Autonomous Pathogen Detector System (right foreground) deployed in a Washington, D.C., Metro station.

Samples from biosensors.

Reducing the Threat from *Weapons of Mass Destruction*

The collapse of the Soviet Union more than 10 years ago created a grave threat of proliferation, with hundreds of weapons and thousands of pounds of weapons-usable materials potentially at risk for theft or diversion. The terrorist attacks in New York and Washington, D.C., in September 2001 transformed the possibility of terrorism against this country into reality. All during this time, Lawrence Livermore has been deeply involved in activities aimed at reducing the threats posed by the proliferation of nuclear weapons and other weapons of mass destruction (WMD) to rogue nations or terrorist groups.

The Laboratory draws on 50 years of experience in all aspects of nuclear weapons to address the challenge of nuclear nonproliferation. It leverages its extensive resources in biology, chemistry, engineering, and computations to tackle the problem of chemical and biological weapons proliferation. Laboratory researchers work closely with the intelligence, law enforcement, emergency response, and public health communities to provide technologies, analytical products, and operational capabilities that meet users' needs and function in real-world settings.

A hallmark of Livermore's threat reduction work is its integrated approach to the complex and interconnected problems of WMD proliferation and terrorism. It addresses the full spectrum of threats—from preventing proliferation at its source, to detecting and reversing proliferant activities, to responding to the threatened or actual use of such weapons, to avoiding surprise regarding the WMD capabilities and intentions of others.

Analyzing samples from biosensors.

Because the materials required for nuclear weapons do not occur naturally, the best way to prevent nuclear proliferation or terrorism is to protect and control nuclear materials at the source. Major efforts are under way in Russia to secure or dispose of at-risk nuclear and radioactive materials. The starting materials for chemical and biological weapons, however, are ubiquitous and have many legitimate uses. Threat-reduction efforts must focus on identifying activities indicative of producing or acquiring chemical or biological weapons and on rapid detection, response, and recovery in the event of a terrorist chemical or biological attack. Still other activities are directed at understanding foreign weapons programs and developing advanced technologies for use by the U.S. intelligence and defense communities.

DHS Secretary Tom Ridge visits Livermore.

A NARAC emergency response team.

Science and Technology for Homeland Security

In March 2003, Congress established the Department of Homeland Security (DHS). In July, DHS Secretary Tom Ridge visited Livermore to see the Laboratory's counterterrorism technologies first hand and to talk with researchers from Lawrence Livermore and Sandia national laboratories about their work. During his visit, Secretary Ridge received updates on the National Atmospheric Release Advisory Center (NARAC), RadScout and nuclear incident response activities as well as BioWatch and biological detection programs at both Livermore and Sandia.

NARAC is a national emergency response service for real-time assessment of the transport and dispersion of nuclear, chemical, biological, or natural hazardous material released into the atmosphere. Its plume predictions are used by emergency response personnel in managing response operations and by emergency response planners in preparing for such emergencies. Since it was established in 1979, NARAC has responded to more than 80 alerts, accidents, and disasters and has supported nearly 1,000 exercises.

The Local Integration of NARAC with Cities (LINC) Program provides local emergency response agencies with direct access to NARAC's plume models and hazard predictions. To date, LINC connections have been established with Seattle, New York City, Fort Worth, Albuquerque, and Cincinnati. Fortuitously, LINC was operational in New York City in February 2003 and was able to assist the agencies responding to the Staten Island fuel barge fire. LINC is one of many examples of Livermore's efforts to partner directly with first responders to understand their needs and develop capabilities that meet those needs.

Lawrence Livermore is also working with state and local homeland security entities. In April 2003, the Laboratory hosted a Homeland Security Executive Summit, co-sponsored by Congresswoman Ellen Tauscher (California, 10th District) and the California National Guard. This summit brought together medical and emergency responders, military representatives, state and local officials, and researchers from the national laboratories to address issues of local preparedness in the event of a terrorist attack.

Biodetection Systems for Early Warning

One of the DHS's first acts was to launch the BioWatch early warning biodetection system at key cities across the nation. BioWatch is being operated through a partnership of federal, state, and local agencies. Key partners include DHS, the Centers for Disease Control and Prevention (CDC), the Environmental Protection Agency, and Livermore and Los Alamos national laboratories. Among other activities, the laboratories are providing technical expertise in biological detection as well as training assistance to state and local agencies.

BioWatch is based on the sample analysis technologies and concept of operations successfully demonstrated with the Biological Aerosol Sentry and Information System (BASIS). BASIS was developed jointly by Livermore and Los Alamos and deployed at the 2002 Winter Olympic Games in Salt Lake City and other high-profile events around the country. The heart of the BASIS field laboratory is the Cepheid Smart Cycler, which uses rapid miniature PCR (polymerase chain reaction) technology developed at and licensed from Livermore. This technology reduces the time for nucleic acid (that is, DNA) analysis from days or weeks to an hour or less.

