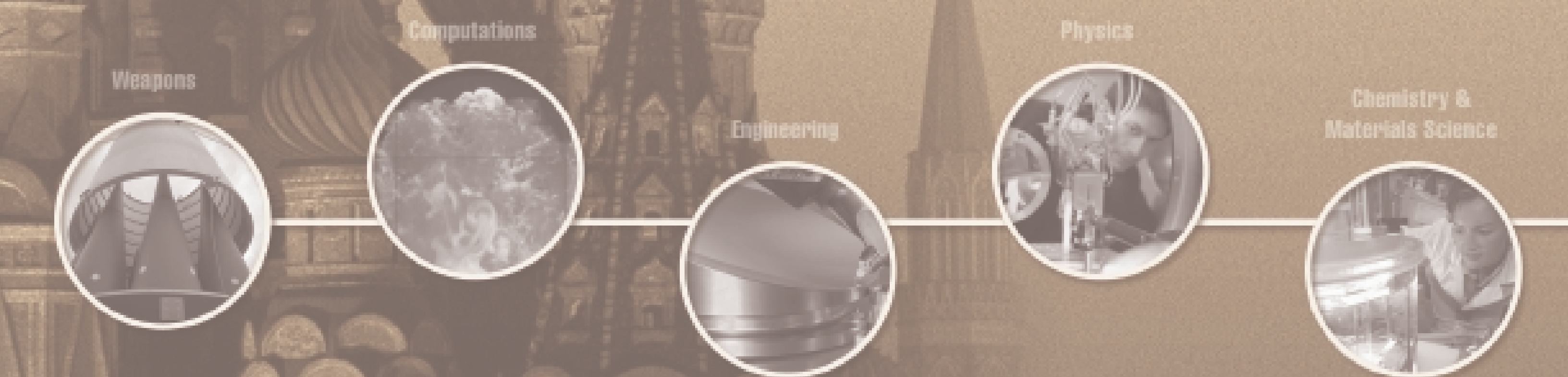
Knowing the Enemy, Anticipating the Threat

In a way, Lawrence Livermore was founded as a result of the nation's not knowing—or at least, underestimating—"the enemy." In August 1949, U.S. reconnaissance planes detected radioactive debris near Japan, proof that the Soviets had detonated an atomic bomb. In *Memoirs*, physicist Edward Teller writes, "Until the fall of 1949, our intelligence community, most of the leading scientists, and general public opinion held that the Soviet Union could not develop an atomic bomb before the 1960s." Within days, Ernest O. Lawrence, Nobel laureate and head of the University of California's Radiation Laboratory, met with federal officials to press for a strong hydrogen bomb effort to hold the Soviets in check. Teller, a leading theorist on the hydrogen bomb, also pushed for a vigorous U.S. hydrogen bomb project. The surprise of the Soviet atomic test and the looming threat of a Soviet hydrogen bomb spurred the creation of a branch of Lawrence's Berkeley Radiation Laboratory in Livermore as a second U.S. weapons laboratory.

"If you know the enemy and know yourself, you need not fear the result of a hundred battles."

Sun Tzu, The Art of War
Circa 400 B.C.

As the 1950s progressed, *Sputnik*'s launch in 1957 and the perceived "missile gap" strengthened the drive for improved U.S. strategic forces and better understanding of Soviet capabilities. Over time, this need has expanded to include understanding the nuclear weapon capabilities, intentions, and motivations of other countries or groups hostile to the U.S. Intelligence analysis efforts at the Laboratory grew in response. With the end of the Cold War in 1992, Livermore Director John Nuckolls merged these efforts into the Nonproliferation, Arms Control, and International Security (NAI) Directorate. This new organization focused on the threat



posed by the proliferation of nuclear, chemical, and biological weapons—collectively called the weapons of mass destruction, or WMD.

Today, NAI researchers address the full spectrum of WMD proliferation issues—prevention, detection and reversal, response, and avoiding surprise.

