Pacific Northwest
NATIONAL LABORATORY

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Science & Technology ACCOMPLISHMENTS

National Security Directorate

U.S. DEPARTMENT OF
ENERGY

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INTRODUCTION

Researchers at Pacific Northwest National Laboratory (PNNL) in Richland, Washington work to transform the world through courageous discovery and innovation that inspires and enables the world to live prosperously, safely, and securely. As one of the U.S. Department of Energy's national laboratories, staff members at PNNL collaborate amongst themselves and with academia, industry and other national laboratory partners to advance science and solve complex programs in energy, the environment, and national security.

Our national security mission is to develop and deploy innovative solutions to prevent and counter acts of terrorism. In order to achieve this mission, we have staff working worldwide in more than 100 countries on a variety of national and international security problems. Our daily research and development efforts are focused on ways to predict, prevent and mitigate acts of terrorism through predictive analysis, counter threats posed by the global expansion of nuclear energy and legacy weapons of mass destruction materials, detect the production, characteristics and movement of weapons of mass destruction and effect, and respond more rapidly and effectively to events of mass effect. National security efforts at PNNL span from protecting public places, to reducing nuclear threats, strengthening nonproliferation efforts, securing our energy future, and ultimately protecting our homeland.

SO MUCH DATA, SO LITTLE TIME

New tool helps analysts comprehend massive amounts of data

Each day hundreds of hours of video are uploaded to YouTube and millions of images are added to Flickr. The quantity of digital images, video, and text added to the World Wide Web each day make it truly a tangled web for intelligence analysts to extract meaningful associations.

To uncover relationships, trends, and themes hidden within large collections of multimedia, researchers at PNNL have developed a cutting-edge analytic software suite called Canopy. This powerful, time-saving tool is built with a user-centered design including easy-to-use interfaces and interactive visualizations. Canopy will not only reduce analysts' time uncovering relationships in mixed-media data collections but is capable of identifying critical intelligence for decision makers.

In testing, it was found that one analyst using Canopy could find the same information—in the same time-frame—that previously required multiple analysts. The time and effort to identify relevant and critical intelligence for decision-makers was reduced by approximately 98%. Analysts involved in this testing cited Canopy as "one of the most awesome tools they had worked with, and the best research grade tool they had ever used – ever."

TWITTERPATED

Tool analyzes social media for quick emergency response

When earthquakes and other natural disasters hit, it can take hours, if not days, to get useful information. Often, the quickest way to get immediate answers is to look to social media avenues such as Facebook and Twitter. The issue then becomes how does one make sense of the blast of information they find? To help discover patterns and find key bits of information amidst the sea of messages, social media analysts created a social analytics tool called SALSA (SociAL Sensor Analytics) that can sift through billions of messages in mere seconds.

SALSA could soon be used to help emergency responders react more efficiently to natural disasters, develop and distribute emergency alerts to the public, or to identify patterns that might indicate coming social unrest. For example, in a retrospective analysis, PNNL researchers were able to detect indications of political instability in a foreign country nearly three weeks before protests turned violent. This exceeds the event detection capabilities of existing technical capabilities by two weeks. In addition, SALSA has potential application in operational environments such as in the biodefense and intelligence communities.

Funding: PNNL Laboratory-Directed Research and Development Program | U.S. Department of Defense | U.S. Department of Homeland Security| Infectious Diseases Society of America | National Institutes of Mental Health | U.S. Department of State

UNDER WRAPS

Chernobyl's blown reactor gets new lid

A nuclear reactor explodes. A country is devastated and one question remains; how do you prevent the further release of radioactive contamination into the environment? Researchers at PNNL have helped engineer a solution—a giant lid.

Within months of a reactor core meltdown at Chernobyl in 1986, Ukrainians built a shelter to cover the open reactor; however, the shelter was a temporary fix. Over time, the temporary shelter became unstable and in need of replacement, so a team of international experts, including PNNL engineers, were called to help devise a longer-lasting solution. The result? A structure taller than the Statue of Liberty, the New Safe Confinement (or NSC) will be 850 feet wide by 500 feet tall. Because the damaged reactor creates potentially unsafe working conditions, the NSC is being built 650 yards away from the reactor, and will eventually be moved on special tracks and slid atop the damaged reactor. Once in place, workers can start dismantling the damaged reactor and disposing of radioactive waste, improving the safety and sustainability of the Chernobyl Nuclear Power Plant.

