"Our challenge is to fight terrorism within our countries, without undermining the ties of commerce and friendship between our countries. Terrorists want to turn the openness of the global economy against itself. We must not let them. We need customs, financial, immigration and transportation systems that make it easier for us to do our business, and much harder for terrorists to do theirs."

—President Bush

Securing Our HOMELAND

The September 11 attack on America forever changed the course of history. Since that pivotal turning point, law enforcement and national security agency resources have been stretched, providing additional protection required by increased terrorist threats and their willingness to use chemical, biological or nuclear weapons of mass destruction. The result has been declined tourism and increased delays in the movement of commerce.

Scientists and engineers at the Pacific Northwest National Laboratory have been helping secure homeland security long before 9-11. In fact, our legacy in supporting the U.S. government's national security mission began nearly four decades ago.

Today, we are assessing the vulnerability of critical infrastructures in the Pacific Northwest and across the nation as well as teaming with organizations to ensure our air and seaports are protected from the threat of terrorist attacks. Around the globe, PNNL is training border enforcement officials to thwart the smuggling of chemical, biological or nuclear materials across foreign borders. We also are instructing emergency first responders in every country that houses a U.S. embassy on how to respond to a nuclear, chemical or biological attack.

Whether it is looking for innovative methods to secure commerce in the Pacific Northwest and across the nation or helping protect international borders, our scientists and engineers are committed to helping win the war on terrorism.

"Our nation will continue to be steadfast, and patient and persistent in the pursuit of two great objectives. First, we will shut down terrorist camps, disrupt terrorist plans and bring terrorists to justice. And second, we must prevent the terrorists and regimes who seek chemical, biological or nuclear weapons from threatening the United States and the world."

President Bush,
State of the Union Address

The Holographic Imaging System detects hidden metallic and plastic contraband hidden under clothing.

Sensors and Electronics for Threat Detection

Electronics experts provide scientific and technology development to meet a broad range of sensor, measurement technology, electronic (including controls), and system integration application requirements to detect chemical, nuclear and biological weapons proliferation. Our expertise is tailored to meet client and project needs and includes:

- scientific investigations and analysis
- feasibility studies
- measurement and data analysis, method development, validation and application
- laboratory testing
- prototype equipment development and evaluation
- development and deployment of field hardened equipment and methods.

Whether it is the development of a security scanner that will detect hidden contraband on passengers passing through airports or innovative sensors that detect the release of radionuclide or chemical nerve and blister agents or bio-agents, our scientists and engineers are developing significant technologies necessary to protect our country.

Technologies to Protect Our Airports

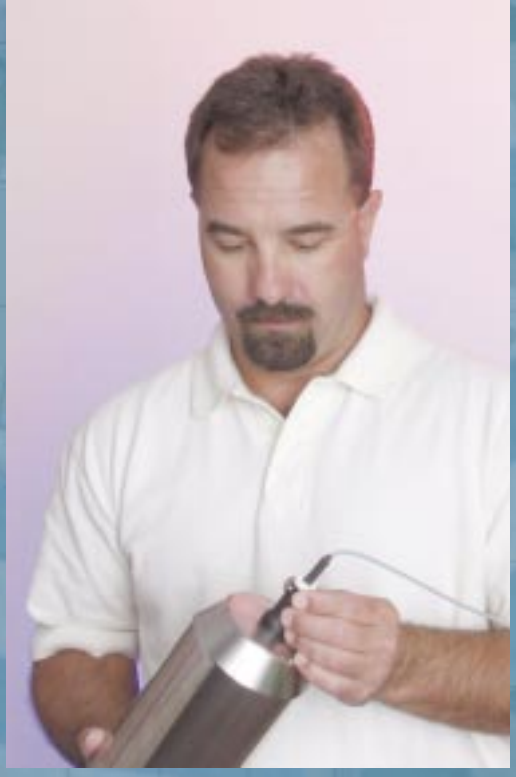
With some fine-tuning, our millimeter wave Holographic Imaging System could help thwart the smuggling of contraband—such as box knives or explosive sneakers—through airports. This imaging system is an innovative technology originally designed for the Federal Aviation Administration to detect metallic and nonmetallic items concealed under clothing as well as more dangerous items such as plastic and liquid explosives. Our system uses millimeter waves that can penetrate clothing but are completely harmless to people. PNNL has had a holography program in place for nearly 30 years.