Biodetectors are only as good as the assays they use to detect pathogens. Livermore has a significant effort in biosignatures, identifying regions of DNA or RNA unique to the pathogens of concern. These signatures are developed with the help of a novel bioinformatics system called KPATH, which uses advanced computational algorithms to identify unique sequences. Candidate signatures are carefully screened, and the most promising ones are developed into assays, which are then provided to the CDC for validation and, if successful, distribution to CDC's network of public health laboratories. Most of the signatures currently used by the BioWatch system were developed at Livermore. The Laboratory has also used its signature development capabilities to respond rapidly to several recent disease outbreaks. For example, in March 2003, candidate signatures for SARS (sudden acute respiratory syndrome) were developed within three hours of a request from the CDC.

Laboratory researchers are also working to develop the next generations to BioWatch. Deployments in the Albuquerque airport; the Washington, D.C., Metro; and a BART station in San Francisco demonstrated the effectiveness of the Autonomous Pathogen Detector System (APDS). APDS can operate in such venues for more than a week without human intervention, electronically

BASIS biosensor deployed in Times Square, New York City.

BASIS field laboratory.

Laboratory leaders join Representative Ellen Tauscher (California, 10th District) and Laboratory Director Michael Anastasio in opening the Radiation Detection Center.

RadScout radiation detector.

reporting results every hour, simultaneously performing up to 100 antibody-type assays, and performing confirmatory PCR on any samples that test positive with the antibody tests. Work is under way on a concept for rapid, reagentless mass-spectrometric analysis of airborne spores (such as those causing anthrax) and for highly multiplexed detection (hundreds of simultaneous assays) of viruses, toxins, spores, and vegetative bacteria. A new initiative is investigating the feasibility of detecting infection presymptomatically, well before exposed individuals know they are sick.

New Radiation Detectors

A ribbon-cutting ceremony in April 2003 marked the official opening of Livermore's Radiation Detection Center. The center serves as a focal point for scientists from across the Laboratory to come together to devise the improved radiation detection technologies needed to counter nuclear smuggling, for medical applications, and for scientific experiments to better understand the universe.

Livermore researchers have developed two new handheld gamma-ray detection and isotope identification instruments, RadScout and CryoFree/25. Their small size is achieved through innovative approaches to cooling the high-purity germanium detector without liquid nitrogen or large refrigeration units. They also incorporate software that analyzes the detected radiation spectrum and identifies the isotopes responsible. These detectors offer Customs, Border Patrol, and other inspectors the combination of portability, high resolution, high sensitivity, and spectral analysis—features not previously available in a single instrument. In June 2003, the Laboratory signed a licensing agreement for RadScout with ORTEC Products of Oak Ridge, Tennessee, in a ceremony at Livermore attended by NNSA Administrator Linton Brooks. In March 2004, the company unveiled its commercial product based on RadScout technology. This agreement is an example of how Livermore works with U.S. industry to move homeland security technology out of the laboratory and into the marketplace.

Laboratory researchers are also tackling the technically difficult problem of detecting smuggled uranium. Unlike plutonium, which emits readily detectable radiation, highly enriched uranium's emissions can be easily shielded, making it difficult to detect using current instruments. Livermore scientists have identified a radiation signature unique to highly enriched uranium based on high-energy gamma rays produced when the material is interrogated with neutrons. This signature is not found in normal background radiation and is detectable through the walls of typical cargo containers. With funding from the DOE Office of Science, experiments were conducted in 2003 at Lawrence Berkeley National Laboratory's 88-inch cyclotron that verified this signature and its predicted characteristics. Additional experiments were then conducted at Livermore using a standard cargo container provided by American President Lines to test the signature in realistic cargo-loading conditions.

Other Livermore researchers are testing systems that can detect, track, and characterize nuclear or radioactive material delivered on roads or waterways. In January 2003, as part of a demonstration project sponsored by the Defense Threat Reduction Agency (DTRA), two buoys containing a suite of gamma and neutron detectors were deployed at the waterway entrance to a U.S. Navy base. For the past year, Livermore has been collecting extensive data on the performance of these detectors in the harsh marine environment. In April 2003, the Detection and Tracking System, developed in partnership with the Remote Sensing Laboratory, was demonstrated near the entrance of a U.S. Army base. The system featured a new tracking algorithm that uses spectral signatures to correlate events detected throughout the network, source material identification capabilities, and a camera to take pictures of suspect vehicles to facilitate law enforcement operations.

International Threat Reduction

Throughout 2003, Laboratory scientists worked around the globe to reduce the threat of WMD proliferation. Livermore is a major participant in NNSA's Material Protection, Control, and Accounting (MPC&A) Program, which is helping Russia enhance the security of vast quantities of weapons-usable nuclear material. Comprehensive MPC&A upgrades continue at Chelyabinsk-70, one of Russia's two nuclear weapons design laboratories. Working with the Russian Navy, four nuclear weapon storage sites in the Kamchatka region are receiving comprehensive MPC&A upgrades. Work was recently begun with the Russian Ministry of Defense to secure hundreds of radioisotope thermoelectric generators in the Russian Far East. These generators contain large-curie quantities of strontium-90 and are used to power various operations in remote locations.

