U.S. DEPARTMENT OF ENERGY

Keeping America Secure: The Science Supporting the Development of Threat Detection Technologies

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Pacific Northwest NATIONAL LABORATORY

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Introduction

Chairman Hall, Ranking Member Johnson, and members of the committee, thank you for the opportunity to contribute to today’s hearing. The topic of this hearing is critical to securing America through the advancement of threat detection technologies. My name is Tony Peurrung, Associate Laboratory Director of the National Security Directorate at Pacific Northwest National Laboratory (PNNL) located in Richland, Washington, adjacent to the Hanford Site. It is an honor to provide testimony on the role of the national laboratories in the national scientific enterprise.

PNNL is one of ten U.S. Department of Energy (DOE) national laboratories managed by DOE's Office of Science (SC). Our research strengthens the nation’s foundation for innovation, and we find solutions for not only DOE, but for the U.S. Department of Homeland Security (DHS), the National Nuclear Security Administration (NNSA), the Department of Defense (DoD), the Intelligence Community (IC), other government agencies, universities, and industry. Our multidisciplinary scientific teams are brought together to address the nation’s most pressing issues in energy, environment, and national security through advances in basic and applied science.

Role of DOE Laboratories

Since the attacks of September 11, 2001, our nation has focused on maintaining the security of the homeland and prevention of further terror attacks. All across the country, industry, academia, and government have worked in tandem toward this goal.

The DOE complex of national laboratories, which have been a centerpiece of the nation’s research and development capabilities for over sixty years, have played a prominent role in developing and deploying detection technologies to protect America against evolving threats.

Important objectives of DOE’s multi-program science laboratories are to accelerate the rate of innovation, steward unique national capabilities, and leverage the national science base for the benefit of diverse applied missions. The threat detection research programs at PNNL successfully illustrate how these objectives come together. We have scientific strengths and historic capabilities with roots dating back to the Manhattan project of the 1940s at the Hanford Site. Today, approximately half of PNNL’s $1.1 billion business is centered on national security missions. Threat detection technology development is a central part of these programs and one in which science plays a particularly critical role.

DOE labs combine deep scientific insight and a keen understanding of operational missions with strategic partnerships—including universities and industry—to develop novel detection technology. The laboratories are working to prepare for tomorrow’s challenges and deliver transformational technological change so that today’s detection challenges are addressed and our country stays ahead of adversarial threats.

Ultra-Trace Detection and Analysis

Ultrasensitive nuclear detection is an area where the interplay between fundamental science and detection technology has been particularly rich and distinguished. Over four decades our ability to detect and characterize trace nuclear materials had improved to the point that radioactive materials eight orders of magnitude less concentrated than those naturally present in this room can be measured. This continuing effort is supported by various security mission stakeholders and by DOE's nuclear physics and high-energy physics programs. For example, after the tragedy at Fukushima, we were the first to detect trace amounts of radioactive material over U.S. territory, providing timely and critical information for U.S. Government decision-makers.

As the steward for various national scientific capabilities, PNNL researchers have been evolving the Multi-Sensor Airborne Radiation System (MARS) to support nonproliferation objectives of the NNSA. The system was recently deployed on a helicopter—a first for a system with this level of precision. (MARS was previously demonstrated on a truck that traveled from Richland, Washington to Charleston, South Carolina, and then on two boats.) The technology advances the state of the art in radiological detection at standoff distances. Using high-purity germanium crystals inside a vacuum cryostat, MARS detects and identifies radiological isotopes, with great precision, from a distance of tens of meters. MARS sends its detection data to a computer in real time, where operators quickly can see what substance is being detected and how radioactive it is. Knowing that, experts can tell what kind of nuclear material is in the vicinity, where it is coming from, and how dangerous it is.

Materials Development

PNNL's understanding of radiation and materials allows researchers to make significant breakthroughs in radiation detection materials discovery and development for DHS's Domestic Nuclear Detection Office (DNDO). Both the scarcity of helium-3 (He-3) and the need for improved radiation detection has focused research on discovering new materials. The recent He-3 shortage threatened to diminish our national ability to detect nuclear threats. Several DOE labs, in conjunction with industry, the DNDO, and NNSA, played critical roles in driving innovation and evaluating technology so that today's detection system needs are met with commercial instrumentation that does not consume precious He-3. In the longer run, improved detection systems will require more rapid discovery of new materials with advanced capabilities. To this end, laboratories such as ours have focused on the fundamental science necessary to understand how and why radiation detection materials function as they do.