Aiding Seaports with AID Technology

Containers shipped into seaports also could be inspected easily using PNNL's Acoustic Inspection Device. AID originally was developed for U.S. and Russian chemical weapons bilateral treaty verification and for inspection of chemical weapon stockpiles in Iraq following the 1991 Gulf War. AID is a handheld device roughly the size and shape of a cordless drill and contains a sensor head. It is tethered to a personal digital assistant, linked to a data library and can determine the contents of sealed, liquid-filled containers. It also can examine bulk-solid commodities—detecting foreign objects, contraband or hidden explosives. Mehl, Griffin, and Bartek Ltd., located in Arlington, Virginia, commercialized AID for the U. S.

The Acoustic Inspection Device enables inspectors to "see" inside sealed containers.

BEADS is a sample preparation system that can be used in biodetectors to quickly identify pathogens.



A researcher applies the black sensor probe of the Dual-Use Analyzer to a canister, which transmits eddy currents to identify the type of metal.

Customs Service. A similar version of the device now is being used along the borders in Eastern Europe for detecting smuggled goods.

Double Duty to Secure Borders

Within seconds, a new portable instrument developed at PNNL can identify high-value metals, such as "dual-use" materials commonly found in industry but also required for production of nuclear weapons. Called the Dual-Use Analyzer, the system enables a border inspector or other field agent to immediately identify cargo and differentiate between metals of similar appearance, eliminating the need for costly off-site analysis.

Device that Delivers On-the-Spot Warnings

Rapid detection of biological threats requires more than a detector. BEADS, Biodetection Enabling Analyte Delivery System, was created by PNNL to fill the gap between dirty environmental samples containing potential biothreats and sensitive detectors requiring a purified cell, proteins or DNA. BEADS isolates bacteria, spores, viruses and their DNA from air, dirt or water samples. The PNNL-developed technology is fully automated so that detectors can analyze samples and monitor for threats without requiring a person to manually prepare the samples. With BEADS sample preparation systems as a front-end technology, detectors can be deployed as unattended biothreat monitors. Using Navy funding, BEADS is being developed to monitor for infectious diseases that may threaten military personnel, while DOE is pursuing BEADS as a front-end technology for multiplexed biodetection units for homeland defense applications.

Special Polymer Senses Nerve Agents

Detecting invisible chemical agent vapors is important in monitoring the safety of air in buildings or subways, and for protecting first responders to terrorist incidents. Scientists at PNNL have developed a novel polymer material for detecting chemical agent threats. When this polymer is applied to a chemical microsensor, the sensor can detect nerve agents with high sensitivity and reliability. The polymer absorbs nerve agent molecules from the air so the sensor can detect them. PNNL technology significantly has increased that detector's sensitivity to nerve agents, such as saran, resulting in faster response times to lower agent concentrations.

PNNL's Jay Grate, Homeland Security Director Tom Ridge and Energy Secretary Spencer Abraham.

PUMA fibers developed at PNNL detect radionuclides.

When fully developed and deployed, MALDI mass spectrometry will be used in the field for real-time screening of biological agents.

Glass Fibers Detect Nuclear Weapons Components

Plutonium Measurement and Analysis, or PUMA, is a revolutionary radiation monitoring system that uses glass fibers to detect the presence of radionuclides, such as plutonium. This flexible, lightweight, low-power detection system can be used to monitor an inventory of nuclear materials and has significant potential in countering the threat of nuclear terrorism. The use of glass fibers is a breakthrough in the field of radiation detectors. Glass fibers offer substantial flexibility over conventional neutron detection technologies, most of which use rigid helium-filled tubes. Nucsafe of Knoxville, Tennessee, currently is commercializing PUMA.

Tracking Down Deadly Pathogens with MALDI

When fully developed and deployed, MALDI, short for Matrix-Assisted Laser Desorption Ionization Mass Spectrometry, will be used in the field for near real-time screening of suspected biological agents. Under development at PNNL, the methodology is designed to analyze and confirm the identity of suspect biological agents providing vital information necessary to help direct the actions of emergency response and investigative personnel.

