Threat Reduction and Homeland Security

Security at home and across the globe requires a reduction in the threat posed by the proliferation of weapons of mass destruction (WMD) as well as their acquisition and use by terrorists. Lawrence Livermore provides technologies, analysis, expertise, and operational capabilities to preclude WMD proliferation or terrorist attack.

A distinguishing feature of Livermore's work for this enduring and compelling mission is its integrated, end-to-end approach. The full spectrum of threats is addressed—from preventing proliferation at its source, to detecting proliferant activities and identifying ways to counter those efforts, to responding to the threatened or actual use of WMD. Because terrorists and other adversaries could use any type of weapon, the United States must counter and defend against all threats: biological, chemical, and nuclear. Systems and technologies for use at home and abroad are required to forestall, interdict, and defuse WMD threats as far from their targets as possible.

The Laboratory draws on more than 50 years of experience in all aspects of nuclear weapons as well as extensive resources in biology, chemistry, engineering, and computations to tackle the challenges of WMD proliferation and terrorism. Livermore researchers are also developing tools and technologies to meet current Department of Defense needs and to assist in the broader defense transformation effort.

Preventing Proliferation at the Source

Lawrence Livermore participates in a suite of international cooperative activities aimed at preventing proliferation by securing nuclear materials at the source. Foremost among these efforts is the National Nuclear Security Administration's Material Protection, Control, and Accounting (MPC&A) Program, which is helping Russia enhance the security of vast quantities of Soviet-legacy weapons-usable nuclear material. Livermore is one of only four U.S. laboratories authorized to work with the Russian Ministry of Defense.

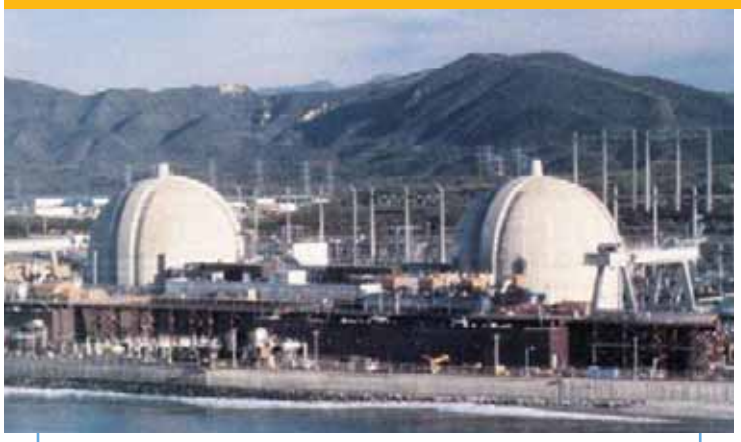
In 2005, the Laboratory completed comprehensive upgrades at the third of four naval nuclear weapons storage sites. In addition, the Kola Technical and Training Center was opened in July to support sustainable MPC&A for the Russian Navy nuclear sites, with courses in physical protection, protective forces, and MPC&A management. Work to maintain previously upgraded Russian Navy sites continued, as did the development of MPC&A regulations for the Russian military. Projects within the civilian Rosatom sector also continue on schedule. These include activities at various sites and the Federal Information System effort, which Livermore leads, to establish a comprehensive national nuclear material accounting system for Russia.

Livermore also participates in the Global Radiological Threat Reduction Program, which aims to keep radiological materials out of the hands of terrorists. Laboratory scientists are working with the Russian Ministry of Defense to remove and secure storage of radioisotopic thermoelectric generators in the Russian Far East. These devices, which contain large-curie quantities of strontium-90 and are used to power various operations in remote locations, will be replaced with power sources—such as solar—that are not attractive to terrorists. Other activities to secure at-risk radiological materials in Albania, Tanzania, and Kenya are nearing completion.

Strengthening International Safeguards

Laboratory scientists have developed a new technology—scintillator-based antineutrino detection—to enhance international nuclear safeguards. This detection methodology provides a

Aid to the Russians in securing their weapons-grade nuclear material included opening the Kola Technical and Training Center in Murmansk (left) and upgrading security at naval nuclear weapons storage sites.