While situations like Chernobyl are tragic no matter the circumstances, the NSC provides a bit of relief and assurance that there will be no continued damaging effects.

Funding: European Bank for Reconstruction and Development

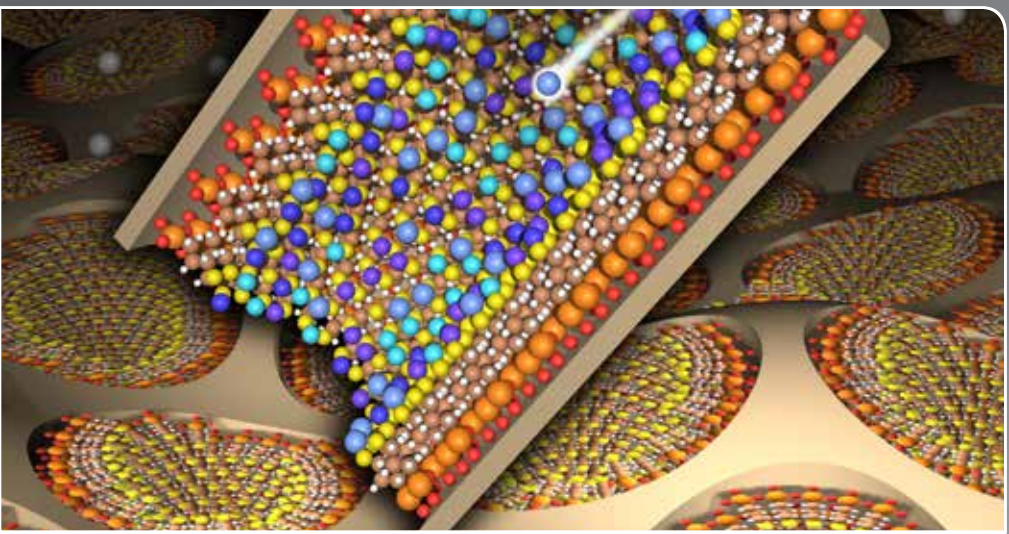
PLEASE USE RESPONSIBLY

Discerning medical isotope use from nuclear explosive tests

Nuclear medicine is becoming a hot topic in the world of health. It's been known for years that certain isotopes can be introduced into the human body to help doctors diagnose and treat diseases. Sounds great, right? So why does the production of medical radioactive isotopes cause concern in the science world? Well, emissions from some medical isotope production facilities look similar to those produced by a nuclear explosion. Furthermore, even just a few facilities using a fission process to produce medical isotopes can interfere with the detection of nuclear explosive testing worldwide.

An ongoing multi-year project at PNNL has resulted in a better understanding of the nuclear signatures created through isotope production and the small yet detectable quantities of isotopes released into the environment. PNNL is a leader in an extensive and coordinated international research and development effort to both reduce these emissions and improve techniques to differentiate between signatures of civil nuclear activities and nuclear explosions. A key component of this coordinated effort, the Workshop on Signatures of Medical and Industrial Isotope Production (WOSMIP), was initiated by PNNL in 2009 and continues to raise awareness and shape U.S. and international policy on Comprehensive Nuclear-Test-Ban Treaty verification.

Funding: National Nuclear Security Administration Office of Nuclear Verification



BREATHE EASY

Technology helps submariners breathe clean air

Nobody likes to breathe dirty air, especially when that air becomes toxic to your health. For years, the U.S. Navy has been tackling this problem as submarines have a limited supply of air, and until now, the air-purifying systems have been large and bulky—making for an even tighter ship. PNNL had the perfect nanotechnology up its sleeve to address this not-so-nano challenge.

SAMMS® (Self-Assembled Monolayers on Mesoporous Supports) material was originally designed to remove contaminants such as mercury from liquid solutions like water. Scientists at PNNL adapted this same technology to absorb carbon dioxide from breathing air in submarines. The technology uses a new class of hybrid nanoporous materials that can rapidly filter out contaminants such as carbon dioxide, mercury, or arsenic directly from the atmosphere or liquid environment.

This award-winning technology has proven successful in improving both water and air quality, but the benefits do not stop there. SAMMS has many applications and might one day be used in space, SCUBA gear, and other closed environments.