Looking for Hidden Clues with Ground-Penetrating Radar

Ground-Penetrating Radar, under development at PNNL, is optimized for short-range detection of objects, structures and materials buried or embedded in the earth or other solid or liquid mediums. GPR has value as a tool to aid in the search for victims buried in building rubble.

Radio Frequency Identification (RFID) Tagging & Tracking Technology

Identifying, tracking, and locating people or objects are natural applications for Radio Frequency, or RF, tags. Researchers at PNNL have developed unique capabilities using semi-passive (backscatter) RF identification tags that could be tailored to track:

- passengers and match them with their baggage
- personnel in secure environments, such as airports
- hazmat cargoes, carriers and operators
- emergency responders and equipment for command and control
- medical dog tags.

TacMedCS for Tactical Medical Coordination System will expedite the process corpsmen use to assess injuries, administer treatment and transport patients.

PNNL scientists are studying the proteins that exist in *Yersinia pestis*, the pathogen commonly known as the plague, using a special approach to mass spectrometry.

Nuclear, Biological and Chemical Health Modeling and Assessments

Our scientists developed an indoor air modeling and assessment system for nuclear, biological and chemical attacks. This tool operates under the Framework for Risk analysis in Multimedia Environmental Systems, or FRAMES, for ease of use and integration with ambient air fate and transport models, waterborne fate and transport models and physiologically based pharmacokinetic models. The prototype system was developed and tested using the Churchville Building at the Aberdeen Proving Ground.

Tackling Bioterrorism One Protein at a Time

Because biological pathogens grow and spread inside the human body on a molecular level, the key to protecting against bioterrorism may rest in understanding how these pathogens function one protein at a time. Scientists at PNNL have begun studying *Yersinia pestis*, commonly known as the plague, and its complement of proteins in an effort to gain the knowledge needed to develop ways to treat and protect against bioterror agents.

Probing for Answers with Field Raman

Working with the Federal Bureau of Investigation, our scientists are using a Raman Spectrometer with a fiber optic probe as an accurate and reliable forensic tool for the identification of potentially hazardous chemicals in a variety of closed containers or on surfaces in the open environment. The tool identifies items such as chemicals and biological warfare agents, toxins and culture media, hazardous industrial chemicals and explosives. Field Raman has many benefits, including: the ability to detect and analyze hazardous chemicals in clear or translucent closed containers, identifying unknown content without exposing personnel to potential hazards, and maintaining the integrity of evidence because handling the sample isn't necessary.

"The fight against terrorism is an international struggle of the free world against the forces of darkness."

Ariel Sharon
Israeli Prime Minister

PNNL experts are assessing and monitoring the vulnerability of critical infrastructures across the nation.

Cyber Security and Information Assurance

Pacific Northwest National Laboratory is advancing state-of-the art tools to address a new realm of security risks—hackers and network attacks. We are researching and developing technologies to ensure the integrity and security of computer-based systems, communications networks and information necessary to support business and the nation's critical infrastructures.

Critical Infrastructure Protection Analysis Laboratory—CIPAL

CIPAL provides a completely isolated computer network for simulated attacks and defenses, where researchers, engineers and users of critical infrastructure technologies can address vulnerabilities of computers, networks or information systems. Using an isolated network enables investigators to simulate attacks that would be untenable on operational real-world systems.

Research within CIPAL focuses on:

