War I, Soldiers used and tested chemical agent, equipment and munitions at the American University Experiment Station in Washington, D.C. After the war, much of it was buried and, over time, it was long forgotten. In recent decades, these hazardous materials have been unearthed in the Spring Valley neighborhood, built over the site where the station was located. The U.S. Army Corps of Engineers (USACE) has led the cleanup effort at this site, and ECBC has supported USACE there for more than a decade. In 2014, USACE removed a house located on top of a heavily contaminated area of soil. The ECBC team provided air monitoring during the excavation of laboratory debris and glassware. ECBC will continue field operations at the site until it is completed in 2017 and returned to American University.

Deseret Chemical Depot, Utah

For more than 50 years, 44 percent of the nation's stockpile of chemical weapons had been safely stored at the Deseret Chemical Depot (DCD). In 2013, DCD had plans to hand the property over to the Tooele Army Depot. However, DCD discovered they had a legacy of chemical agent contamination to deal with first, so they turned to CBARR to help them clean up and close down the facility.

In 2014, ECBC continued to lend its expertise in near real-time and historical air monitoring, which has played a critical role during cleanup operations by helping to determine proper shipment and disposal for analyzed soil and debris samples. Samples requiring additional low-level analysis are cleared onsite using Depot Area Air Monitoring System (DAAMS) or Miniature Continuous Air Monitoring System (MINICAMS) detection equipment, and then shipped back to Edgewood for a chemical agent and agent breakdown product analysis. ECBC conducted surface sweeps of two large areas to pick up debris left over from the disposal of material from chemical operations as well as the recovery of munitions, such as grenades buried in a large dirt pit.