A new radiation detection technology that measures a reactor's antineutrino emissions was tested at the San Onofre Nuclear Generating Station.

Livermore scientists helped to install the first seismic measuring stations in the United Arab Emirates.

non-intrusive, near-real-time way to monitor for unauthorized plutonium production. Using a 0.64-ton antineutrino detector located a few tens of meters from the core of a commercial power reactor in Southern California, the research team demonstrated experimentally the ability to track power, fuel burnup, and plutonium content using the antineutrino signal. These measurements are taken at the earliest point in the fuel cycle at which plutonium content can be assessed, namely the moment of production.

The detector measures about two meters on a side; the goal is to reduce its size to about one meter on a side with no cryogenics or other complicated "life support" systems. The result will be a readily deployable and movable system. The International Atomic Energy Agency has expressed interest in antineutrino detectors to ensure that nuclear fuel in civilian power reactors is not diverted for weapons purposes.

Engaging Scientists Worldwide to Prevent Proliferation

Laboratory researchers participate in Global Initiatives for Proliferation Prevention, which strives to create sustainable jobs for former Soviet weapons scientists and engineers in the high-tech commercial marketplace. In one such project, the Laboratory is working with the Lebedev Physical Institute and Valley Forge Composites Technology, Inc., on an accelerator-based device to detect hidden explosives in luggage and cargo. The explosives-detection system is based on a small-scale electron accelerator developed by Lebedev. The potential market for this technology is huge; the U.S. market demand alone is approximately $2 billion per year for hardware and $2.5 billion for maintenance and support services.

The Laboratory is also involved in a variety of activities to engage scientists and engineers in regions of the world where WMD proliferation is a concern. Scientific collaboration on issues of regional interest helps to promote understanding and cooperation and defuse tensions. For example, Lawrence Livermore and the United Arab Emirates (UAE) University organized the Gulf Seismic Forum 2005, held in Al Ain, which brought together scientists and engineers from Saudi Arabia, Yemen, Oman, UAE, Kuwait, Iran, Iraq, Jordan, Egypt, and Turkey. The forum laid the groundwork for establishing a regional data-sharing network to mitigate the effects of such natural disasters as

earthquakes and foster cooperation in data sharing, analysis, and interpretation.

Advanced Nuclear-Threat Detectors

In January 2005, *Discover* magazine named its "top 100 stories," including a technology being developed by the Laboratory to counter the threat of nuclear or radiological terrorism. The device can detect highly enriched uranium inside cargo containers through active interrogation using a 14-MeV neutron source. In 2005, a new neutron source was installed, which led to a breakthrough in eliminating interference from oxygen activation. Now the highly enriched uranium signal stands out clearly, five to ten times above background signals.

Livermore scientists are enhancing gamma-ray imaging technologies to detect small quantities of hidden nuclear material or locate nuclear material at a distance. One such technology is a large-area (0.6-m^2), scintillator-based, coded-aperture gamma-ray imager. This instrument provides real-time measurement of the radiation background and is ten times more sensitive than a non-imaging system of the same size. The imager, mounted inside a medium-size cargo truck moving at 16 kilometers per hour, was able to detect a one-millicurie cesium-137 source 83 meters away. The source was not detected when the instrument was in its non-imaging mode.

Versions of Livermore's Adaptable Radiation Area Monitor (ARAM) have been demonstrated in such challenging venues as the Defense Threat Reduction Agency Unconventional Nuclear Warfare Defense Program, the Department of Homeland Security (DHS) Countermeasures Testbed, a large FedEx package-handling facility, and various law enforcement agencies. The technology for this rugged, autonomous detection system has been licensed to a commercial partner. In 2005, *R&D Magazine* honored ARAM developers with an R&D 100 Award (see p. 49).

Deterring Nuclear Terrorism

A key deterrent to nuclear terrorism is the ability to identify the origin of interdicted nuclear materials or terrorist nuclear devices, information that offers clues to the identity of the perpetrators. An outgrowth of nuclear test activities in the 1980s, nuclear forensics work at the Laboratory makes use of an array of

The sensitivity of the large-area, scintillator-based gamma-ray imaging detector makes it able to detect very small quantities of nuclear material.