Livermore is assisting in various activities to develop nonweapons enterprises for former Soviet weapons workers. One such project is

Radiation detection test of a cargo container.

Radiation detection buoys.

Livermore seismic specialists and colleagues in the Middle East.

CAPS operations room supporting Operation Iraqi Freedom.

establishing a positron emission tomography (PET) facility for cancer diagnostics at Snezhinsk (home of Chelyabinsk-70). This facility would be only the third such facility in all of Russia. Another project, a joint effort involving the Laboratory, Cyclotec Medical Industries in Lauderhill, Florida, and Biofil (a private company employing former weapons workers in Snezhinsk), has developed and put into production a transcutaneous electrical nerve stimulation device. This device, which treats acute pain noninvasively, recently won an R&D 100 Award.

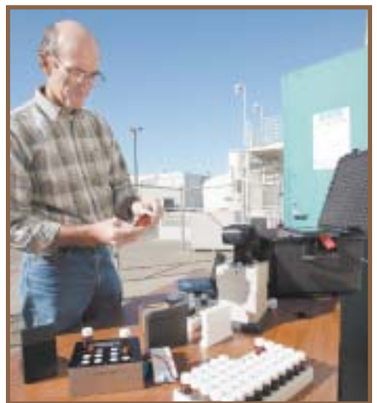
Laboratory scientists also participate in regional engagement activities, with a focus on regions where WMD proliferation is a concern. Projects are designed to provide technical assistance to regions on a multilateral basis, with the goal of bringing together the scientific communities from several countries in a region to work on specific technical issues. One ongoing project involves the exchange of seismic waveform data and seismic hazard information among Israel, Syria, Jordan, Iran, and other countries in the Middle East. For another project that includes scientists from Oman, United Arab Emirates, Qatar, and Saudi Arabia, Livermore helped deploy seismograph stations around the epicenter of a recent earthquake in Oman. Other projects are under way in South Asia (seismology) and in Central Asia (environmental remediation).

Supporting Military Operations

During 2003, the Laboratory provided multifaceted support to U.S. operations before, during, and after Operation Iraqi Freedom. Efforts included participation in International Atomic Energy Agency (IAEA) inspections in Iraq before the conflict began as well as deployment of several Laboratory employees to Iraq after the war to provide technical assistance to the Iraq Survey Group.

The Laboratory's Counterproliferation Analysis and Planning System (CAPS) team supplied 24/7 on-call support to the Defense Department throughout Operation Iraqi Freedom. CAPS also deployed a nuclear engineer, biotechnology engineer, and chemical engineer to the U.S. Central Command (CENTCOM) in Florida to lead DOE's collaborative WMD support team during the war. From mid-March to early May 2003, the CAPS team fielded roughly 200 requests for analysis, some that could be answered within a few minutes or hours and others requiring days of round-the-clock work. Developed and continually updated by the Laboratory, CAPS is a powerful modeling system for analyzing a country's WMD production processes and infrastructure and for assessing interdiction options and their corresponding consequences.

Many other projects at Livermore are aimed at meeting important needs of the U.S. military and other national security programs. The Laboratory's special capabilities are being used to devise novel sensors for challenging monitoring situations, secure high-bandwidth communications technologies, and advanced conventional munitions. Other efforts are developing powerful conflict simulation models and tools and methodologies for cyber security and information operations. Wherever appropriate, these technologies are transferred to end users or are commercialized. For example, the Laboratory recently licensed its field-portable, thin-layer chromatography (TLC) kit, for assessing the safety of munitions by analyzing the presence and quantity of stabilizers in propellant mixtures, to Ho'olana Technologies of Hilo, Hawaii. Kits went into production in 2003.



Kit for testing the safety of munitions.

Atoms for Peace: 50 Years Later

In a two-day symposium held at Livermore in November 2003, distinguished experts in science, technology, and policy examined how President Dwight D. Eisenhower's "Atoms for Peace" speech in 1953 affected the world. Eisenhower called on the nuclear states to help nations willing to forgo nuclear weapons acquire the benefits of civilian nuclear applications. A wide range of views were expressed at the symposium on the future prospects of nuclear technology—both benefits and risks—and the interrelationship between defense and civilian applications of nuclear energy. In the keynote talk, Susan Eisenhower, chairwoman of the Eisenhower Institute and granddaughter of President Eisenhower, combined warm personal reflections with insightful policy perspectives. (Eisenhower is shown below right with Ron Lehman, director of the Laboratory's Center for Global Security Research [CGSR].) The symposium wrapped up a year-long study sponsored by the CGSR. The Atoms for Peace after 50 Years project included exploratory workshops in Livermore, Japan, and France; a conference in Washington, D.C.; the two-day symposium at Livermore; and a final report, which is available at http://cgsr.llnl.gov/.