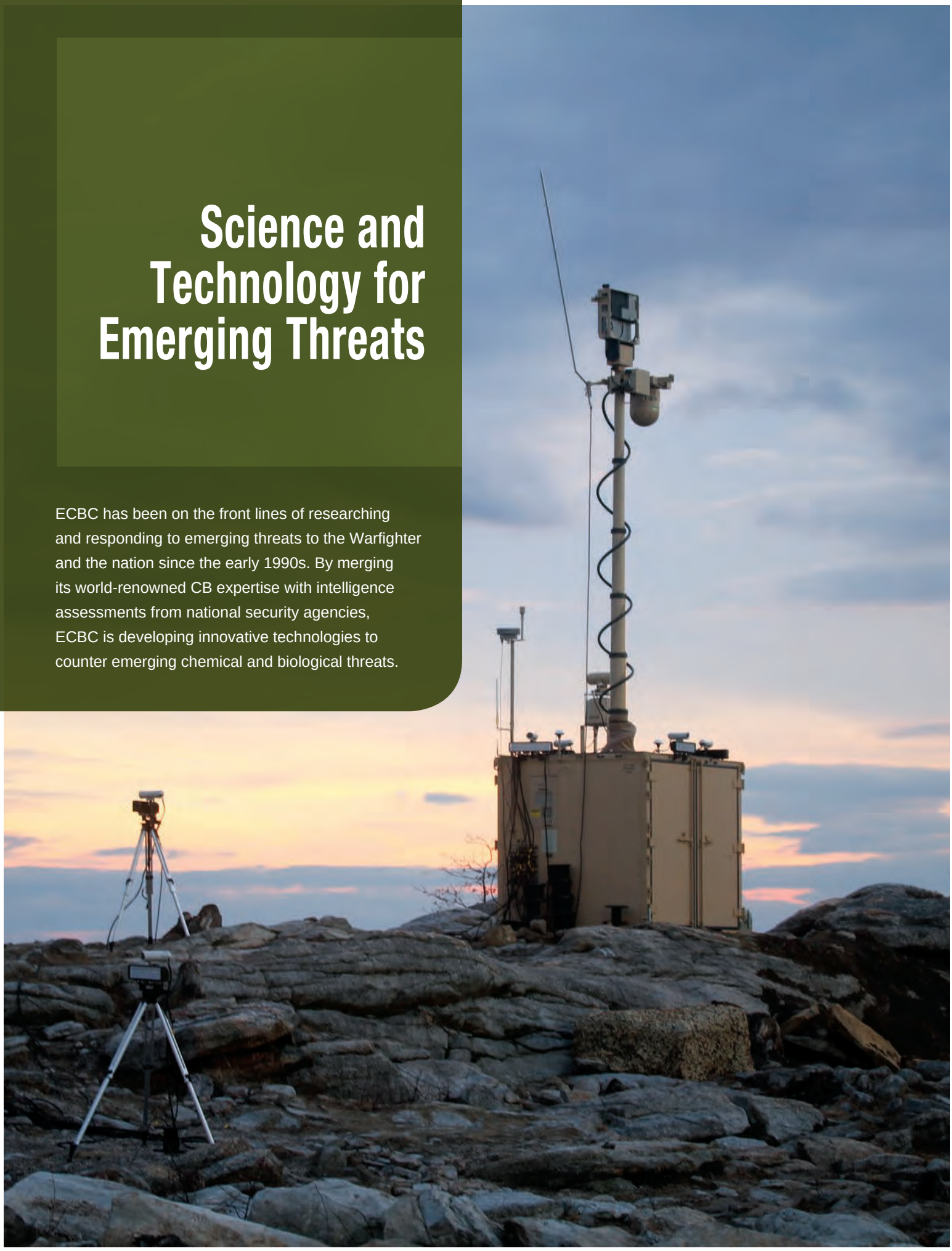
Dover Air Force Base, Delaware

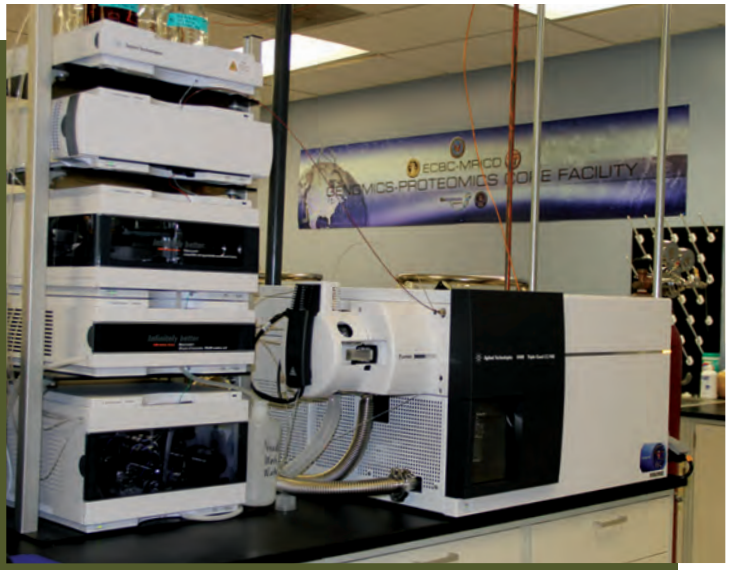
ECBC has performed eight remediation missions for CMA at Dover Air Force Base over the past 10 years as possible chemical agent-filled rounds were recovered during commercial sea-floor dredging operations in the Atlantic.

In 2014, ECBC was called to Dover Air Force Base for a two-day operation to safely destroy two 75 millimeter rounds inside an enclosed structure with engineering controls. The two munitions were suspected to be filled with mustard agent and were sealed in protective overpack containers, including one munition that was suspected of leaking mustard. ECBC safety experts developed a specific job safety analysis that allowed ECBC operators to securely destroy the munitions using CMA's Explosive Destruction System. ○

Science and Technology for Emerging Threats

ECBC has been on the front lines of researching and responding to emerging threats to the Warfighter and the nation since the early 1990s. By merging its world-renowned CB expertise with intelligence assessments from national security agencies, ECBC is developing innovative technologies to counter emerging chemical and biological threats.





In 2014, ECBC continued to enhance and expand the capabilities of its novel ABOid software suite of bioinformatics algorithms, which is capable of identifying biological microbes in various backgrounds without any prior knowledge of the sample.

New Detection Technologies

In 2014, ECBC achieved numerous successes in developing the detection technology that keeps the United States a step ahead of new threats.

Agents of Biological Origin Identifier (ABOid)

From studying the cause of bee colony collapse disorder in 2007 to working with the Public Health Command to ensure safety of the food chain for the U.S. Army and government officials, ECBC has met the nation's immediate need for biological threat identification through ABOid. ABOid is an innovative detection algorithm capable of providing automated identification of the sample contents from both pure cultures and mixture of microbes present in culture, environmental or biological matrices in far less time than traditional techniques - minutes versus days. ABOid uses a taxonomic classification approach to classify emerging or unknown - or unsequenced - microbes. If a specific bacteria or microbe is not sequenced, the team can use this approach to determine the closest near-neighbor to a given microbe. This complements polymerase chain reaction (PCR) technology and genomic sequencing, providing a critical first step to a genomics team to design an effective primer to sequence the bacteria to a specific target.

In 2014, in support of Project JUPITR, ECBC upgraded ABOid from primarily a research laboratory instrument to a tool to put in Warfighters' hands. Through the use of parallel processing, ECBC cut analysis time down to as little as two to three minutes. ECBC also made the interface – what the Warfighter sees on the screen – simpler and easier to read and understand. Also in 2014, ABOid proved itself by accurately identifying the presence or absence of Salmonella in 150 out of 150 mashed potato study samples and is poised to provide the Army with rapid, accurate testing of any food. Ultimately, ABOid will be a valuable tool in outbreak scenarios, biosurveillance and bioforensic profiling.