For example, over the last few years, PNNL has been using its expertise in materials discovery to identify, select, and develop new materials that will improve the resolution and processing time in detecting radiological and nuclear devices. Experts now have a greater understanding of the potential materials covering the four conventional semiconductor material classes. They were able to narrow over 2,000 material compositions to a list of 245 that may have comparable performance characteristics to cadmium zinc telluride, a well-known radiation detection material. This work has drawn collaborative interests from multiple industrial and academic partners with plans to develop new detection instruments, increasing effectiveness in the field.

Cyber Security

In the mid-1990s, a new DOE user facility—the Environmental Molecular Sciences Laboratory, or EMSL—came on line at PNNL and made state-of-the art research equipment available to researchers across the nation and around the world. The vision was to provide virtual access to this equipment so researchers would not have to be physically located at PNNL. This drove some of our initial work in cyber security. Today, major cyber attacks occur on a regular basis across the U.S. Cyber security researchers combat over 500 million events per day at 90 DOE sites. Their efforts are changing the paradigm away from reactive efforts to more proactive approaches through programs such as Digital Ants™. As the name suggests, this program provides a framework for decentralized coordination modeled on the real ant behavior known as "swarm intelligence." Cited as one of ten innovative technologies in "World Changing Ideas" in the December 2010 issue of Scientific American, the Digital Ants™ solution reduces the level of required human involvement in problem detection and resolution while retaining the human ability to intervene as desired. If the "ants", small computer programs, find a symptom, they wander through computers searching out and then swarming on viruses and worms. This novel, flexible approach reduces cyber threats for individuals, industry, and critical national infrastructures. In the longer run, PNNL researchers are striving to make a range of national infrastructure dramatically more resilient in a way that does not require inordinate cost or hinder normal operation.

Partnerships

The DOE laboratories actively engage academia and industry to advance threat detection technologies. A couple of examples include the DHS Science and Technology (S&T) Directorate and PNNL-led National Visualization and Analytics Center (NVAC) and DHS's Centers of Excellence. NVAC develops the advanced visual analytics capabilities to help respond to accidental, intentional, and natural disasters. NVAC coordinates with other such centers globally to bring a wide range of new technologies to bear through academic, government, industrial, and international partnerships. For example, NVAC supported DHS in the development of a formal U.K. Visual Analytics Consortium. Researchers from PNNL participated in the third International Workshop on Visual Analytics in September 2011 and the kickoff meeting of Visual Analytics for Security Applications. Both events provided an opportunity for the U.S. and Germany to discuss technical objectives and scope. NVAC also conducts collaborative research in visual analytics with the DHS S&T Command, Control, and Interoperability Center of Excellence co-led by Purdue University and Rutgers University.

DHS's Centers of Excellence draw upon expertise from the national laboratories, universities, and industry to advance technology, including advanced-imaging technologies (AIT, formerly known as whole-body imaging). The averted terrorist events of December 2009 hastened the deployment of these technologies which hold promise for detection of explosives at checkpoints (portals). Significant ongoing scientific challenges regarding personal privacy and automated threat detection are preventing widespread acceptance and deployment of these systems. Expertise in AIT exists within the national laboratory system, particularly at PNNL, as well as within the DHS Center of Excellence in Explosives, ALERT (Awareness and Localization of Explosives-Related Threats) located at Northeastern University. Leveraging these capabilities, PNNL is working with researchers, scholars, and university students as well as industry representatives to collaborate on AIT challenges.

Advances in Threat Detection

Significant advances in threat detection technology are ongoing, and there is an exciting vision for the future. New discoveries have the ability to transform the way threats are detected in such places as our airports and border crossings. It is also worth noting that detection research and development not only involves physical detectors, but also important areas such as the discovery of novel signatures and performing large-scale data analysis.