Funding: Department of Energy Office of Biological & Environmental Research | Environmental Science Program Environmental Management | Office of Science and Technology | Office of Basic Energy Sciences | PNNL Laboratory Directed Research and Development Program

DISRUPT ILLICIT NUCLEAR TRAFFICKING

Objective

The U.S. government has invested significant resources to secure facilities around the globe that produce and house nuclear materials, to detect and interdict the illicit movement of these materials across international borders, and to identify and disrupt organized terrorist networks. The focus has now shifted to detecting and disrupting the illicit activities associated with the intention or act of trafficking nuclear materials, or the knowledge, technologies, or commodities required to produce them.

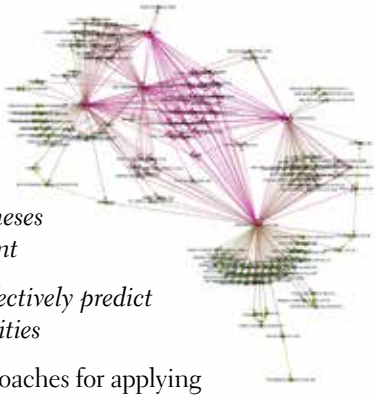
PNNL is developing the methods and tools required to anticipate and interrupt the flow of nuclear materials and strategic goods through transformational advancements in analytics, signatures and measurement science.

Vision

To disrupt trafficking of nuclear materials and strategic goods before they occur by developing and exploiting anticipatory signatures.

Approach

- Signatures: Apply rigorous and innovative methodologies to identify signatures indicative of illicit activity that integrate expert- and data-driven analysis of complex activities and data sets
  - *Better detect and understand complex threats*
  - *Enable early detection and correlation of activities indicative of illicit nuclear trafficking*
- Modeling and Framework: Given the complexity of human behavior, develop incremental machine learning techniques, symbolic reasoning, and dynamic models
  - *Evaluate and rank candidate hypotheses to explain actor motivation and intent*
  - *Model supply-chain behaviors to effectively predict and disrupt nuclear trafficking activities*



- Analytic Solutions: Develop novel approaches for applying trusted analytics on data within individual organizations; identify methods for integrating community information using common knowledge representations
  - *Create statistical models to aggregate indicators to improve threat assessment and model supply-chain behaviors to effectively predict and disrupt nuclear trafficking activities*
  - *Apply PNNL analytic capabilities as appropriate to create a robust analysis platform and evolve capabilities through the execution of mission-oriented challenge problems*
- Support to Analysis Operations: Combine PNNL's expertise in the nonproliferation and counterterrorism domains with novel analytics and tradecraft to expand reachback and analysis support to clients

Impact

Shift U.S. posture from a defense to offensive position thus increasing the probability of early stage detection and disruption of nuclear trafficking activities.

RUNNING AWAY WITH GAMMA RAYS

Faster and more accurate measurement of nuclear materials

Like Usain Bolt off the blocks or Jeff Gordon on the racetrack, PNNL is out in front when it comes to gamma ray detection. Five-times faster than the world's current leader, a new gamma-ray detector developed by PNNL is paving the way in the measurement of nuclear materials.

Radioactive sources produce gamma rays of various energies and intensities. Gamma-ray detectors collect and analyze these rays to analyze special nuclear material for treaty verification and characterizing radiological threats, among other applications. The problem is that current technology is easily overwhelmed with the high numbers of photons in a high-radiation environment.

In contrast, the new detector processes photons much more rapidly and actually thrives in high-radiation environments, providing direct and accurate nuclear material measurements. The instrument greatly reduces testing time and impact on facility operations.

This new gamma-ray detector makes life easier for nuclear facility operators, the emergency response community, and government agencies by providing the world's fastest high resolution gamma ray detector.

Funding: National Nuclear Security Administration Office of Defense Nuclear Nonproliferation Research and Development

TESTING THE WATERS

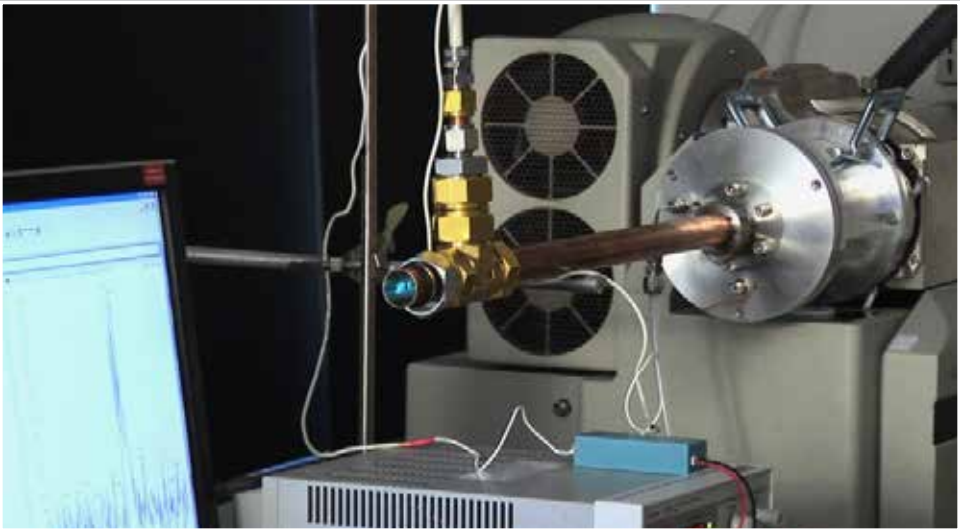
Detecting illicit nuclear materials on small vessels in maritime environments