Tactical Biological (TACBIO®) Generation II Detector

As part of ECBC's constant effort to put the best possible CB detection technology in the hands of the Warfighter and first responders, ECBC developed the TACBIO®. It is a biological agent sensor that is low-cost, requires very little power and is compact in size. It is designed to rapidly detect the presence of an airborne biological threat and provide an early warning to minimize exposure and casualties. The device exploits the scientific principle that biological aerosols will fluoresce and scatter light when exposed to UV light. These signals can be used to detect the existence of a threat by using a light-emitting diode (LED) developed under the Defense Advanced Research Projects Agency (DARPA) that replaces the larger and more costly UV lasers previously used.

The next generation tactical biological (TAC-BIO II) detector reduces technology costs, saves production time and uses a power source that is more energy efficient than its predecessor.

ECBC transitioned the TACBIO® to private industry through patent licensing agreements with three separate commercial vendors and a CRADA for large-scale distribution and fielding. TACBIO® won the 2014 FLC Award for Excellence in Technology Transfer. ECBC continues to work on the design to make the product simpler to use, more durable in all weather conditions and more capable.

CB Detection Program

Starting with seed money from an ECBC new technology contest, a team of ECBC scientists, working with a small Boston-based technology company and the U.S. Army Communication Electronics, Research, Development and Engineering Center (CERDEC), combined several technologies to develop a highly compact, rugged and transportable Smartphone based CB threat detector called the VOCkit. The VOCkit uses stamp-sized volatile organic compound (VOC) colorimetric assay arrays to identify the CB threat. The paper arrays are spotted with up to 100 indicator dyes that react in unique patterns to identify chemicals and pathogens.

A Warfighter in the field will be able to use the VOCkit to sample suspected liquid or powdered substance placed next to a VOC stamp-sized paper array. Current versions of the VOCkit are about the size of a baseball and are light enough to carry in a rucksack or large pocket. A Warfighter in the field will be able to use the VOCkit to sample suspect liquids or powders by injecting or dropping them into a disposable cartridge which contains an absorbent pad and the stamp-sized paper known as the VOC array. The Warfighter can then leave the area while the VOCkit reads the paper array by comparing sample-induced color changes in the array to a database using ECBC-developed detection algorithms.

The VOCkit provides the test results remotely by transmitting the data to the Warfighter's Smartphone using an encrypted Army network. The VOCkit will also geotag the sample location so that if the sample is positive, the area of contamination can be communicated to other Warfighters and units. Currently, the system is being tested on the Korean Peninsula as part of the JPEO-CBD's Project JUPITR. In addition to protecting the Warfighter, the VOCkit can be used as a tool for Customs and Border Protection, USDA, and by the Food and Drug Administration.

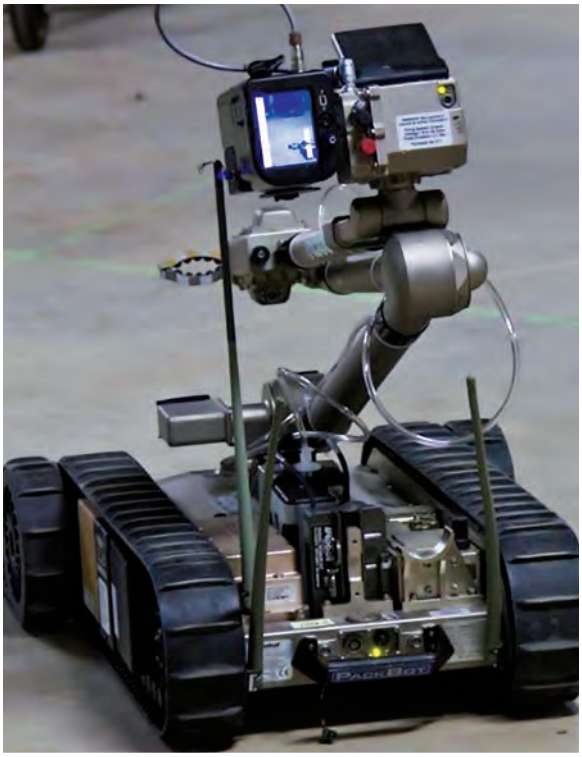
Chemical Reconnaissance Explosives Squad Screening (CRESS) Kit

In response to an immediate need for improved detection of potential bulk explosives, ECBC developed an easy-to-use, pocket-sized screening kit to detect chemicals commonly used in HMEs. Known as the Chemical Reconnaissance and Explosives Screening Set (CRESS) Kit, it uses colorimetric chemistry to enable Soldiers to easily and safely sample bulk solids and subsequently test them for the presence of four HME precursor materials often used in combat zones. The kit provides results in minutes and can distinguish between urea (safe fertilizer) and urea nitrate (a powerful HME). ECBC is now expanding the kit's capabilities to detect additional HME precursors and commonly abused drugs.

ECBC's screening kit for detecting common fuels and oxidizers used in the manufacture of homemade explosives is already being used by Warfighters in the field to detain suspects.