Improving Airport Security

One particular example of technology advancement is in airport security. PNNL's Millimeter Wave technology is helping to detect concealed weapons, explosives, and contraband. The roots of the technology date back to the 1960s when researchers at PNNL pioneered the development of optical and acoustic holography—the foundation of the millimeter-wave technology. In 1989, PNNL worked with the Federal Aviation Administration (FAA) to perform feasibility studies and the first patent was issued in 1995. Today, airport scanners are equipped with this detection technology across the globe.

In the future, the Millimeter Wave technology can be used in standoff detection of explosives and nondestructive detection and evaluation of objects under a much wider range of scenarios. For example, DHS and DoD jointly supported integrated research that promises to enable standoff detection of person-borne explosive threats in crowds. This effort involves partnership with the National Institute of Standards and Technology (NIST), the United Kingdom Home Office, and industry. Other breakthroughs such as novel vapor detection approaches and novel x-ray signature development continue to result from our combination of fundamental chemical science and applied explosive detection capability. PNNL continues to work with federal agencies and industry to expand the next generation of threat detection technology for aviation security.

Advancing Data Analytics

Another example is the nation's ability to analyze large volumes of heterogeneous data for potential threats. The analysis of data has evolved from yesterday's scenario of individuals reading volumes of printed materials to the use of electronic tools that visually represent data from disparate sources. Researchers are using visual and data analytics to study and understand the capabilities, motivation, and intent of our nation's adversaries. Our process uses data representations and algorithmic techniques from other basic and fundamental science domains and creatively applies them to national security problems. Flagship products like IN-SPIRE and Starlight, are now deployed to hundreds of U.S. Government analysts and used every day. Through these creative and powerful tools and methods, researchers are discovering new ways to detect relationships, trends and themes across many domains including cyber analytics, the electric grid, law enforcement, and systems biology. Tomorrow's tools will analyze not only text input from documents, websites, and social media tools but will address image, audio, video, and sensor data as well.

Complementary Work

The cross-cutting work that national laboratories conduct for one federal agency are often leveraged for the benefit of others. Examples include advancements in standoff detection technologies initially funded by DHS and now leveraged and funded by DoD, health research funded by the National Institutes of Health (NIH) that is now used in bioforensics research funded by DHS, and DOE seed investments—Laboratory Directed Research and Development (LDRD)—that focuses on discoveries for tackling the nation's greatest challenges.

Deployed Standoff Detection

One illustrative example of cross-cutting work is the Standoff Technology Integration and Demonstration Program (STIDP) at PNNL. This project was initially funded by DHS S&T in 2007 to develop and test an integrated countermeasure architecture to defeat person-borne improvised explosive devices (PBIEDs) using standoff technologies in an operational environment. Then in 2010, after a visit by DoD to the operational test site, there was a realization that the work being performed by PNNL for DHS was well beyond anything they were undertaking to detect improvised explosives in the battlefield. DoD is now funding this project exclusively and applying advances in standoff detection to the real-world. Partnerships include work with NIST, the United Kingdom Home Office, and industry.

Leveraging Medical Research

Medical research initially funded by NIH has been leveraged by DHS and others to advance bioforensics research. Viral pathogens are one category of a potential bioattack. PNNL is improving the detection of virus production signatures in bioforensic samples, via detection of proteins found in viruses. This project is using proteomics datasets and advanced mass spectrometric methods to analyze the *Vaccinia* virus. As stated by the Federal Bureau of Investigation's (FBI) Chemical Biological Sciences Unit, this work improves the detection of virus production signatures in bioforensic samples and fills an important gap in forensic method development.