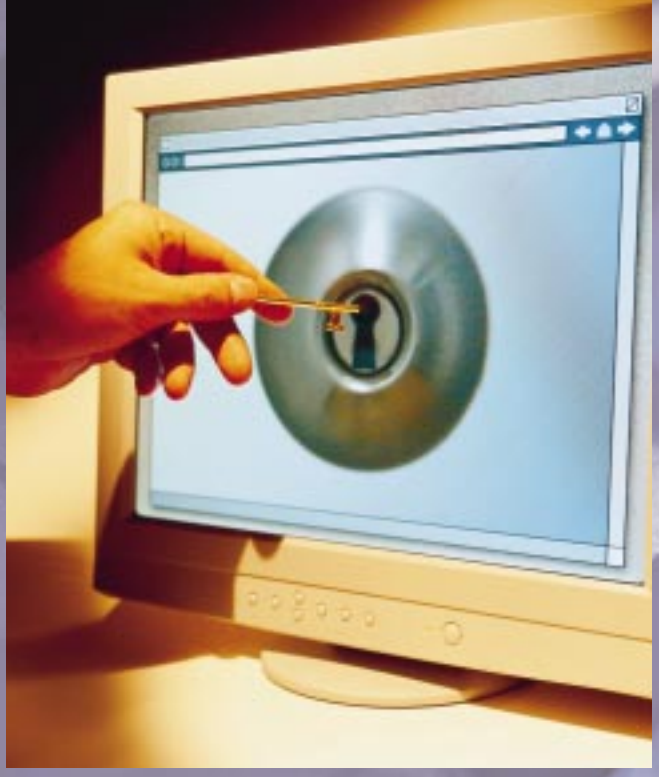
- vulnerability simulation
- plug-and-play vulnerability assessment
- information assurance, operations and warfare
- software agents
- advanced intrusion detection sensors
- secure software engineering processes
- Supervisory Control and Data Acquisition (SCADA) vulnerabilities
- critical infrastructure modeling.

Information Assurance Outreach Program

Since 1997, PNNL researchers have served as executive agents for the Energy Department's Infrastructure Assurance Outreach Program. The program focuses on:

- raising awareness of electric, oil and gas infrastructures regarding vulnerabilities and risks in the 21st Century
- conducting vulnerability assessments of selected, high-consequence energy infrastructure providers to help industry identify and reduce vulnerabilities
- teaming with industry to collectively advance critical infrastructure protection.

Organizations in the electric utility industry request the voluntary assessments, which are subject to stringent nondisclosure agreements that allow no one but the client to receive the report. The assessments may include reviews of computer network architecture, operational and physical security, administrative policies and procedures and configuration management. They also take a close look at interdependencies that result from sharing information within an organization and with contractors, suppliers and subsidiaries. PNNL has assessed 10 organizations in the electric utility industry over the past five years.



PNNL's Critical Infrastructure Protection Analysis Laboratory was established to expose vulnerabilities and identify response techniques to cyber attacks.

Similar to a flight simulator, PNNL researchers are developing a tool to remotely train system administrators to prepare for and protect against cyber attacks.

Planning and Analysis Simulation Models

PNNL maintains a full suite of monitoring, planning and simulation models for the Western U.S. electric grid system reliability. Capabilities focus on the dynamic stability of the U.S. and foreign power grids. We provided technical support for the Secretary's Energy Advisory Board on Electric System Reliability Study, contributed to the DOE Power Outage Study Team, and served on the Consortia for Electric Reliability Technology. We have developed an electric and gas interdependency analysis tool for the Department of Defense Technical Support Working Group, which was applied to the Salt Lake Region to anticipate protection needs for the 2002 Winter Olympic Games.

"Flight" Simulator for Computer System Administrators

Just as flight simulators provide real-world experience to pilots without jeopardizing lives, a new cyber security training capability under development at PNNL will give computer system administrators experience defending against cyber attacks without compromising their networks.

PNNL scientists have created a prototype Systems Administrator Simulation Trainer, or SAST, to rapidly develop the cyber security experience of system administrators in any type of organization to identify, circumvent or recover from hacker activity. The program consists of a network of training tools that simulate the cyber environment and are launched through an automated system. When fully developed, students with broadband Internet access would use these tools remotely, reducing training costs and allowing continual access.

Wide Area Measurements System—WAMS

The Energy Department launched the WAMS Project to develop the next generation tools for operating the electric power transmission system. The WAMS infrastructure is available immediately as an evolving resource, test bed and template for addressing many infrastructure protection issues. Virtually continuous monitor records provide high-quality data from which small signatures can be extracted for suspicious activity. A new generation of precisely synchronized digital technology enables assembly and comparison of data from distant locations for on-line analysis of simultaneous or historical records. The technologies are currently are being applied in the western power system.

The Laboratory's Internet Presence Assessment Guide is used to assess a site's Internet presence.