The Adaptable Radiation Area Monitor, which won an R&D 100 Award, has been commercialized and is in use at California borders.

Nuclear forensics can track illicit nuclear material back to its source. Recovered uranium oxide materials (left) are analyzed and compared to a collection of known uranium oxide samples.

equipment to develop physical, chemical, and isotopic profiles of a suspect sample down to the nanometer scale. Optical and scanning electron microscopy and other nondestructive techniques are first applied to determine the sample's overall composition and structure. Radiochemical and mass spectrometric analysis—including use of Livermore's newest secondary ion mass spectrometer, NanoSIMS—are the final steps to completely characterizing the sample.

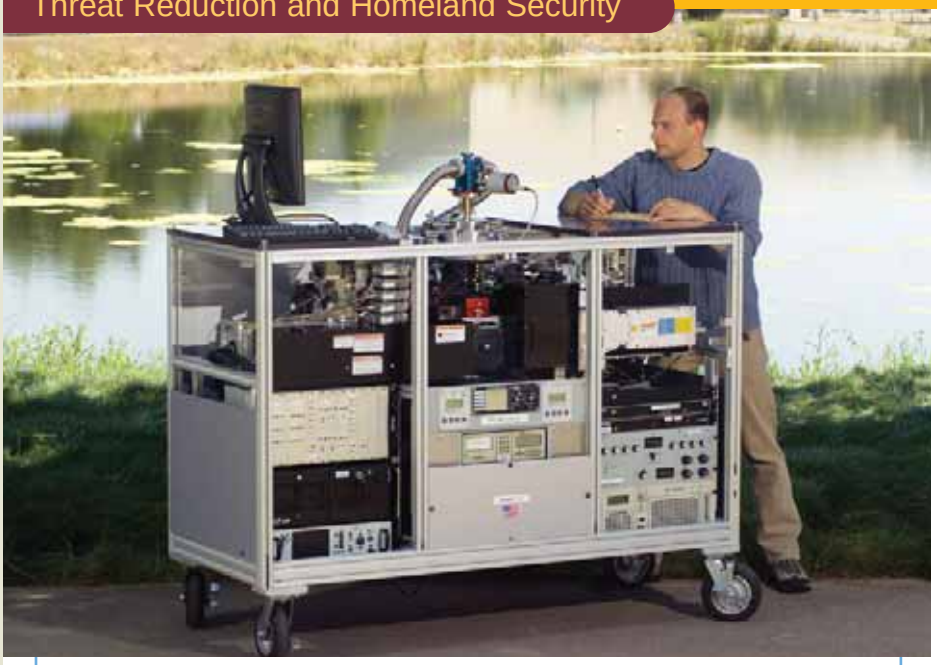
With funding from several sponsors, Livermore is extending its anti-nuclear terrorism activities on several fronts. Nuclear forensics will benefit from a revitalization of the Laboratory's base of expertise in radiochemistry. Researchers are extending models to better understand the effects of weapons in urban scenarios. In addition, operational procedures are being developed for collecting forensic evidence in the event of an actual nuclear terrorist incident.

Defending Against Biological Terrorism

Lawrence Livermore is one of the nation's leaders in the fight against biological terrorism and a major participant in the DHS multilaboratory Chemical and Biological Countermeasures Program. Laboratory scientists provide technical support to BioWatch, the national system for detecting a large-scale bioattack against key U.S. cities. Livermore is furnishing reachback expertise by on-call subject matter experts as well as capabilities in supplementary sample analysis and consequence management.

The Laboratory is also developing several systems that offer improvements in autonomy and speed over BioWatch. For example, the Autonomous Pathogen Detection System (APDS) can operate for more than a week without human intervention in airports, subways, and other high-traffic venues. In 2005, multiple APDS units were deployed in a major urban area and successfully operated as a network to monitor for the airborne release of biological agents. To ensure that APDS meets real-world needs, it is being improved upon and demonstrated through extensive interactions with public health officials, facility operators, security and law enforcement agencies, and other stakeholders.