In the summer of 2013, CRESS kits were fielded to RDECOM's Field Assistance in Science and Technology (R-FAST) forces in Afghanistan, where they enabled Soldiers to detain suspects who otherwise would have been released based on insufficient evidence. ECBC is also developing an Android app to digitize data analysis and reporting. This capability will enable colorblind Warfighters to read the results there by minimizing color interpretation error.

In July 2014, Special Forces Soldiers evaluated CRESS during a technical experiment hosted by the Special Operations Command (SOCOM). The Soldiers who used it gave positive reviews. In a showcase of CBRNE technology hosted at Aberdeen Proving Ground, Maryland, in August 2014, FBI personnel and civil first responders expressed a keen interest in acquiring CRESS kits for investigations and emergency responses. CRESS has since been licensed to an ECBC industry partner, with other potential partners currently negotiating patent licenses. Meanwhile, ECBC is supporting the JPEO-CBD in further development of the CRESS for eventual fielding to Warfighters across the services.



The RASR integrated into a robot allows for agent detection at extended ranges.

Rapid Area Sensitive-Site Reconnaissance (RASR)

Warfighters entering a site suspected of containing chemical contamination have to be prepared to face both the chemical threat and hostile forces. The ability to quickly detect and identify the presence of potential threats is critical for proceeding into the battle space. The Rapid Area Sensitive-Site Reconnaissance (RASR) system, developed for DTRA JSTO, provides a capability for surveying potentially contaminated areas remotely through automated means.

ECBC has served as the Technical Manager of the RASR ATD program since 2008. The primary sensor, the Avalon, uses a powerful near-infrared laser to scan for and identify chemical threats using Raman spectroscopy. The Avalon's laser scatters the light to interact with individual molecules. The scattered light returns to the sensor at shifted wavelengths, based on the structure of targeted molecules. The wavelength shifts reveal a unique signature, like a fingerprint, which is matched against a library of known chemical signatures in near real-time. The Avalon can be used for hand-held operation, or operated remotely when mounted on an unmanned ground vehicle.

During the execution of the ATD, the RASR system was subjected to several early user assessments, laboratory and field technical demonstrations, and culminating in an operational demonstration using Warfighters from multiple services. The data and user comments collected resulted in RASR receiving a favorable joint military utility assessment in 2012. In 2013, Warfighters from the U.S. Marine Corps, 3rd Marine Regiment (CBRN Section) and U.S. Army 20th CBRNE Command, 21st Chemical Company were trained to use the RASR system, beginning the Extended User Evaluation (EUE) phase of the program.

Over the course of a year, EUE participants incorporated the system into training exercises, and in 2014 provided valuable user assessments on the system operation, capabilities, and limitations. User feedback was collected and provided to ECBC via questionnaires and monthly after-action reports. ECBC compiled all data collected during the EUE period and will further refine RASR to best protect the Warfighter.

Joint Chemical Agent / Explosive Detector

The Joint Chemical Agent Detector (JCAD) was first fielded to serve as a portable, automatic chemical warfare agent detector. Currently, there are approximately 56,000 JCADs in service. The nation's current conflicts point to a need for the Army to leverage existing technology to detect explosive materials. ECBC scientists found a way to make that possible through improvements to the widely used JCAD.

As a chemical detector, the original JCAD is designed to detect vapors. However, explosive materials are usually low vapor pressure solids. So in 2014, ECBC scientists developed a method to allow the JCAD to detect solid explosive materials without changing the hardware or original intent of the detector. They designed two add-on pieces, a new rain cap with a probe swab. Within the JCAD itself, two external on-demand vapor generators were added to change the chemistry of the detector when selected so that it can more easily detect explosives.

ECBC expanded the capabilities of the highly portable, user-friendly JCAD to detect solid explosive materials.

Once configured to detect explosives, users can wipe any surface using the probe swab, which then retracts back into the inlet. At the push of a button the probe swab tip with the sample placed on it heats up to an elevated temperature, vaporizing the explosive residue. These additional features allow the original JCAD to now serve the role of a portable, automated explosives detector without adding to the Warfighter's rucksack.

Transatlantic Collaborative Biological Resiliency Demonstration

Anthrax mailed to the Hart Senate Building in 2001 starkly highlighted the need for biological defense planning. ECBC, working with the DTRA and the U.S. Army European Command (EUCOM), has spent the past two years developing and refining the Transatlantic Collaborative Dashboard (TaCBoaRD) software, a suite of decision analytics software that will help governments provide quick, decisive and effective

The Republic of Poland serves as the partner nation for the U.S. for TaCBoaRD technology demonstrations. Over the course of three years demonstrations have been held in both Poland and the U.S.

answers to a biological incident such as a bubonic plague or anthrax exposure. TaCBoaRD consists of a series of hands-on workshops, tools and demonstrations.