Researchers at PNNL are advancing state-of-the-art tools to address a new realm of security risks.

Web Assessment Tool

Security experts agree that the Internet provides our adversaries with a potent instrument to obtain, correlate and evaluate an unprecedented volume of aggregated information on business, government and private activities. Nowhere is the potential danger of this more clear than in a January 2002 threat advisory from the FBI which stated, "uncorroborated information indicates that terrorists may be using U.S. web sites to obtain information regarding local energy infrastructures, water reservoirs, dams, highly-enriched uranium storage sites and nuclear and gas facilities."

Mozart automates PNNL's award winning written Internet Presence Assessment Guide. This Guide defines the techniques and methodologies needed to perform an assessment of a site's Internet presence. The intent of this endeavor was to develop a written protocol of Internet techniques that could be used to determine if there is sufficient information on a site's Internet web pages to compromise sensitive, proprietary or classified activities or support adversarial targeting of individuals and programs.

Command and Control

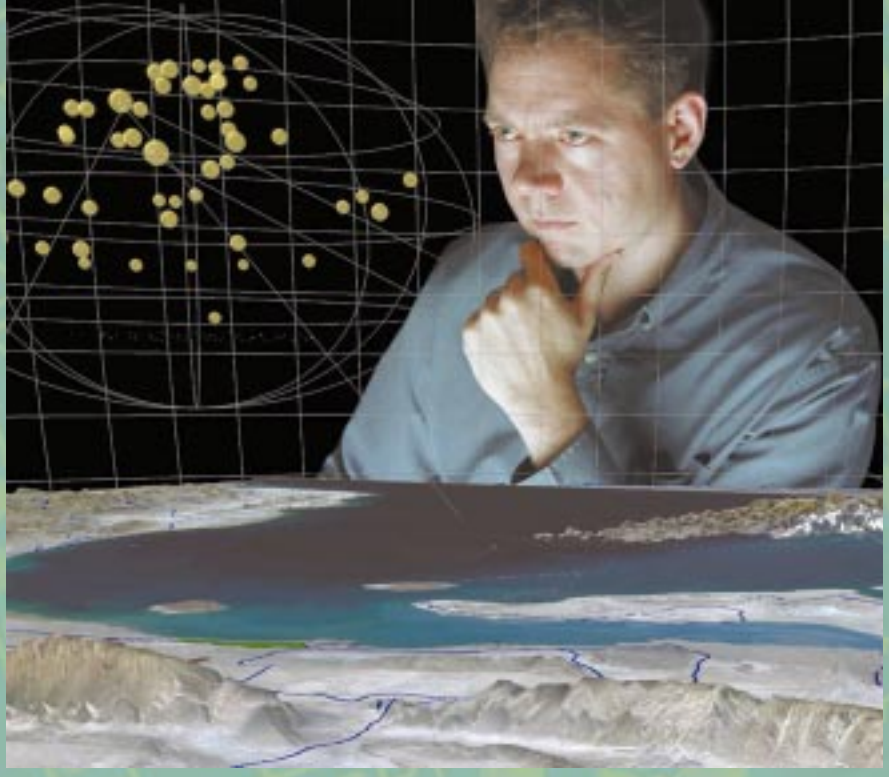
EMADVANTAGE is an automated decision support architecture that provides situation planning and response capabilities for a large multi-user environment. It has been used to support the Chemical Stockpile Emergency Preparedness Program in FEMIS, the Federal Emergency Management Information System. Many components of the EMADVANTAGE architecture are directly applicable to other emergency management efforts. Its capabilities include:

- threat and risk identification
- protective action decisions
- electronic plan generation/execution
- EOC activation/emergency declaration
- community profile
- evacuation modeling
- facility/resource management
- activity tracking
- reporting and status boards
- activity descriptions
- hazard modeling and incident tracking.

PNNL is expanding the decision support architecture to allow for the integration of wireless technologies. Working with NASA, AEPTEC, and the Maryland Emergency Management Agency, our scientists will demonstrate the integration of wireless devices into EMADVANTAGE. Earth Alert demonstrates the ability to use wireless devices to acquire damage assessment and other conditional information from the field in real-time. The Small Business Institute recognized AEPTEC with the Tibbett's Award for their success in working with PNNL and Maryland to demonstrate the application of new technologies.