Avoiding Surprise

After the Soviet Union's initial atomic bomb test, monitoring the Soviet weapons program became a paramount concern of U.S. intelligence agencies. In 1965, a formal relationship with the intelligence community was drawn up in a memorandum of understanding between the Central Intelligence Agency (CIA) and the Atomic Energy Commission (predecessor to the present-day Department of Energy). Livermore's Special Projects Group, known as Z Division, was established to provide the intelligence community with technical assessments of foreign nuclear programs and weapons capabilities. According to Dale Nielsen, the first Z Division leader, the division's initial charter was twofold. "We looked at the weapons fired by Russia, and later by China, to see what they were shooting, and we developed intelligence-related equipment as requested."

Z Division scientists gathered radiological samples from Soviet and Chinese nuclear tests, using technologies developed for collecting and analyzing atmospheric samples from U.S. tests. (See *S&TR*, June 2002, pp. 24–30.) They also developed new technologies for monitoring tests and collecting data that allowed analysts to tell what kind of weapons—atomic or thermonuclear—were being tested. Among the many intelligence-related systems, Nielsen recalls a clever "bug sniffer" designed by physicists and electronic engineers for detecting minute electronic monitoring devices. "The CIA wanted to test the system and told us, 'We've set up four bugs in a Virginia safe house. See if you can find them.' We gathered up the equipment, flew out there, and found five out of four. They never told us if that fifth was an actual part of the test."

As time went on, Z Division evolved to respond to the growing list of countries that concerned the nation's intelligence agencies. The division teamed regional and country-specific experts with weapons scientists and engineers to make analyses based on technical knowledge about nuclear weapons development and testing, specifics about each country's nuclear capabilities, and evaluation of nontechnical issues that motivate nuclear programs. Z Division also provided technical knowledge and intelligence information needed to control U.S. exports that could support WMD proliferation.

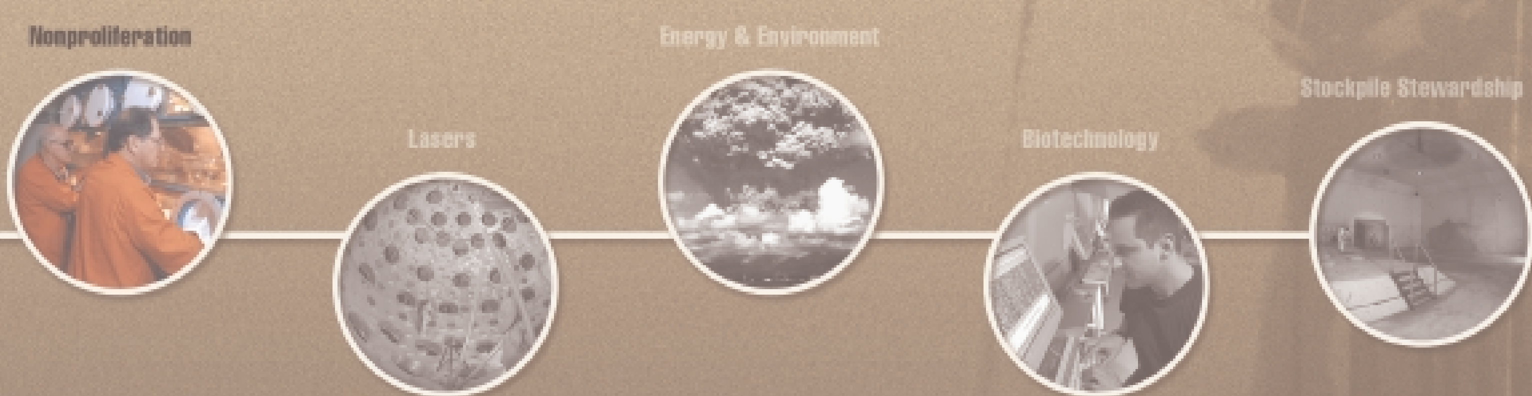
With the formation of the NAI Directorate, Z Division became the International Assessments Program and broadened its focus to include chemical and biological weapons proliferation. In addition, with the globalization of commerce and technology, Livermore's intelligence analysts recognized the need to assess the WMD capabilities of nonstate groups such as terrorists and patterns of cooperation among countries and groups of concern.

