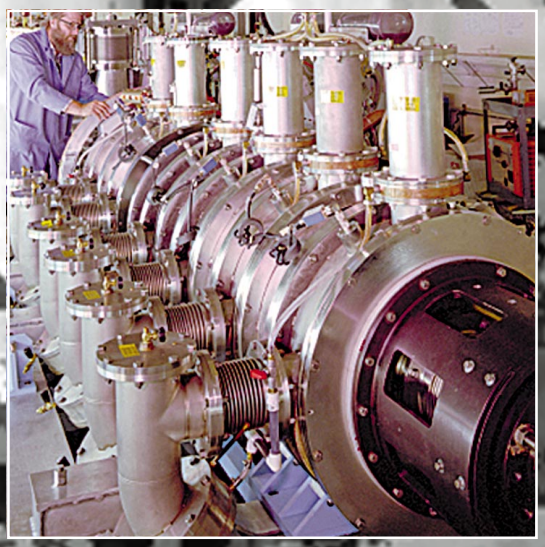


PROVIDING FOR NATIONAL SECURITY

National security is the defining responsibility of the Laboratory.

The breakup of the Soviet Union brought an end to the bilateral tensions that dominated U.S. national security policy for decades. However, the world remains a dangerous place. Economic disparities, cultural and ethnic differences, regional tensions, and uncertainties about the future can give rise to international tensions and conflict. Global interests will keep the U.S. actively engaged in world events. Thus, the nation must both prepare for anticipated security threats and expect surprises.

Threats to national security and international stability are heightened by the spread and potential use of nuclear, chemical, and biological weapons (collectively referred to as weapons of mass destruction, or WMD). At least 20 countries, some of them hostile to U.S. interests, are suspected of or known to be developing WMD. In addition, the increasing potential availability of WMD materials and technical know-how makes terrorist acquisition of such weapons a realistic possibility.

Nuclear deterrence and nonproliferation are important elements of U.S. national security policy. The U.S. is committed to halting the spread of WMD worldwide while maintaining sufficient nuclear forces to deter any adversary. As one of the Department of Energy's three national security laboratories, Livermore plays a prominent role in the Stockpile Stewardship and Management Program for maintaining the U.S. nuclear stockpile in the absence of nuclear testing. We are addressing the increasingly serious problem of WMD proliferation through a wide spectrum of analysis and technology development activities. The Laboratory provides the government with technical information and assistance to support the development of national policy on nuclear weapons, nonproliferation, and arms control matters. We also develop advanced defense technologies to increase the effectiveness of U.S. military forces.

STEWARDSHIP OF THE U.S. NUCLEAR STOCKPILE

The future course for the nation's nuclear weapons program was set in 1995, when President Clinton announced that the U.S. would pursue a comprehensive nuclear test ban. In making that decision, he reaffirmed the importance of maintaining a safe and reliable U.S. nuclear stockpile. Subsequently, the President directed necessary programmatic activities to ensure stockpile safety and reliability in the

The Flash X-Ray (FXR) Facility is used in hydrodynamic tests to provide detailed, ultrahigh-speed images of dense, imploding devices.

"... I consider the maintenance of a safe and reliable nuclear stockpile to be a supreme national interest of the United States."

President Clinton
August 11, 1995

absence of nuclear testing. The Stockpile Stewardship and Management Program was developed in response to this directive, and in 1996 the President signed the Comprehensive Test Ban Treaty.

The architecture of the Stockpile Stewardship and Management Program was defined by the Record of Decision for the Programmatic Environmental Impact Statement in December 1996. The program is designed to ensure stockpile performance in an era of no new weapons development, an aging stockpile of fewer weapons and fewer types of weapons, no nuclear testing, and a production complex with reduced capacity and capability. It integrates the efforts of the three Department of Energy national security laboratories (Livermore, Los Alamos, and Sandia), the Nevada Test Site, and the four production facilities (the Kansas City Plant, Pantex, Savannah River, and Y-12 at Oak Ridge). The program is managed by the Department of Energy's Office of Defense Programs. It consists of three major elements—surveillance, assessment, and manufacturing (including the production of tritium)—which are melded together through integrated program management and formal validation processes.