TaCBoaRD is a collaboration between ECBC, the Department of Defense, the U.S. Department of State and Department of Homeland Security (DHS). It demonstrates the United States' capacity to respond to a wide-area biological incident that impacts the U.S. and partner-nation civil and military personnel. In the current round of demonstrations, the Republic of Poland is the partner nation.

Four technical demonstrations have been held at different locations around the world. The participants run through incident scenarios and use TaCBoaRD tools

International participants at a TACBoaRD workshop learn how to track and respond to biological threats.

to develop response plans. The purpose is to create a planning infrastructure that will increase an attacked nation's resilience and recovery actions – the ability to rehabilitate an area after a wide-scale biological incident has occurred. This includes methods of treating everyone exposed to the agent, plans to handle any biological waste, bringing the right remediation resources to the site, getting infrastructure re-established quickly, and properly allocating resources.

JUPITR

Project JUPITR is a JPEO-CBD led, and ECBC executed, three-year advanced technology demonstration (ATD) of biosurveillance technology for deployment on the Korean Peninsula consisting of four legs:

- Development of a web-based information portal, known as the Global Biosurveillance Portal, with a cloud library that tracks biological events, pools the latest research on biological threats, connects subject matter experts, and provides response commanders with information fusion and decision support.
- Upgrading and expanding the Republic of Korea's laboratory facilities so that biological samples can be collected and analyzed in-country and within hours instead of days.
- An assessment of 10 different biological agent detection technologies in the field to determine their speed, accuracy and suitability for a field environment.
- Development of a multi-functional, all-seeing sensor combining multiple detection technologies to rapidly sense biological threats along a defensive perimeter.

ECBC is providing unique biological detection capabilities that will address the demand for stronger biosurveillance capabilities on the Korean Peninsula.

As the largest ATD ever undertaken by DoD, it was initiated as a response to both DoD and White House national security policy plans that recognize natural outbreaks of disease to be as much of a national security threat as an overt attack with chemical or biological weapons. By establishing this ATD, the United States was able to build in the kind of experimental approach that allows the project team to become self-learning as the project proceeds. The specially selected, interdisciplinary ECBC ATD project team quickly proved that it possesses both the technical sophistication and the nimbleness needed to take full advantage of the ATD concept.

The team approached each leg of Project JUPITR with an eye to avoiding the purchase of more equipment when non-material solutions would do as well or better. This included finding better ways to use existing equipment, and identifying places in the detection process where the real solution had better tactics, techniques and procedures, not more equipment. For example, the ATD team put in place ways to link the laboratories together across the Korean Peninsula so that they could share information and materials more efficiently.

The members of the team also developed an understanding of Korean culture, which proved invaluable when it came time gain the host nation's concurrence on major project decisions. As a result of the relationships developed by the ATD team, DoD scientists are co-developing CB detector technology and exploring the genetic diversity of pathogens in the Korean environment with Republic of Korea scientists. The team also developed a bilingual Global Biosurveillance Portal, in English and Hangul.

Ultimately, all the legs of Project JUPITR will be integrated through a data fusion effort that will provide an on-the-scene battlefield commander with a data wall to which each of the legs contributes. The commander will see everything in one place and be able to communicate with anyone who needs to know. The Korean version will serve as the proof of concept for fully integrated biosurveillance to be replicated by other allied nations, and be applied to both war-related and natural threats, such as the Ebola virus. ○

Achievements

Students at a local middle school performing a biological screening test for the presence of simulated biological agents.

STEM

ECBC has been actively promoting science, technology, engineering and math (STEM) education in nearby Harford and Cecil County schools since the 1980s. In 2014, more than 100 ECBC subject matter experts (SMEs) reached out to more than 10,000 students in 60 schools in two school districts and worked with nearly 900 teachers.

ECBC's STEM Educational Outreach Program is an offshoot of the National Defense Education Program sharing its mission of inspiring, developing and attracting the STEM talent essential to deliver innovative solutions for the nation's current and future challenges. ECBC sends its scientists and engineers to classrooms to speak to students as SMEs - providing guest lecturers; hosting field trips; judging competitions and science fairs; assisting with senior capstone projects; and exhibiting at career fairs and expos.

ECBC SMEs classroom engagements often include hands-on activities. Sometimes the SME gives a lecture and presents a real-world problem the students can solve using the Engineering Design Process, a kind of scientific method for engineers. These activities allow students to make the connection between what they are learning in the classroom and what scientists and engineers are doing with the same concepts in the field. Some of the hands-on projects include building live electrical circuits, designing catapults that launch marshmallows, chemical and biological reactions, an egg drop challenge demonstrating Army packaging, and DNA extractions. All of these activities reinforce the real-world application of STEM principles to students and entice them to learn more.