Deployment of the Autonomous Pathogen Detection System in subway stations demonstrated the system's ability to perform reliably without human intervention.



The Bioaerosol Mass Spectrometer, which won an R&D 100 Award, was connected to the air handling system in a major airport. The instrument demonstrated long-term, reliable performance.

Biorestoration after a terrorist attack could make use of L-Gel, a spray-on material for quickly and effectively destroying bioterror agents.

Another instrument under development at Livermore is the Bioaerosol Mass Spectrometer (BAMS). Unlike APDS and other assay-based instruments, BAMS does not require reagents. It uses a combination of laser-induced fluorescence and mass spectrometry to rapidly detect and differentiate a broad range of biothreat agents (e.g., bacterial spores, bacterial vegetative cells, viruses, and toxins). BAMS tests particle by particle in real time (under one minute) without any sample preparation. In 2005, as part of the DHS Enhanced Bioaerosol Detector Project, BAMS was connected to the air handling system of a major airport where it demonstrated its ability to operate autonomously at 95 percent availability for weeks at a stretch. BAMS also received a 2005 R&D 100 Award (see p. 49).

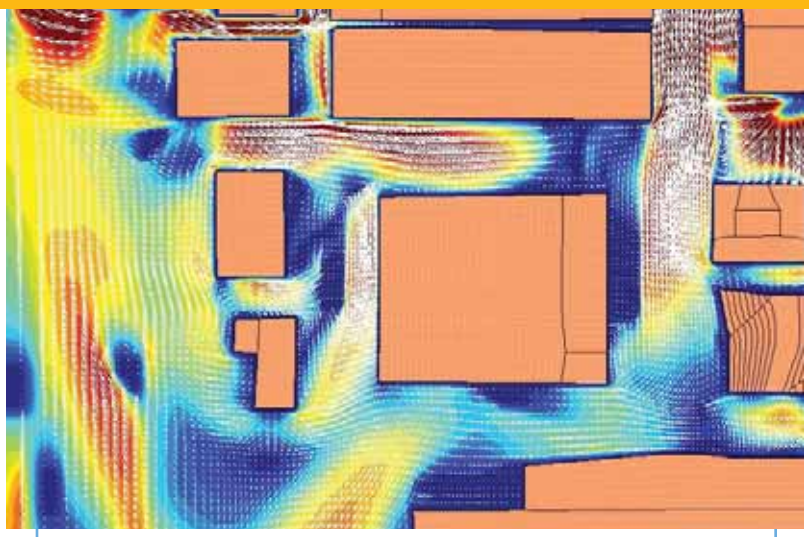
Technical Support for Anti-Bioterrorism

Livermore researchers are developing new diagnostics for key agricultural diseases. For example, under DHS's Bioassay and Signature Program and in partnership with the U.S. Department of Agriculture, the National Animal Health Laboratory Network, and the Plum Island Animal Disease Center, the Laboratory developed multiplexed assays for foot and mouth disease virus (FMDV) and endemic animal diseases that cause clinical signs that are indistinguishable from FMDV. In addition, in collaboration with the National Center for Foreign Animal Disease (Canada), Livermore developed a multiplexed protein-based test to differentiate animals infected with FMDV from those vaccinated against the disease.

Established by DHS at Livermore to provide in-depth analysis of biodefense issues, the Biodefense Knowledge Center (BKC) activated a 24/7 reachback capability in 2005 for all-WMD assessments under the new National S&T Threat Awareness and

Livermore has developed several diagnostics for animal diseases, including new assays for foot and mouth disease virus.

Department of Homeland Security Secretary Michael Chertoff (center) visited the Laboratory, including NARAC/IMAAC, in July.



NARAC/IMAAC models can accurately simulate building-scale flow and dispersion.