Integrated Program Management and Validation

Through integrated program management, comprehensive life-extension plans for each weapon system in the enduring stockpile are being defined and will enable the laboratories and plants to anticipate most of their activities and workload. Program integration is tied to complementary formal processes for validating assessments of stockpile performance and certifying modification actions. These processes involve the Department of Energy, the national security laboratories, and the program's customer, the Department of Defense.

• **Annual Certification.** Annual certification responds to Presidential direction for a yearly assessment from the Secretaries of Defense and Energy on the safety and reliability of the stockpile under a Comprehensive Test Ban Treaty. Each year this certification will be based on

Livermore's Contributions to the Integrated Nuclear Weapons Complex

Independent Expertise. In an era of no nuclear testing, it is particularly important for the nation to have multiple centers of expertise about nuclear weapons. For security reasons, only a small community of people has the necessary knowledge and access to tools to deal with the details of modern nuclear weapons. Two formal shared-effort validation processes are used to assess stockpile modifications and performance: dual revalidation and annual certification. Each process relies on formal reviews and the independent expertise provided by each of the national security laboratories. There are both close cooperation and healthy competition among the laboratories in all aspects of stockpile stewardship.

Responsibility for Weapon Designs. Livermore is responsible for the W62 and W87 ICBM warheads, the B83 bomb, and the W84 cruise missile. Three of these weapons have all modern safety features.

Special Facilities at Livermore. Each of the national security laboratories operates unique experimental facilities used by all of them to obtain data for resolving stockpile issues. For example, Livermore's High Explosives Applications Facility is the most modern facility for high-explosives research in the world. The Nova Laser Facility is a unique facility for weapon physics experiments; its capabilities will be greatly surpassed by its successor, the National Ignition Facility.

Annual certification, which includes rigorous internal and external review processes, will provide an important focus for stockpile stewardship and life extension activities at Livermore.

technical evaluations made by the laboratories and on advice from the three laboratory directors, the Commander in Chief of the Strategic Command, the Chairman of the Joint Chiefs of Staff, and the Nuclear Weapons Council. Annual certification, which includes rigorous internal and external review processes, will provide an important focus for stockpile stewardship and life extension activities at Livermore.

• **Dual Revalidation.** Dual revalidation is a review process to assess even more thoroughly the condition of U.S. stockpiled weapons. Two teams will perform each evaluation, one with personnel from the laboratory that originally designed the weapon and the other with experts from the second nuclear design laboratory. Sandia will participate on both teams. Managed jointly by the Departments of Defense and Energy, each dual revalidation will take two to three years to complete.

Surveillance

We are augmenting our ability to predict and detect aging-related changes that could degrade weapon safety or reliability and jeopardize stockpile performance. Weapons in the U.S. nuclear stockpile are now older on average than ever before. Materials inside a weapon degrade over time as they cycle through temperature changes and are exposed to radiation and gases released from other materials in the weapon. Surveillance with predictive capabilities will permit a systematic program of refurbishment and preventative maintenance. With planned production capacity and capabilities, we must be able to predict weapon performance 10 to 15 years in the future. Such predictive capabilities require an in-depth understanding of how aging alters the physical characteristics and properties of weapon materials.

• **Subcritical Experiments.** We must acquire a fundamental understanding of plutonium in general and of aging plutonium in particular. Plutonium has properties that are critical to the performance and safety of nuclear weapons, but it is one of the most complex and least understood of all metals. Livermore and Los Alamos will conduct subcritical (no-nuclear-yield) experiments at the Nevada Test Site to gather information about plutonium at conditions similar to those that occur during nuclear weapon operation.

A stainless-steel containment vessel is used for high-explosives experiments at HEAF, Livermore's High-Explosives Application Facility.

