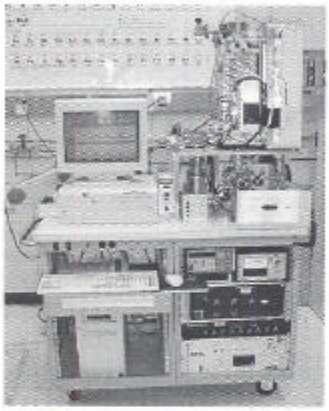
COUNTERTERRORISM RESEARCH AT THE INEEL

Steven J. Fernandez, Idaho National Engineering and Environmental Laboratory (INEEL), Box 1625, Idaho Falls, ID 83415-3840, (208) 526-3675 (phone), (208) 526-3360 (fax), sfernand@inel.gov

The INEEL is recognized as a leader in the development of technologies that are applicable to the national effort to combat terrorism. This recognition has been achieved through the development of sensors such as the portable isotopic neutron spectrometer (PINS) used to determine the chemical contents of conventional, nuclear and chemical munitions and the secondary ion mass spectrometer (SIMS) used to identify chemicals from trace residues on surfaces. The INEEL has successfully completed the integration of sensors and communication systems for assessment, control and monitoring in response to national security needs. These systems include the mobile munitions assessment system (MMAS) for the Department of the Army, an integrated material surveillance system (IMSS) test-bed for the Department of Energy, and Theater Battle Management and Air Support Operations Center (TBM Core/ASOC) for the U.S. Air Force. In addition to providing working systems for federal government organizations, the INEEL has demonstrated that technologies developed at the INEEL can be transferred successfully to the private sector for manufacture and distribution to law enforcement agencies. These technologies include the SecureScan 2000® concealed weapons detector (CWD) and RoadSpike® vehicle pursuit device. The INEEL continues to develop other technologies through programmatic research for federal agencies such as the Federal Aviation Administration, U.S. Customs Service, National Institute of Justice, and the Office of National Drug Control Policy. Additionally, the INEEL is investing in future counterterrorism technologies through internal research support for the Center for Ion Mobility Spectrometry, the Biologically Active Materials Research Enterprise, and the Human-System Simulation Center. Other internal investments include support of university collaborations through memorandums of understanding with the University of Idaho for cooperative research in information security and the Idaho State University Idaho Accelerator Center. The INEEL is leveraging these successes and investments to be recognized as a significant provider of the science and technologies necessary for the next generation of counterterrorism needs. These next generation technologies will rely on INEEL strengths in the development of new sensor concepts and unique protective materials, integration of orthogonal technologies, and demonstration and testing of prototypes.



SIMS detection system configured for van-mounted detection of chemical agents.

INTRODUCTION

Recent, well-publicized violence against the public has sharply raised government, corporate, and public awareness of the relatively limited levels of available protection for federal and public facilities, dignitaries, critical infrastructure, citizens, and schools. Several federal counterterrorism panels have been formed to identify the advanced science and technologies needed to oppose the terrorist threat. Previous counter-terrorism technologies were developed primarily to counter the use of conventional weapons and information gathering. Now, funded research and development activities are directed towards the detection of unconventional weapons such as nuclear, biological, chemical, and explosive materials; intrusion into communications, information and transportation systems; and tampering of food, air, and water supplies.

The technologies that have resulted from these efforts and have been deployed within the counterterrorism community have become an every-day-matter-of-fact in public life. These technologies include x-ray scanners, metal detectors, vapor sniffers, electronic firewalls, encrypted communications, and radiation detectors. However, the constant use of these technologies highlights the technical shortcomings as most, implemented protective systems are limited to single threats, require skilled labor, and overtly intrude upon innocent individuals. Developing integrated and intelligent screening systems; advanced protective materials; secure information systems; and investigative database and modeling tools are areas in which the INEEL is planning to make major near-term contributions to the counterterrorism community. These development efforts will focus on alleviating the perception that 'Enhancements to existing technologies, needed immediately, will provide a temporary level of protection or deterrence from the expanding threats. However, "silver bullet" protection and security technologies are non-existent and must be available in the near future.'

These future INEEL technologies are expected to address a broad range of applications such as: 1) low cost, compact, stand-off detection systems that detect weapons, vehicles, and packages; 2) low-cost, rapid detection or treatment systems that protect air or water supplies; 3) intelligent software that prevent or correct damage caused from intrusion of databases or electronic operating systems; and 4) monitoring systems that evaluate the deterioration or attack upon critical infrastructure resources.

INEEL combined portal concept using concealed weapons detector, millimeter wave detector, and IMS detector.