"You can discover what your enemy fears most by observing the means he uses to frighten you."

Eric Hoffer
U.S. philosopher



Starlight is a powerful information visualization tool.

Information Visualization

The amount of information available today to businesses, governments and scientists is unprecedented. Businesses must pay close attention to marketing plans, strategy reports and government regulations. Governments must analyze satellite data, news and intelligence reports quickly and thoroughly. Mathematicians and computer scientists at PNNL have been developing innovative tools that will help analysts look for trends in a vast amount of information.

A Picture is Worth Thousands of Words

PNNL-developed software will help investigators sift through the blizzard of data compiled in complex data bases. Starlight and similar tools under development at the Laboratory, offer high-powered, three-dimensional, visualization technology originally developed for the U.S. Army.

Starlight enables users to analyze massive volumes of information contained in various media, including structured and unstructured text, maps, digital data, video and even satellite imagery. Its powerful capabilities will enable law enforcement personnel to discover unseen patterns in some of the most notorious crimes. Starlight now is being tested in a variety of other domains, including public health, patent analysis and logistics.

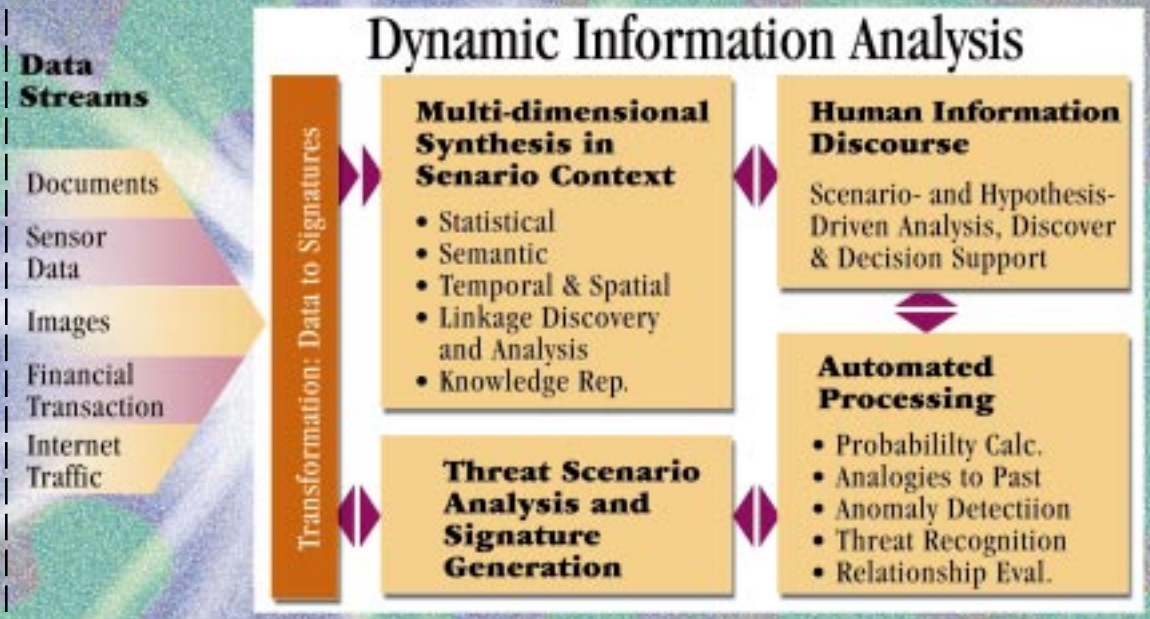
Risk Management

PNNL has developed and refined quantitative and qualitative methods to conduct a risk management program that includes decision-support tools to aid in critical risk and risk management strategy tradeoff decisions and measure and validate risk management program success. Tools range from simple risk source templates and checklists through risk value matrices and risk classification criteria development/application, to sophisticated quantitative analyses consisting of detailed cost-benefit approaches to choosing risk control (prevention and mitigation methods) strategies. Specific decision support tools to support the risk program include a refined special purpose risk database system that produces tailorable and easily understood risk management watch lists and other reports appropriate for both mid-level as well as senior-level management. Other decision support tools include both qualitative and quantitative risk metrics for measuring program success.