Researchers in the International Assessments Program are also addressing the national security implications of the U.S.'s rapidly growing reliance on critical networked infrastructures. The country—indeed the entire world—is becoming more dependent on computing, communication networks, and information technology. These researchers have developed a suite of sophisticated network analysis tools to assist government agencies in detecting, responding to, and preventing computer network attacks. Through this work, Livermore has become a national leader in information assurance technology.

Preventing Proliferation

The most effective way to prevent the spread of nuclear weapons is at the source, through treaties limiting or banning such weapons and, in the case of nuclear weapons, by securing weapons-usable nuclear materials. Material control is less effective in preventing the proliferation of chemical or biological weapons because the starting materials for these weapons have many legitimate uses.

The Laboratory first became involved in arms control in the 1950s. Public concern over atmospheric testing led the U.S. and the Soviet Union to establish a Conference of Experts to examine the technical issues associated with a comprehensive ban on nuclear weapons testing in all environments—the atmosphere, outer space, under water,



and under ground. Ernest O. Lawrence served as one of three U.S. representatives to this conference. Harold Brown, who became Livermore's director in 1960, was a member of the delegation's technical advisory group that developed a concept for verifying compliance with a comprehensive ban on nuclear weapons testing.

A number of Laboratory scientists participated in the technical working groups complementing the negotiations on a comprehensive test ban, examining ways to detect—and hide—explosions. Measuring seismic signals was seen as one technique for detecting underground explosions, and a worldwide network of seismic stations was built as part of this effort. (See box on p. 29.) However, Laboratory scientists were concerned that

The 1964 Salmon Event, a 5-kiloton detonation conducted 280 meters deep in a Mississippi salt dome, confirmed the theory of decoupling as a means of concealing clandestine nuclear explosions. In this photo, experimenters are lowering a canister containing the nuclear explosive for the Salmon Event.

a large cavity would reduce, or muffle, the shock wave by a factor of 30 to 50, essentially decoupling the strength of the seismic signal from the size of the explosion. The possibilities for such decoupling became a key issue in the U.S. negotiating position during early comprehensive test ban discussions. The Soviets' resumption of nuclear testing in September 1961 broke the bilateral moratorium and ended the negotiations at that time.

In the ensuing decades, Laboratory personnel continued to contribute to various arms control negotiations on both strategic force levels and nuclear testing. For instance, Livermore scientists participated in the technical working groups supporting Limited Test Ban Treaty negotiations and in the Nuclear Non-Proliferation Treaty. In the fall of 1977, negotiations on a comprehensive test ban resumed after a hiatus of many years. In the 1980s, issues regarding the verification of the Threshold Test Ban Treaty were resolved with the Joint Verification Experiment (JVE), a pair of nuclear tests jointly carried out at the U.S. and Soviet test sites. (See *S&TR*, June 1998, pp. 10–16.)

Geophysicist Eileen Vergino provided technical support to the U.S. delegates in Geneva during the treaty's protracted negotiations. Vergino remembers, "JVE was a turning point in Soviet relations with the West. Many American–Russian friendships were forged, and the more open atmosphere anticipated the post–Cold War era." In 1992, U.S. nuclear testing ceased, and the Comprehensive Test Ban Treaty was signed, although it has not been ratified by the U.S. Senate.

After the Soviet Union collapsed, the Lawrence Livermore, Los Alamos, and Sandia national laboratories established Lab-to-Lab interactions with the former Soviet nuclear institutes in former closed cities. The activities gave rise to a suite of cooperative programs with former Soviet laboratories to prevent the spread of weapons expertise or materials to other nations. (See *S&TR*, September 2000, pp. 4–11.) Through the Materials Protection, Control, and Accounting program, Livermore is working with several Russian sites to improve their protection of fissile materials and with the Russian Navy to strengthen the protection of fresh and spent fuel for its nuclear-powered vessels. The Laboratory is also working with the Russian Customs Service to curtail the smuggling of nuclear proliferation items by equipping high-risk border crossings with radiation detection equipment and training front-line customs officials in using the equipment.