Those pesky waterways have long proven difficult for detecting illicit materials—until now. The Department of Homeland Security and PNNL have set sail with a first-of-its kind maritime radiological and nuclear detection testing site. At the PNNL Marine Science Laboratory in Sequim Bay, Washington, PNNL constructed an innovative on-the-water testing venue. The venue provides a controlled, open-water maritime environment for small vessel radiological and nuclear standoff detection testing.

This unique venue allows for the testing of systems that will minimize inspection times and increase the distance at which law enforcement personnel can scan a small vessel. PNNL spent significant time and effort collecting over 150 hours of test data on over 1500 test runs. The resulting capabilities reduce the need to board small vessels for detection purposes and mitigate the threat of radiological and nuclear devices coming through the waters on small boats.

The Marine Science Laboratory testing venue is also used for drills and demonstrations to inform federal, state, and local maritime law enforcement agencies of the importance for preventative radiation and nuclear detection on small vessels.

Funding: Department of Homeland Security Domestic Nuclear Detection Office



SNIFFING OUT TROUBLE

Instrument's ability to "sniff" for explosives vapor capability is giving canines a run for their money

It's long been recognized that canines are one of the most effective bomb sniffing technologies. However, researchers at PNNL, unwilling to believe that science cannot match nature, set out to create a new method to identify minute amounts of explosives in the air. PNNL's vapor detection technology fulfills a long-sought after method of explosives detection, greatly advances our ability to identify explosives simply by "sniffing" the air, similar to a dog.

The direct, real-time detection of low-pressure vapor explosives is a substantial leap forward in explosives detection technology. Developed by combining novel enabling reaction chemistry with a commercial off-the-shelf spectrometer, the technology is sensitive enough to detect commonly used military explosives that have almost no vapor component. The technology samples the air and efficiently converts the small number of explosives molecules to ions within a reaction tube. The ions then move directly to a mass spectrometer for detection and identification for a nearly instantaneous response, also similar to a dog.

Currently in the prototype phase, PNNL's vapor detection technology has a huge potential to revolutionize security operations, such as in airport screening, port security and military applications.

Funding: PNNL's Laboratory Directed Research and Development Program

PLUGGING UP HOLES

Giant balloon-like plug could halt storm water, keep communities safe

At the end of every summer, meteorologists begin buzzing about the next alphabet-labeled super storm and public safety officials start preparing for the worst case scenario that could blow through their region. Hurricanes, known for their howling winds and punishing rain, are forces to be reckoned with. City officials strive to maintain control of public services and infrastructure, but how does one prepare for rivers that threaten to surge through tunnels, knock out power, and cripple key transportation nodes? Traditionally, options have been limited. However, the Department of Homeland Security Science and Technology Directorate has initiated a program to develop methods for protecting transportation tunnels. As part of this effort, PNNL, in partnership with ILC Dover and West Virginia University, has coordinated the demonstration of a new technology that has the potential to stop storm water in its tracks.

The Resilient Tunnel Plug is an enormous inflatable cylinder, roughly 32 by 16 feet, capsule-shaped, with rounded ends. Constructed in three layers, including an inflatable bladder and a webbed exterior made of a high-strength synthetic fiber called Vectran™, it can be pumped full or water or air in minutes to quickly seal off a section of tunnel and control the spread of powerful waters. With proper placement and use of these systems, the potential impacts to transportation systems can be greatly reduced.

Funding: U.S. Department of Homeland Security Science and Technology Directorate

NO SCREEN NEEDED

First-ever 3D virtual retinal display allows for extended media viewing

The larger-than-life screen, surround sound, and popcorn all contribute to the immersive viewing experience that movie theaters provide. While you'll still be responsible for your own popcorn, scientists at PNNL have developed a technology that allows users to experience digital media in this immersive environment from the comfort of their own home, or even on-the-go.