In 2014, in addition to classroom engagements, ECBC SMEs took part in judging projects for the national eCybermission competition where students from all across the nation in grades 6 through 9 submit projects, and have SMEs from across DoD judge their projects. The local schools have taken advantage of their proximity to ECBC and go on tours of the unique lab facilities. This opportunity allows students the ability to interact with SMEs in the field as well as see the equipment that is used in the different areas around ECBC.

In 2014, ECBC also provided Cecil County Public School teachers professional development in math robotics to make math lessons more applicable to the real world of science and engineering. Participating teachers called upon the assistance of ECBC scientists and engineers, who contributed to their expertise. SMEs were also invited into classrooms to help implement training modules.

In the summer of 2014, ECBC participated in the Army's "Gains in the Education of Mathematics and Science" program, which was held at APG's new STEM Education and Outreach Center. ECBC scientists and engineers offered fifth-, sixth- and seventh-graders a hands-on STEM activity called 'The Color of Science' that enabled them to explore the difference between acids and bases and how to use a pH indicator.

A student at a local high school prepares a swab to sample a simulated suspicious powder.

Departures

Departures

ECBC Director
Joseph Wienand

Mr. Wienand retired from government service in October after serving at ECBC for 15 years, and as ECBC's director since June 2010. He served in various positions in the federal government since 1979, having begun his career as an active duty U.S. Army Chemical Officer stationed at APG. His tenure will be remembered for his constant encouragement to his staff to innovate, and the solutions to the Warfighter and the nation those innovations yielded.

Senior
Research Scientist
for Biotechnology (ST)
James J. Valdes, Ph. D.

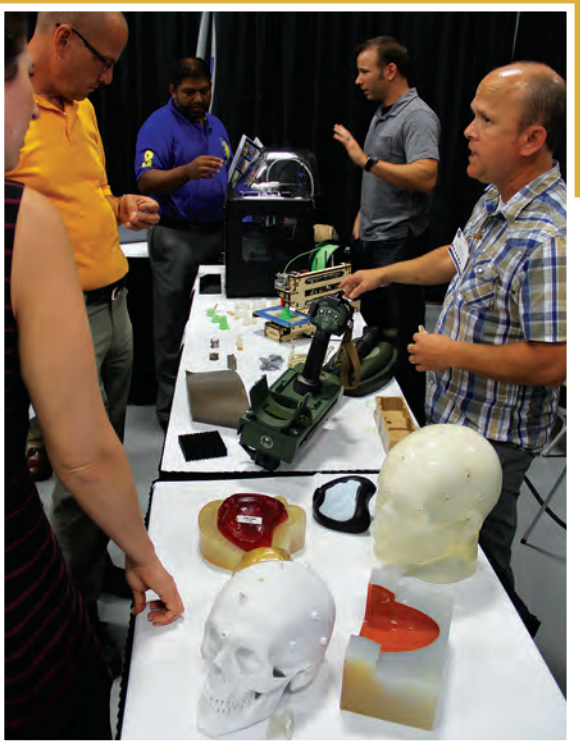
Dr. Valdes retired in January, after 32 years of civil service and 14 years as an ECBC scientific advisor, making him the longest serving ST in the Army. During his career, Valdes won many top awards and honors. He twice won the Department of the Army Research and Development Achievement Award which highlights the best in Army science and technology. In his time at ECBC he pioneered and championed ECBC's development of bioprocessing capabilities.

Engineering Director
Alvin D. "AJay" Thornton

Mr. Thornton retired at the end of January after more than 30 years of government service and four years as ECBC Engineering director. Over the course of his career he served as a physical scientist, systems engineer, team leader, executive action officer, technical liaison, test leader, and project manager for organizations such as RDECOM, Army Materiel Command, PEO Soldier, and Headquarters, Department of the Army. He was the 2014 recipient of the Black Engineer of the Year SES Award from U.S. Black Engineer & Information Technology magazine.

Senior
Research Scientist
for Biochemistry (ST)
Jose-Luis Sagripanti, Ph.D.

Dr. Sagripanti retired at the beginning of Fiscal Year 2014. Early in his career at ECBC, he directed the re-design, construction, equipment, and staffing of BSL-3 laboratories for biodefense research. As Senior Scientist for Biochemistry, his efforts focused on countermeasures against genetically engineered threats. He was named in December 2012 among the top five most prolific inventors of the U.S. Department of the Army.