INEEL TECHNOLOGY DEVELOPMENTS

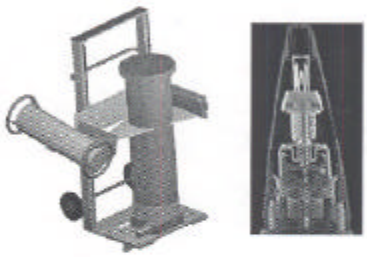
PINS Chemical Assay System: The Portable Isotopic Neutron Spectroscopy (PINS) chemical assay system is a field useable, non-destructive evaluation tool to identify the contents of munitions and chemical storage containers safely and reliably. PINS uses neutron radiation from a small radioisotopic source as a probe to determine the chemical contents of an enclosed item. The chemical contents' characteristic gamma-ray signature, measured by a high-resolution HPGe spectrometer, reveals the chemical elements inside the item. The system computer infers the contents from the elemental data. PINS has been extensively tested with live chemical weapon agents [GA, GB (sarin), VX, mustard gases, and lewisite) and high explosives (Composition B, RDX and TNT).

Direct Detection of VX on Particulate Surfaces Using an Ion Trap SIMS: VX is a lethal chemical warfare agent, which has high viscosity, low volatility, and high surface adsorptivity. These characteristics make VX difficult to detect as a gas-phase molecule, yet very amenable to a surface detection approach. A transportable, secondary ion mass spectrometry (SIMS) instrumentation has been developed at the INEEL. This SIMS instrumentation, which is based on ion trap technology, functions by blasting VX from the surface, then separating and concentrating VX as the protonated molecule in the gas phase, prior to specific detection. As little as 0.002 monolayer on as little as 1 milligram of soil can be detected using the technique. SIMS has also been demonstrated to be effective for detection of adsorbed G and V agent degradation products (alkylmethyl phosphonates), and blister agent-related sulfides. SIMS is amenable to a wide variety of sample types (vegetation, metals, and polymers), including water samples, which can be analyzed subsequent to evaporation. Other attractive attributes of SIMS include that analyses can be performed in less than 10 minutes without generating any analysis waste. A van-mounted SIMS instrumentation is under development at the

INEEL for the U. S. Army.

INEEL Concealed Weapons Detector: To meet the needs for personnel screening of entryways to buildings and events, ICTec is developing a threat detection screening portal that will integrate the INEEL concealed weapons detector (CWD) with a novel INEEL ion mobility spectrometer-based sampling system and a scanning stand-off millimeter wave detector. Research will include the development of the sampling system and intelligent threat decisions algorithms. The CWD has already been installed in the Idaho Bannock County courthouse through the sponsorship of the National Institute of Justice. Completion of the portal will involve leveraging research performed by the INEEL-sponsored IMS research center and collaborating with Chang Industries (millimeter wave technology); Quantum Magnetics (magnetic field and ultrasonic detectors); and Innovation Engineering Solutions (CWD).

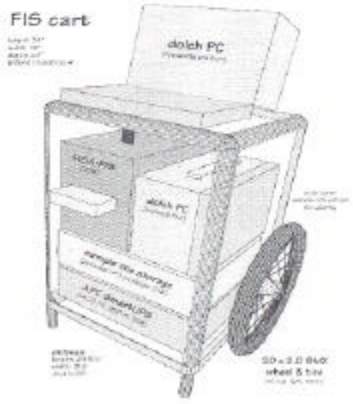
Field-Portable Digital Radiography and Computed Tomography (DRCT): The INEEL has developed a field-portable, high-resolution Digital Radiography and Computed Tomography (DRCT) system for x-raying munitions. This x-ray system was developed under the sponsorship of the U.S. Army to determine the liquid level and the status of the fusing and firing train in a munition. This system incorporates a vertically scanning x-ray source, linear detector array, and a stage that rotates the munition. The transport dolly serves as the mounting stand for the modular assembly. All system functions can be controlled from a remote location. A two-dimensional tomographic slice at any height on the munition can be produced in about one minute, whereas a full 3-D image can be generated in about 10 minutes. The DRCT system allows the operator to review the image in near real-time and make system adjustments, if necessary, to improve the image.



Portable x-ray system for 3-D imaging provides a means to interrogate packages and containers.

Digital Signature Technology for Relational Databases: The INEEL is developing technology to allow digital signatures to be applied to electronic forms where the forms' content is comprised of elements of several disparate, network-distributed databases. Digital signature technology for databases is needed for an efficient, validated paperless process. The developing system is intended for integration with database applications containing data with legal significance or national security concerns. What the user gains is an automated mechanism to verify the authenticity of both the signed data and the data signer. The INEEL is developing this technology for a general deployment using standard secure worldwide web interfaces and applications built using commercial relational databases.

Electronic Watermark for Digital Files: The INEEL is developing technology to mark electronic documents such that their owner can verify that the document has not been altered. Digital signature technology will combine stenographic techniques to invisibly embed the required information. The owner will be able to verify the integrity of the document yet the fact that the document possesses ownership and integrity information will be hidden from others. The system will read, write, analyze, and verify covert electronic watermarks embedded within binary format computer files. Watermark data will include encrypted text, encrypted images, and most significantly a digital signature.



Detection system is capable of field screening for traces of chemical agents.