Using PNNL's licensed technology, Avegant Corporation has introduced the Glyph™, an innovative product that uses micro-mirror technology to project images directly onto the retina, eliminating the need for a screen. The virtual retinal design allows the user's eyes to focus at infinity (the natural state of the eye) to enable Glyph™ users to view electronic media comfortably for long periods of time with minimal fatigue. The flexible design of the imaging optics also accommodates for a variety personal vision needs.

In addition to digital media, the technology has potential applications in areas such as minimally invasive surgery and training and simulation. The Department of Defense can also benefit from the device's capabilities for night-time maneuvers and piloting armored or unmanned autonomous vehicles.

Funding: PNNL's Laboratory Internal Research and Development Program | U.S. Department of Defense

RISKY BUSINESS

Decision-support algorithm greatly reduces risk in mass transportation

Mass transportation plays a crucial role in the solution set to the nation's economic, energy, and environmental challenges. Often times though, some of the largest transportation systems face the greatest risks.

To minimize this risk, PNNL developed the Risk Reduction and Resource Assessment Model (3RAM) for use in mass transportation applications. The tool has been approved for operational use by the United States Coast Guard and is currently being used by the Washington State Ferry System and Washington State Patrol. Based on patterns of operation and usage, 3RAM computes risk across the entire ferry system and recommends appropriate deployment of available security resources such as canine teams and law enforcement officers. One of the most significant aspects of 3RAM is the ability to compute risk continually over time and balance the available security assets that minimize risk at each hour of the day.

This technology has resulted in a significant reduction in mass transportation risk and allows Washington State Ferry-goers to use the nation's largest and highest-risk ferry system safely.

Funding: U.S. Department of Homeland Security Advanced Incident Management System

NATIONAL SECURITY DIRECTORATE INITIATIVES

The National Security Directorate invests in a portfolio of strategic initiatives that will advance delivery of transformational science and technology, accelerate innovation, and deliver greater mission impact.

Asymmetric Resilient Cybersecurity (ARC)

ARC is delivering the theory, processes, methodologies, and algorithms that will enable a resilient cyber infrastructure with an asymmetric advantage to thwart adversaries who seek to infiltrate and damage our national security through digital means. ***http://cybersecurity.pnnl.gov/arc.stm***

Analytics in Motion (AIM)

AIM is accelerating knowledge discovery from high-volume data streams by inventing new techniques to help automate the process of creating and validating hypotheses. Moreover, AIM is developing a new analysis paradigm to provide continuous, automated synthesis of new knowledge to enable measurement systems to be steered in response to emerging knowledge, rebalancing the effort between humans and machines. ***http://aim.pnnl.gov/***

Signature Discovery (SDI)

SDI is developing a methodology that will enable decision-makers' ability to anticipate future events by detecting precursor signatures, characterize current conditions by matching observations against known signatures, and analyze past events by examining signatures left behind. The transformational research agenda is expected to yield new algorithms, methods, tools and techniques that will solve pressing national challenges. ***http://signatures.pnnl.gov/***

Ultra-Sensitive Nuclear Measurements (USNMI)

USNMI is discovering and exploiting signatures from rare physical decays and trace radioisotopes across multiple domains from probing fundamental physics to environmental science to disruption of illicit nuclear material trafficking. Efforts will give greater insight in areas ranging from nuclear nonproliferation, to analysis of nature's radioisotopes and the composition of the Universe. ***http://www.pnl.gov/physics/Ultrasensitive.stm***

ON THE COVER:

PNNL's shallow underground facility houses some of the world's most sensitive radiation detection systems and supports ultralow-background research and development for environmental, national security, and fundamental physics. PNNL scientists are able to measure low-background radiation with a high level of sensitivity. One of the capabilities in this facility is the electro-formation of ultra-pure copper for use in ultralow-background radiation detectors.

DISCOVERY *in action*

ABOUT
Pacific Northwest National Laboratory

The Pacific Northwest National Laboratory, located in southeastern Washington State, is a U.S. Department of Energy Office of Science laboratory that solves complex problems in energy, national security, and the environment and advances scientific frontiers in the chemical, biological, materials, environmental, and computational sciences. PNNL employs 4,300 staff members, has an annual budget of nearly $1 billion, and has been managed by Ohio-based Battelle since 1965.

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