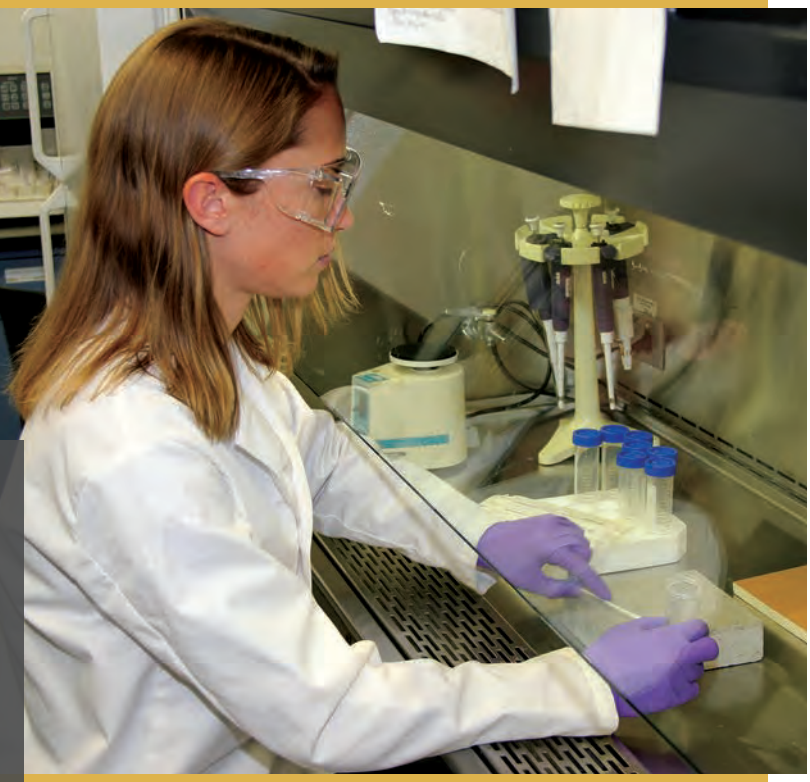


Visitors to ECBC's 2014 CBRNE Capabilities Showcase learn about new developments in additive manufacturing.

Workforce Development

The pursuit of technological advancement is nothing new in the scientific and engineering community, but the ability to engage end-users early in the process is what makes ECBC a game-changing organization for the employees who work here.

"It's typically rare for engineers and scientists to have the opportunity to work directly with the customers and users they serve," said Nichole Mortin, chemical engineer with the Detection Engineering Branch. "Unlike a traditional engineering firm, we're having direct and immediate impact on the lives of Warfighters and first responders.



Enclosed biosafety cabinets ventilate any potentially pathogens away from the operator and into carbon filters.

Some of the most rewarding work I've ever done here is while working hands-on with the Soldiers: fixing equipment, providing training, or just seeing the equipment I've supported being used in the field."

ECBC's workforce values a strong work ethic, hard science, and real engineering. That means working collaboratively when necessary and letting a technical skill set emerge when appropriate. Leadership is a key ingredient for ECBC's operational success, which is

> "[ECBC] believe[s] in **developing** the younger generation to become **new leaders**"

why the Center offers a variety of mentoring, training and leadership developmental programs to cultivate the growth of its employees. This year, ECBC provided workforce opportunities to participate in programs such as the Leadership Cohort, Mid-Level Career Development Programs, and other educational offerings.

"The best training courses I've taken are the non-mandatory ones that I had to sign up and apply for," said Mortin. "I truly see the benefit of the Mid-Level Cohort and the Executive Presentation Skills courses, when you learn a lot about yourself and then try to improve the ways that you interact with other people. That is important at any level."