Field Ion Spectrometry for Vapor Detection of Chemical Warfare Material: A variation of Ion Mobility Spectrometry (IMS), Field Ionization Spectrometry (FIS), has shown the potential for increased sensitivity and resolution in the detection of chemical warfare agents (CWA) over conventional IMS systems. The INEEL is adapting a FIS made by Mine Safety Appliances Company into a field portable sampling and analysis station for CWA detection. The system is designed to move to the general survey location. There, a heated sampling wand is energized and deployed to "sniff" potential contamination on surfaces. The system is capable of multi-agent identification with immediate analysis response time (<5 sec. for a single agent; < 60 sec. for multiple agents). Data have shown detectability for CWA surrogates DMMP at 400 ppt and DPM at 170 ppt.

Portable Raman Spectrometer for Chemical Agent Characterization: Recently, new, smaller, lighter, and more robust Raman spectrometers have been developed to allow the possibility of field portability. In support of the U.S. Army Program Manager for Chemical Demilitarization, Non-Stockpile Chemical Materiel Project, the INEEL has packaged such a system for use in the field characterization of Chemical Agent Identification Sets (CAIS), consisting of samples of chemical agent in bottles and ampoules. The INEEL's portable Raman Spectrometer has the ability to identify contents of these containers without opening the bottles. The spectrometer is mounted on a suspension system and housed in a rugged transport case so that the spectrometer can be checked onto a commercial airliner as baggage and transported to a field site. Upon deployment, the optical head is removed from its carrying case and taken to where the samples are located. An armor shielded fiber-optic cable (current options are 2 meters and 100 meters) is used to transmit the excitation laser light to the sample and return the Raman scattered light from the target material. System control, data acquisition, and field analysis is performed with a field-hardened portable computer, which is about the size of a briefcase. Electrical power is standard 120 VAC, which can be supplied by a small, portable generator. This system can easily be deployed in the field within 15 min. Analysis time is less than one minute per sample.

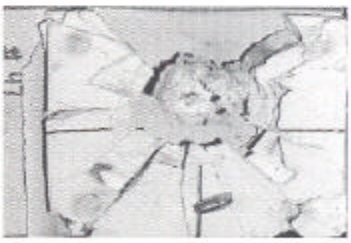
Raman spectrometer configured for field analysis of chemical agents.

Biometrics Technology Test and Evaluation Capabilities: The INEEL offers a unique combination of factors to meet the test and evaluation (T&E) needs of the biometrics technology community. These factors include broad, long-term operational testbed experience; an objective and independent perspective (minimal conflict of interest); world class skills in the relevant technologies; and existing facilities suitable to the application. Over the past 40 years, INEEL has performed formal T&E activities internally and for numerous outside customers. Programs that are currently on going include testing trace-level explosives detection instruments for the Federal Aviation Administration (FAA), and T&E and administration of access control biometrics equipment at DOE Headquarters. Two recent projects involved T&E of components for Cooperative Remote Monitoring for DOE NN-20, and an assessment for the Defense Special Weapons Agency (DSWA) of the hardware and software included in the Corral Monitoring System, another system for treaty monitoring. INEEL personnel have tested and performed integration/development of "traditional" biometrics systems (i.e., units for access control). Besides this and other biometrics work, the INEEL has a strong technology background in all the important scientific and engineering disciplines that underlie most kinds of biometrics systems. These include world class human factors engineering capabilities; image, voice, and other signal processing expertise; and specialty engineering with specific proficiency in automatic pattern recognition.

Blast Mitigation Materials: The INEEL has proven capabilities to respond promptly to the changing explosive threats from the terrorist community. Recently, the INEEL built a full size mock-up of an existing access door to a special nuclear material storage facility. Computer modeling of the impact event determined that a new weapon could defeat the doors and allow access to the strategic materials. The mock-up was tested against the new threat at the INEEL and the live-fire test result validated the simulation results. The access door was subsequently redesigned at the INEEL to stop the specific threat, using the same modeling software that accurately simulated the earlier vulnerability. The new design is being built at the INEEL's SMC facility, which built the earlier mock-up and weapons.

The INEEL has the to develop blast resistant materials.

Advanced Lightweight Armor materials for Personal Protection Gear: The INEEL has been developing new advanced materials and processing technologies for applications, such as, high temperature structural support, nuclear shielding and armoring. Currently INEEL has in place several advanced ceramic and ceramic composites developmental programs to address lightweight armor material requirements for personal and vehicle protection applications. For example, special high strength, non-brittle alumina and silicon carbide have been developed, offering potential armor applications. A high strength, high toughness ceramic fiber reinforced nano-crystalline Silicon Carbide composite is under development for both armor and high temperature - high load applications. To increase ballistic efficiency of commercial off-the-self materials, the functionally graded material and thermal arc spray technologies developed at the INEEL – has been employed to create an advanced lightweight armor system for personnel and vehicular protection.



Thermal arc sprayed functionally graded armor test panel designed to defeat 7.62 AP threat.

INEEL's COUNTERTERRORISM MISSION

Law enforcement and counterterrorism technologies are one of the six pillars of the INEEL's National Security Business Objective. The individual technologies applicable to supporting the counterterrorism community have their heritages in the INEEL's energy, environment, national security and nuclear business objectives. The INEEL's remoteness, national security requirements, and technological capabilities have positioned the laboratory as a national resource that has expanded from nuclear reactor and environmental development programs to include capabilities to support counterterrorism technology development and testing.