Diagnostic Systems

Diagnostic technology has been developed for monitoring and detecting off-design performance in large energy systems. DSOM, short for Decision Support for Operations and Maintenance recently was the recipient of an R&D 100 Award in 2001 and for buildings energy systems (Whole Building Diagnostician—WBD). These systems can be used to facilitate detection of errant operation that would jeopardize safety, security, efficiency or operational viability of predominantly energy-related systems and sub systems. This includes an alert for abnormal equipment behavior (including unexpected occupancy or manual defeat/failure of critical HVAC controls). Both of these technologies are being employed in the field.

"Steadfast in our purpose, we now press on. We have known freedom's price. We have shown freedom's power. And in this great conflict, my fellow Americans, we will see freedom's victory."
President Bush
State of the Union Address



A new laboratory at the PNNL will help annalists integrate massive amounts of information in real time.

Dynamic Information Analysis Laboratory

The integration of massive quantities of information from multiple sources is a critical component in ensuring national security. Drawing up on existing information visualization capabilities and expert staff, PNNL is building a new laboratory to invent, test and deploy innovative tools and techniques to assist analysts in discovering relevant information in real time from dynamic, massive data sources.

Data Signature Transformation

Data occurs in a complex variety of types such as financial transactions, telephone information, news wire documents, and internet traffic, making the integration and synthesis of knowledge difficult for humans and computers alike. PNNL has developed innovative technologies to reduce the complexity of the data analysis, in real-time using data signatures, or mathematical representations, rather than raw data. These data signatures will enable identification of similarities in the patterns within and across data sets providing a broad range of analytical processes regardless of original data type.

Multi-Dimensional Synthesis in Scenario Context

Humans often have a large vocabulary to represent individual concepts (e.g. cat and feline) but computer applications cannot accommodate these sorts of differences easily. Researchers at PNNL have created and validated technology to enable computers to extrapolate concepts from multi-dimensional data sets. These techniques will be used to enhance automated analytical processes such as the discovery of linkages between data items.

Human Information Discourse

The intense nature of information analysis within the domain of security imposes requirements on software tools to ensure that the tools provide rapid, accurate information to the human analyst. PNNL researchers have investigated alternate hypothesis and scenario driven analysis methods that enable the analyst to combine their knowledge with theories of plausible events with masses of information flowing into a dynamic analytic environment.

Automated Processing

Innovative tools developed in the Dynamic Information Analysis Lab will work behind the scenes (much like a spelling checker) to provide new capabilities for information analysts. These tools will use techniques like probability calculations, anomaly detection, and analogical reasoning to enable functions such as pattern analysis, historical comparisons and alternate hypotheses generation for the analyst.

"I am in politics because of the conflict between good and evil, and I believe that in the end good will triumph."
Margaret Thatcher
Former Prime Minister, Great Britain

PNNL's Infrared Sensing Program is developing rapid, ultra sensitive and ultra selective measurement of chemicals in the environment.

Using the Wind Tunnel, researchers can "mimic" Mother Nature.

Sophisticated analytical equipment for measuring atmospheric phenomena is located inside the Grumman Gulfstream 1 Aircraft.

Atmospheric Monitoring and Research

PNNL scientists are world leaders in atmospheric monitoring and research. We have developed computer models that can be applied on a regional basis to better understand how changes in temperature and precipitation patterns will impact agriculture, rangeland, forests, fisheries, water resources and, of course, people. Much of the experience is drawn upon to support the nation's countering terrorism efforts.

Infrared Sensing Initiative

The Laboratory is investing in developing infrared sensors to detect and identify chemicals in the atmosphere and on surfaces, and to measure aerosols, particulates, winds, water vapor and temperatures in the atmosphere. Developing these sensors is key to DOE's mission in detecting proliferation of nuclear, chemical or biological weapons, countering terrorism, law enforcement and environmental research.