Reachback Program. The BKC prepared several detailed material threat assessments for biological, chemical, and radiological materials as well as rapid assessments on specific topics of concern. In May, the BKC deployed a state-of-the-art data-fusion architecture, developed by Laboratory researchers in the Information Operations and Analysis Center, that enables the integration of various static and real-time data feeds. The BKC also participated in three major exercises, including the TopOff-3 full-scale national counterterrorism response drill.

Under a three-year DHS Bio-Restoration Demonstration Project, Lawrence Livermore and Sandia researchers developed restoration plans to enable an airport hit with a bioterrorist attack to be quickly decontaminated and reopened while protecting human health and the environment. They devised improved, statistically based sampling methodologies that allow public health agencies to better characterize and understand the extent of contamination. The team developed a rapid viability test that can determine within a few hours (instead of days) whether pathogens are dead or alive, which will greatly shorten cleanup times. This project focused on San Francisco International Airport, but many of the concepts are applicable to other airports and other transportation systems, such as subways.

Emergency Planning and Response

Lawrence Livermore participates in numerous emergency response activities. In addition to providing critically needed local, regional, and national response capabilities, these efforts give Laboratory personnel first-hand experience in field operations, insight into the needs of emergency responders, and guidance to technology development efforts.

The National Atmospheric Release Advisory Center (NARAC), sited at and operated by Lawrence Livermore, is the premier capability in the U.S. for real-time assessments of the dispersion and potential impact of hazardous materials released into the atmosphere. NARAC models the behavior of radiological, chemical, biological, and natural (e.g., smoke) materials on global, regional, local, urban, and building scales. Since April 2004, NARAC has been the interim provider for the DHS-led Interagency Modeling and Atmospheric Assessment Center (IMAAC), which serves as the coordinating center and single source of federal plume modeling predictions in the event of a nationally significant incident.

In 2005, NARAC/IMAAC supported thousands of drills and exercises and 20 real-world events. As part of the research and development portfolio that keeps NARAC/IMAAC capabilities on the cutting edge, Livermore scientists have developed a method for reconstructing events that integrates observational data with predictive models to determine unknown source terms. In most real-world events, rapid characterization of the source of the

Livermore maintains the highest level of expertise to respond to and train others to respond to nuclear incidents.

release (location, composition, and release rate) from limited information is critical to providing the timely and accurate predictions needed by decision makers.

The Laboratory is a key member of the DOE's nuclear emergency response programs that deal with the full range of nuclear incidents, from missing industrial sources to nuclear weapon accidents. These programs are more important than ever, given the clearly stated desire of various terrorist groups to acquire and use nuclear weapons or radiological dispersal devices. Livermore provides expert personnel for field and home teams, specialized equipment and technical capabilities for locating and identifying radiological materials and for diagnosing and disabling nuclear devices, as well as hands-on training for government agencies in nuclear incident response technologies and procedures.

More than 140 Laboratory staff members were deployed to more than 25 events, including the major multiagency exercise Dingo King in August. Livermore also responded to nearly 60 requests for reachback analysis and assistance. More than 20 training sessions were held at Livermore in the use of advanced diagnostic instrumentation, technologies for disabling nuclear devices, and other incident response assets.

Armoring Gun Trucks in Iraq

With funding from the Defense Advanced Research Projects Agency and in collaboration with the U.S. Army, Livermore researchers developed gun truck armor kits that are now providing convoy protection for American troops in Iraq. The protection kits provide modular, easy-to-assemble armor that, with the addition of several machine guns, allows the military to convert five-ton supply trucks into gun trucks to protect convoys. The Laboratory developed the kits in response to a request by House Armed Services Committee Chairman Duncan Hunter (52nd District, California).

After Livermore built the first prototype truck, the technology was transferred to U.S. companies for production. To date, 71 armor kits are in service and another 45 are en route to Iraq and Afghanistan. Their effectiveness was dramatically demonstrated when a gun truck with the armor kit was struck by an improvised explosive device on March 23, 2005, near Fallujah, Iraq. All fourteen U.S. soldiers walked away unharmed.

Gun truck armor kits developed at Livermore are protecting American soldiers in Iraq.