In 2001, lengthy negotiations by Livermore scientists culminated in a formal agreement between a Russian weapons assembly facility and a medical equipment manufacturer to establish a commercial manufacturing facility at Sarov. This agreement was part of the Nuclear Cities Initiative, which seeks to create self-sustaining commercial enterprises for the closed cities, thereby helping to accelerate the downsizing of the Russian weapons complex and preventing displaced weapons workers from seeking employment with potential proliferators.

Detecting and Reversing Proliferation

To reverse proliferation of WMD requires detecting and identifying proliferation-related activities. If such activities are detected, the next step is to evaluate options for reversing the proliferation. Livermore provides expertise in this area by developing technologies to monitor and evaluate weapons proliferation activities and to protect critical U.S. facilities and troops from attack.

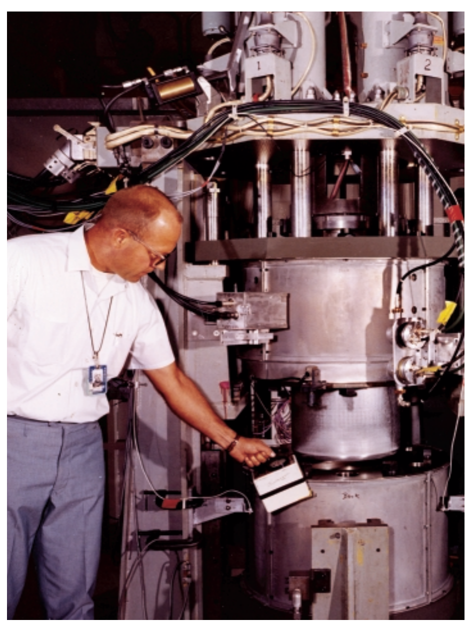
Predating this effort was work by Livermore weapons scientists who examined the consequences of various "us-versus-them" scenarios. By the mid-1960s, with the large buildup of Soviet nuclear weapons and delivery systems, the U.S. faced some serious "what-if" questions. If a nuclear exchange occurred between the U.S. and the Soviet Union, U.S. warheads would have to contend with defensive countermeasures such as a nuclear-tipped interceptor or antiballistic missile, which could deliver a blast aimed at destroying or disabling a U.S. warhead before it reentered the atmosphere. Would such a countermeasure work? Nobody knew for certain. The Super Kukla reactor at the Nevada Test Site was designed to find out. Super Kukla, an ultrahigh prompt burst reactor, produced an intense pulse of neutrons and gamma radiation to simulate the environment a U.S. ballistic missile warhead might encounter during enemy countermeasures—in essence, a nuclear blast without the blast.

This focus on nuclear effects was one mission of D Division, which was also tasked with anticipating the strategic and tactical needs of the U.S. military services. In an effort to meet these needs, the Laboratory developed an early presence in the arena of computer-driven conflict simulation. Since the mid-1970s, Livermore computer scientists have led in the development of increasingly realistic software to simulate the tactical battlefield. "At first, you had to program the orders of the opposing force into the computer ahead of time, which didn't make for a very realistic scenario," recalls Paul Chrzanowski, who joined D Division in 1977 and became its leader in 1982. "Then George Smith, a very creative guy, developed a simulation in which two opposing players observe the battle on separate computer monitors and give orders."

The Laboratory's landmark Janus program, developed in the late 1970s, was the first conflict simulation tool that was real-time player-interactive and used a graphical user interface. Livermore simulations were employed in Operation Desert Storm in the Middle East as well as in combat planning for Somalia, Bosnia, and other international trouble spots. In 1997, a team of NAI computer scientists unveiled Joint Conflict and Tactical Simulation (JCATS), the culmination of more than two decades of computer-driven mission analysis and rehearsal experience. (See *S&TR*, November 1996, pp. 4–11; June 1999, pp. 4–11; January/February 2000, pp. 4–11.)