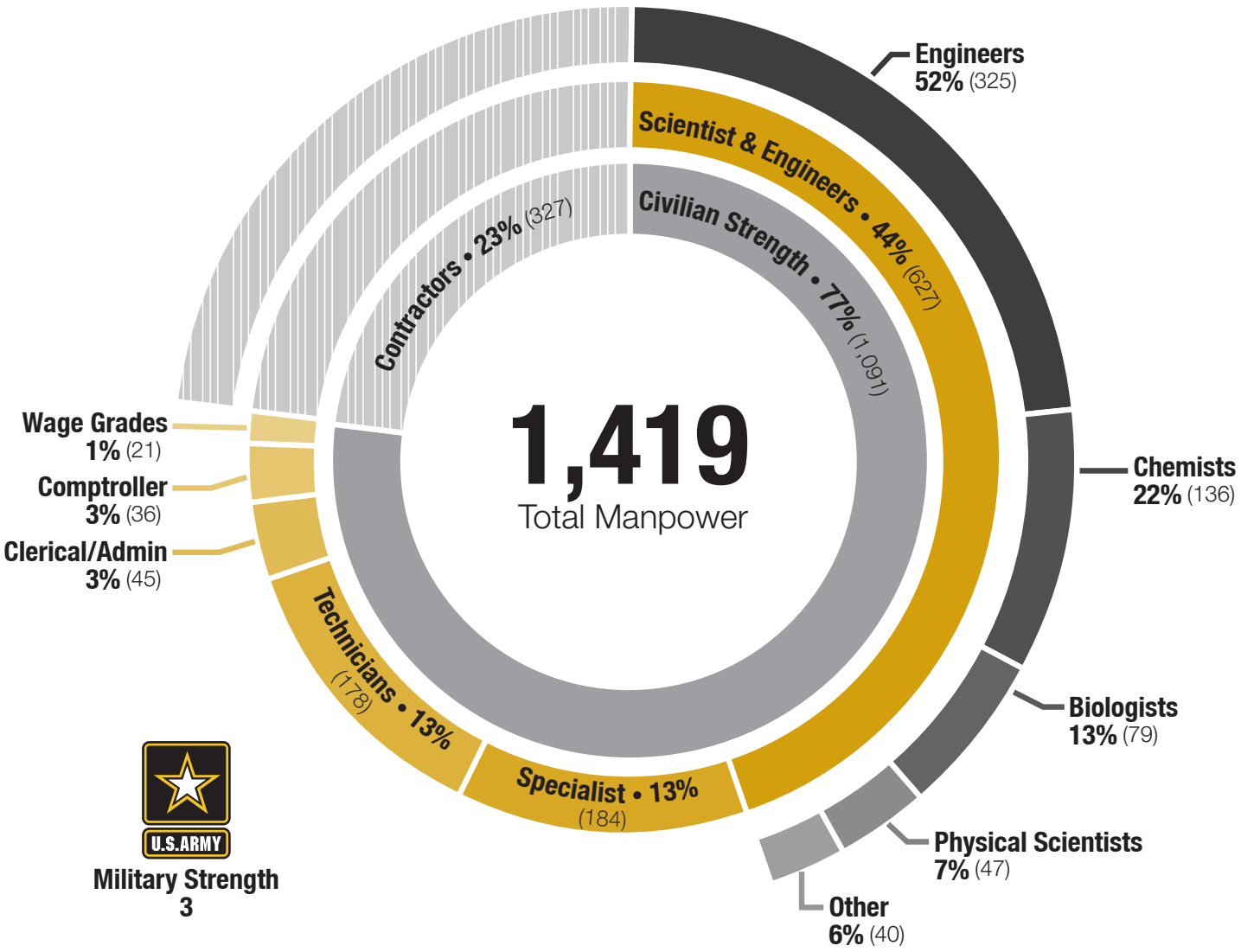
> "**Direct** and **immediate** impact on the lives of **Warfighters** and **first responders**"

Mortin also participated in the Aberdeen Proving Ground (APG) Greening Course, where employees are able to experience situations from the Soldier's perspective for a week.

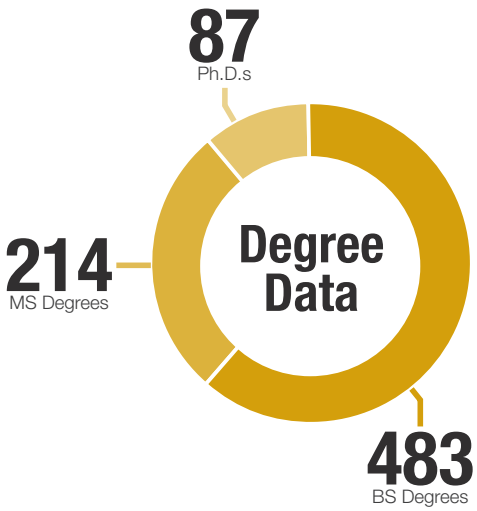
"My supervisors have always been extremely supportive of me taking these kinds of courses because they believe in developing the younger generation to become new leaders. For as long as I've been here, I've always felt that there is a direct correlation between career advancement and the level of effort you're willing to put forth, and the responsibility you're willing to take on," Mortin said.

Greg Peterson is a research chemical engineer with the Chemical, Biological, Radiological (CBR) Filtration Branch

ECBC arms a group of 10 students with hands-on skills for future science, technology, engineering and math (STEM) careers during its ten-week Minority Undergraduate Summer Internship Program (MUSIP) initiative.



who echoes Mortin's sentiments about the opportunities at ECBC. He also participated in the APG Greening Course and several leadership development classes, and is currently taking technical courses at the University of Delaware to pursue his Ph.D.



"This is a unique way of progressing my career without being a supervisor," Peterson said.

These external opportunities allow ECBC employees to enhance their expertise and bring back new knowledge that benefits the collective ECBC workforce. The Center's culture of collaboration is advantageous for employees to learn from one another on joint projects, and also lend their skill sets in ways that bolster ECBC capabilities as CBRNE defense advances.

"Although I work primarily in filtration, many times we end up developing materials that are useful for decontamination, sensing or some other application," Peterson said. "It's great to have immediate access to subject matter experts in those areas to discuss these new ideas. The ability to develop materials to counter super toxic chemicals, and the ability to test those materials, gives ECBC a leg up over 99 percent of others working in materials development. The new and unique challenges that continuously come up makes for an exciting career." ○

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A U.S. Army RDECOM Laboratory

usarmy.APG.ecac.max.communications–office@mail.mil
tel 410.436.7118 | **fax** 410.436.2014
www.ecbc.army.mil

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