Investing in the Future

The national laboratories invest in initiatives to deliver transformational science, technology, and impact; accelerate the rate of innovation; develop new partnerships for national and international impact; transform our science and technology workforce; and nurture and evolve the nation's core scientific capabilities. PNNL's LDRD program is a mechanism for bringing forward novel ideas that will become the next generation of science and technology. LDRD strengthens the nation's fundamental research component, builds capability in support of applied research and development programs, and translates scientific discoveries into real-world technology applications. One such investment is the Ultra-Sensitive Nuclear Measurement Initiative, which is focused on addressing the need for increasingly sensitive nuclear measurement systems to discover, analyze, and interpret extremely weak signals, including those from rare physical events. Another example is the Signature Discovery Initiative, which will deliver a systematic process and set of analytic tools to accelerate the discovery of new signatures in any domain, including threat detection. This research will produce an integrated analytic framework with new algorithms and methods for efficiently analyzing multisource data to uncover patterns and relationships that can be correlated with some measureable phenomena or event.

Conclusion

Shortly after the attacks of September 11, 2001, the National Academy of Sciences undertook a comprehensive study examining the importance of science and technology to tackle the multitude of threats to the homeland. The 2002 report entitled, *Making the Nation Safer*, stated "strengthening the national effort in long-term research that can create new solutions should be a cornerstone of the strategy for countering terrorism." I believe this has occurred with considerable benefit to our national security. Largely because of the strength of our national science base and its effective application to threat detection, we continue to be global leaders in this area.

There are challenges as well. Science programs are not always easily integrated with threat detection research because of cultural differences between the open, global scientific endeavor and programs that are frequently sensitive. The DOE national laboratories are ideally suited to take on this challenge and I assure the committee that the leadership team at PNNL will continue to do so.

Although extremely valuable, science programs targeted at pressing national security threats are fragile. They can be harmed not only by the inevitable fluctuations in funding support, but also by rapid shifts in the leading threat of the day or by excessively short-term objectives. I recommend that strategic stewardship of our threat detection research capabilities and the science that underlies them remain a high federal priority.

I am optimistic that the tremendous benefits of science-driven innovation will continue to make our nation safer. We will continue to develop threat detection technologies that are more effective and operationally attractive. We will retain an ability to react rapidly to new, changing, or elevated threats.
I thank the committee again for their time and attention.

About the Speaker

Dr. Anthony (Tony) Peurrung is the Associate Laboratory Director of the National Security Directorate at Pacific Northwest National Laboratory (PNNL). Dr. Peurrung oversees the portfolio of national security programs and commercial enterprises at PNNL. Under his leadership, PNNL delivers scientific insights, tools and methods to deploy impactful science and technology to clients in the Department of Energy, Department of Homeland Security, Department of Defense, the Intelligence Community and the National Nuclear Security Administration.

Dr. Peurrung has contributed to a variety of fields within fundamental and applied physics including fluid mechanics, plasma physics, medical physics, separations science, environmental remediation, nuclear physics, and radiation detection methods and applications. His current research interests are centered on detection and characterization of special nuclear material, particularly problems where strong links to fundamental science capability are important.

About PNNL

Located in Richland, Washington, PNNL is one among ten U.S. Department of Energy (DOE) national laboratories managed by DOE's Office of Science. Our research strengthens the U.S. foundation for innovation, and we help find solutions for not only DOE, but for the U.S. Department of Homeland Security, the National Nuclear Security Administration, other government agencies, universities and industry. Unlike others, our multidisciplinary scientific teams are brought together to address their problems. More specifically, at PNNL we

- provide the facilities, unique scientific equipment, and world-renowned scientists and engineers to strengthen U.S. scientific foundations through fundamental research and innovation
- prevent and counter acts of terrorism through applied research in information analysis, cyber security, and the non-proliferation of weapons of mass destruction
- increase U.S. energy capacity and reduce dependence on imported oil through research of hydrogen and biomass-based fuels
- reduce the effects of energy generation and use on the environment.

Today, approximately 4,700 are employed at PNNL; our business volume is more than $1.1 billion. Our Richland campus includes unique laboratories and specialized equipment as well as the William R. Wiley Environmental Molecular Sciences Laboratory, a DOE Office of Science national scientific user facility. In addition to the Richland campus, we operate a marine research facility in Sequim, Washington; and satellite offices in Seattle and Tacoma, Washington; Portland, Oregon; and Washington, D.C.

Battelle—the world's largest independent scientific research and technology development organization—has operated PNNL for DOE and its predecessors since 1965. One unique feature of Battelle's contract with DOE allows research to be conducted for private industry.

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