A more recent computer-driven innovation developed for the U.S. military is the Counterproliferation Analysis and Planning System (CAPS), which is widely used by military planners to evaluate the WMD production capabilities of a country of concern and assess interdiction options. Drawing on information

Livermore provided key support in upgrades made on four nuclear refueling ships for the Russian icebreaker fleet and the Russian Navy. The upgrades improve the protection of fresh, highly enriched reactor fuel for the nuclear-powered vessels. Work such as this involves direct interactions with the Russian Ministry of Defense, an activity that would have been inconceivable during the Cold War.



The Super Kukla reactor, operated at the Nevada Test Site between 1965 and 1978, simulated the hostile environment of a nuclear exchange. Nuclear weapon components and materials were placed inside an experiment cavity, and instruments measured how well the tested samples stood up to the hostile radiation environment.

from multiple sources, CAPS can model the various processes—chemical, biological, and metallurgical—that are used to build WMD and delivery systems. CAPS identifies critical processing steps or production facilities which, if denied, would prevent that country from acquiring such weapons.

Responding to Threats

When—despite everything—bad things happen, the Laboratory has the personnel and the science and technology to help the nation respond.

(a)

(b)

(a) In the mid-1970s, the Janus code developed at the Conflict Simulation Laboratory ran an early, very simple conflict simulation. (b) Today, the Livermore-developed Joint Conflict and Technical Simulation (JCATS) models are used by the U.S. military commands and services and various U.S. security forces for training, tactical analysis, and mission planning for battlefield and urban conflict situations.

Since the early 1970s, Livermore has coordinated its responses to off-site nuclear emergencies through NEST—the Nuclear Emergency Search Team. When the Soviet satellite Cosmos 954 fell to Earth in northern Canada in 1978, Laboratory researchers tracked the reentry path, provided estimates of reentry location, and participated in a multinational effort to locate and retrieve radioactive debris. Members of NEST—health physicists, chemists, nuclear physicists, and engineers—hauled radiation detectors, liquid nitrogen, sample containers, power generators, portable computers, and even a helicopter to a desolate area populated only by caribou and Inuit hunters. The international team successfully found hundreds of very small pieces Cosmos left that survived reentry, and Livermore researchers identified the reactor fuel and estimated the fission-product inventory.

In addition to NEST, Laboratory employees also participate in the Radiological Assistance Program, which helps deal with civilian incidents involving radioactive materials; in the Accident Response Group, which responds to accidents involving a U.S. nuclear weapon; and in the Joint Technical Operations Team, a nuclear response team that assists the Department of Defense in dealing with terrorist nuclear devices.