There's Something in the Air

PNNL operates a state-of-the-art, twin-engine Grumman Gulfstream 1 (G-1) research aircraft that would be ideal for predicting the effects and extent of attacks against U.S. targets using chemical and biological agents. The G-1 is capable of taking measurements at altitudes approaching 30,000 feet over ranges of 1,500 nautical miles, and can be operated at speeds that enable relatively slow sampling and rapid deployment to field sites throughout the world. The plane also can accommodate a variety of instrument systems and experimental equipment configurations, including external probes for contaminant sampling and atmospheric measurements. An array of surface monitoring equipment is available to support field experiments, including portable towers, wind profilers, sodars (sonic Dopplers), balloon-borne instrumentation, aerosol samplers and gaseous contaminant sampling equipment.

Wind Tunnel Provides Answers

PNNL's Atmospheric Research Facility features a wind tunnel that can simulate a wide variety of environmental conditions, such as determining the effects of breathing air containing hazardous substances. Using this world-class facility, our researchers can begin to understand the behavior of chemical, biological or nuclear substances in the air by conducting studies using dynamic, controlled and reproducible (on-demand) test conditions. The facility is used to research:

- aging aerosols in natural environments influenced by sunlight, humidity, temperature and other parameters
- disposition of airborne particles, whether by diffusive or inertial forces to plants, soils and water surfaces
- fate of particles deposited to surfaces (including the transfer of contaminants from the surface to soils, flora and fauna)
- transport, fate and survival of airborne microorganisms as influenced by sunlight, temperature, relative humidity, particle size, pollutant concentrations and attachment to other particles
- chemical and physical (kinetic) interactions between potential attack agents and other constituents of the atmosphere.

"September 11 was not the beginning of global terror, but it was the beginning of the world's concerted response."

President Bush

CNN, March 11, 2002

Marine scientists and biologists are applying their expertise to help solve coastal and near shore national security issues.

Center for Coastal Security and Protection

Through its geographical location, unique technical expertise, infrastructure and links to other Battelle entities, the Marine Sciences Laboratory is uniquely positioned to build a coastal security business focusing on opportunities in:

- Homeland Security—coastal and near-shore monitoring, ballast water mitigation

- Intelligence—information analysis; multi-source signatures analysis; coastal/estuarine mapping and characterization, geospatial intelligence and modeling; technical support for military operations in littoral regions; systems of coastal detection and sensors (biosensors and biomonitors); unmanned aerospace vehicles, unmanned underwater vehicles and autonomous robotics systems.

"Forgive your enemies, but never forget their names."
John F. Kennedy

Through hands-on training, emergency personnel learn how to respond to a nuclear, chemical or biological attack.

Weapons of Mass Destruction Emergency Response

Anti-Terrorism Assistance Program

PNNL has been contributing to a State Department training that teaches foreign fire fighters, police and emergency medical personnel how to deal with Weapons of Mass Destruction—chemical, biological and radiological—that may be used by terrorists for many years. The training is offered to first responders in partner nations, generally in the capital, where the United States has an embassy or consulate. PNNL offers two other components of the State Department's Anti-Terrorism Assistance program. We support one-week introductory training classes given in the foreign countries, providing instructors with expertise in radiological hazards and weapons of mass destruction. Our researchers also will be partnering with the State Department to develop mail handling training for international mail handlers.

International Border Security Training Program

Through the International Border Security Training Program, we train and equip international border-enforcement officials and U.S. Customs inspectors to detect, identify, interdict and investigate all aspects of smuggling related to the proliferation and diversion of materials, commodities and components associated with the development and deployment of nuclear, chemical and biological weapons and their related missile delivery systems.

Through both programs, PNNL is partnering with HAMMER, a multi-agency training facility designed to provide training "as real as it gets" in dealing with hazmat incidents, interdiction, search and rescue, and incident management. At HAMMER, located in Richland, Washington, PNNL has trained hundreds of customs and border security officers from nearly 20 eastern European and former Soviet countries. In addition to in-depth classroom training, HAMMER props can be configured to simulate biological weapons labs, hostage environments or chemical production areas for hands-on exercises.

Counter-terrorism training supports domestic law enforcement and police, military and federal officials, U.S. Department of State, as well as security specialists from friendly countries.

Pacific Northwest National Laboratory

Operated by Battelle for the U.S. Department of Energy

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PNNL-SA-37200