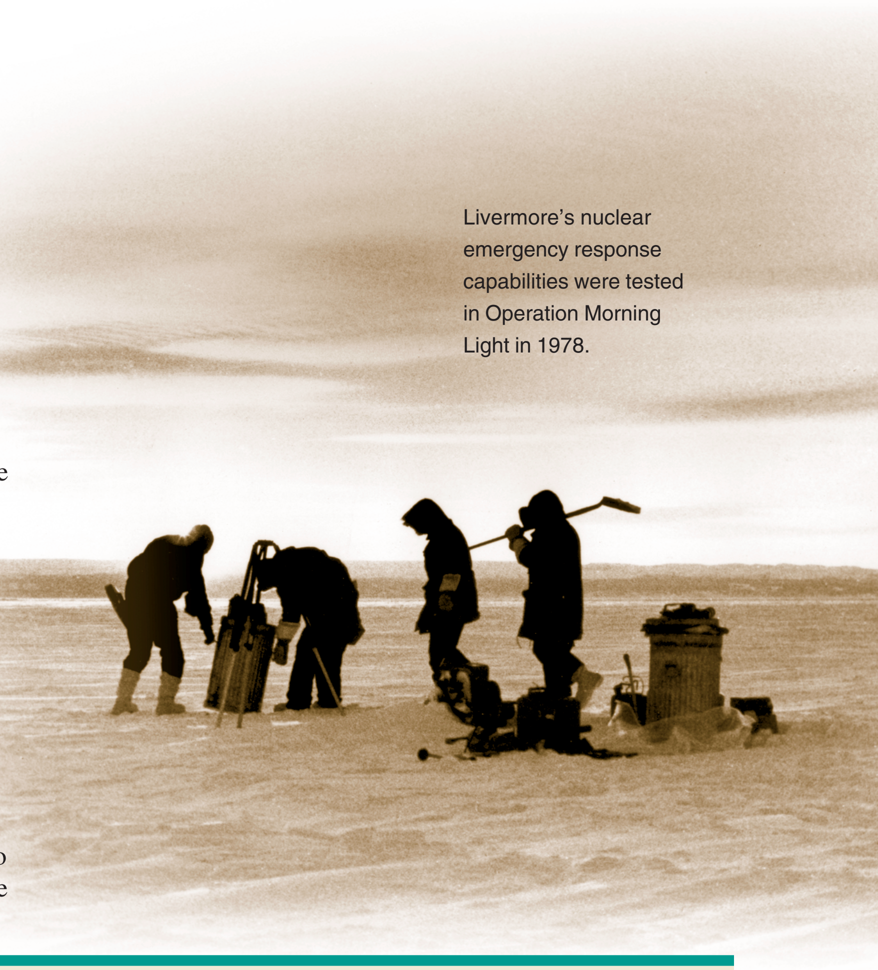
Livermore's NAI directorate is home to a number of technologies and capabilities that address the response end of the threat spectrum. In the Forensic Science Center, for example, experts in organic and inorganic chemistry and biochemistry determine the composition and often the source of minute samples of materials. (See *S&TR*, April 2002, pp. 11–18.) A major effort since the center's founding in 1991 is the development or adaptation of forensic analysis technologies for field use. In 1994, the Department of Energy asked the center to help investigate two gaseous-diffusion uranium enrichment plants that would be subject to international inspections. (See *S&TR*, August 1995, pp. 24–26.) DOE wanted to know whether an inspector could walk through a plant, surreptitiously collect samples of material, and later replicate the enrichment process. In 1998, the center used its portable thin-layer chromatography system, which can simultaneously analyze 100 samples, in the field for the first time to examine more than a thousand World War II munitions that had been unexpectedly unearthed. (See *S&TR*, December 1998, pp. 21–23.)

For almost a decade now, Laboratory researchers, working on the "when" rather than "if" premise, have been developing systems to rapidly detect and identify biological warfare agents including anthrax and plague. In 1999, Livermore scientists and engineers unveiled the Handheld Advanced Nucleic Acid Analyzer (HANAA), the first truly portable battery-powered device for identifying bioagents in the field. HANAA can analyze samples in less than 30 minutes, compared to the hours or days that regular laboratory tests typically require. (See *S&TR*, January/February 2002, pp. 24–26.) Another device, the Autonomous Pathogen Detection System (APDS), is being designed to continuously monitor the air for pathogens as a sort of biological smoke alarm for airports, stadiums, or conference halls.

Ron Koopman, an associate program leader with the Chemical and Biological National Security Program, notes that the availability of HANAA and APDS owe much to forward-thinking efforts begun in the previous decade. "A number of people recognized the vulnerability of the country to bioterrorism a long time ago," he says. "Back then, although bioterrorism seemed far away and was something we hoped would never happen, the Laboratory and members of the defense community decided to invest in the research. Thanks to that investment, we now have something to put in the hands of people to protect us all, something that can help during the current crisis and in the long run."

Laboratory scientists also worked with their counterparts at Los Alamos to develop the Biological Aerosol Sentry and Information System. This system, which reduces the time for detecting a bioagent release from days or weeks to less than a day, was deployed as part of the security strategy for the 2002 Winter Olympics in Salt Lake City.

Biodetectors require unique DNA sequences or antibodies to identify and characterize pathogens. Researchers at Livermore



Livermore's nuclear emergency response capabilities were tested in Operation Morning Light in 1978.

Detecting Clandestine Nuclear Tests and Verifying Treaties: Two Sides of the Same Coin

Lawrence Livermore scientists have long played an important role in providing monitoring technology that supports test ban treaty verification and site inspection. On September 19, 1957, the Laboratory detonated the first contained underground nuclear explosion, Rainier, in a tunnel at the Nevada Test Site. The Rainier Event was announced in advance so that seismic stations throughout the U.S. and Canada could attempt to record a signal. Information from this event ultimately led to an array of seismic detectors for monitoring nuclear test activities worldwide, as part of the Limited Test Ban Treaty.

Nearly 35 years later, when the world received news of the Indian and Pakistani clandestine underground nuclear tests, Livermore researchers used the tests to validate modern seismic methods they had developed to monitor the Comprehensive Test Ban Treaty. (See *S&TR*, September 1998, pp. 4–11.) Using data recorded worldwide by a host of seismic monitoring stations, the team successfully differentiated the nuclear blasts from typical regional earthquakes, characterized the yields of the tests, and noted inconsistencies between the announced test yields and the seismic data. The seismic signals from the nuclear tests provided important new data for calibrating seismic stations in important regions of the world.

Livermore researchers have also developed on-site inspection procedures and technologies for collecting samples of soil, gases, and water to look for radioactive materials and for identifying underground explosion cavities or rubble. In the early 1990s, a team led by geophysicist Charles Carrigan theorized that highly sensitive instruments might be able to detect small amounts of rare, radioactive gases generated in underground nuclear detonations. In 1993, a chemical explosion called the Non-Proliferation Experiment was conducted at the Nevada Test Site to simulate a 1-kiloton underground nuclear detonation. Results from the experiment and computer simulations imply that sampling soil gases for rare, explosion-produced radioactive tracer gases at the surface near a suspected underground test could help detect nearby underground nuclear explosions that do not fracture the surface, even several months after the test. (See *S&TR*, January/February 1997, pp. 24–26.)

and elsewhere are developing a comprehensive array of such signatures. One effort focuses on analyzing the genome of the various strains of the bacterium that causes plague. Laboratory researchers are searching for the DNA sequences that are unique to all strains of the pathogen but are not found in any of its close relatives. (See *S&TR*, March 2002, pp. 4–9.)

In a project for the U.S. Army in 1998, Livermore's Jeff Haas examined more than 1,200 mortars in two days using the Forensic Science Center's thin-layer chromatography screening system.

Facing the Threat, Knowing the Enemy

"Over the years, researchers at the Laboratory have had the foresight to analyze and prepare for many versions of the 'catastrophic maybe,'" says NAI Associate Director Wayne Shotts. For most of the Laboratory's existence, the consuming national security threat to the U.S. was the nuclear arsenal of the Soviet Union. The energies, talent, and resources of the national security laboratories were dedicated to checkmating the Soviet threat. "That world," notes Shotts, "no longer exists." Today, the most serious threat arises from the proliferation of nuclear, chemical, and biological weapons, and the very real threat of terrorism using those weapons. In a development that defines the national focus on this growing threat, NAI has broken ground for a new building—the International Security Research Facility. According to Bruce Tarter, who recently stepped down as Lawrence Livermore's director, this building will serve as the Laboratory's "command post for connectivity to Washington" and its efforts to fight WMD proliferation and terrorism.

Through NAI, the Laboratory applies its nuclear weapons expertise, developed through its historical weapons program and continuing stockpile responsibilities, to the challenge of nuclear nonproliferation. In addition, NAI draws on the Laboratory's chemical and biological expertise to help stop the spread of chemical and biological weapons. From one end of the threat spectrum to the other—prevention, detection and reversal, response, and avoiding surprise—Livermore stands ready to help the nation face the threat and know the adversary.

—Ann Parker

Key Words: biodetection, biological and chemical weapons, conflict simulation, Comprehensive Test Ban Treaty, forensic analysis, nonproliferation, seismic monitoring, treaty verification, weapons of mass destruction (WMD).

For more information about the Nonproliferation, Arms Control, and International Security Directorate, see:

www.llnl.gov/nai/nai.shtml

For further information about the Laboratory's 50th anniversary celebrations, see:

www.llnl.gov/50th_anniv/