We have created state-of-the-art underground laboratories at the Nevada Test Site to study highly shocked plutonium. Streak cameras and holographic techniques are used to record data in these subcritical experiments.

• **Nondestructive Surveillance Techniques.** Livermore, Los Alamos, and Sandia will develop new sensors and techniques for use in stockpile surveillance that are more sensitive to physical changes in the weapon and do not affect weapon components when used in inspections. For example, we are testing a new technique that is extremely efficient and nonintrusive for sampling evolved gases within stockpile weapons.

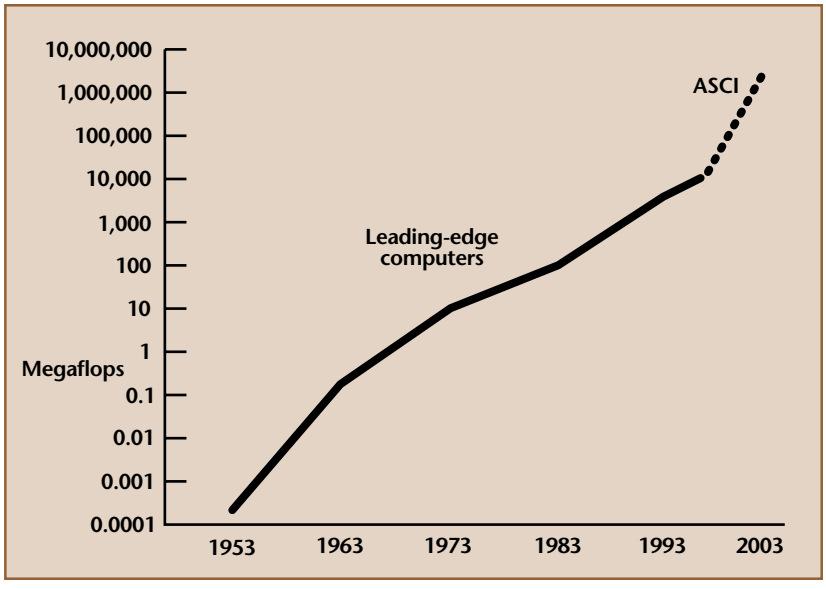
Assessment

We will evaluate the significance of issues that arise in surveillance and assess their effect on weapon safety and performance. When modifications are deemed necessary, viable options for refurbishing or replacing specific warhead components must be determined and evaluated. Assessments will be based on demonstration, using archival data together with non-nuclear experiments and experimentally validated computational models. We will bring into operation new scientific capabilities that are needed to make these assessments. These tools will also enable experienced weapons scientists and engineers to train the next generation of stockpile stewards.

• **Higher-Resolution Computational Models.** High-resolution, three-dimensional weapon physics and engineering models are needed to assess the performance of nuclear weapons and the conditions affecting weapon safety. Through the Accelerated Strategic Computing Initiative, the national security laboratories are working with U.S. industry to develop successively more powerful supercomputers, leading to a 100,000-fold increase in computational speed and data capacity. Each advance will represent the world's largest, fastest computer. Computer scientists will be challenged to develop algorithms and simulation codes that take full advantage of the parallel architecture of the new machines. Using the first elements of the Laboratory's next-generation supercomputer (the IBM SP, delivered in September 1996), weapons experts are already benefiting from unprecedented new capabilities.

• **Improved Physics in Computational Models.** To make full use of increases in the resolution of weapon physics and engineering simulation codes, we must also improve the science in the codes. We will combine theoretical work with a variety of laboratory experiments to develop improved, validated physical databases and physical models for simulation codes. We must understand in detail the interaction of matter

The Accelerated Strategic Computing Initiative (ASCI) will provide a rapid expansion of Livermore's computing capabilities, here measured in computer speed (millions of operations per second).



"The National Ignition Facility will unleash discoveries that we can only now dream of . . . . The NIF will help us unleash the power of the heavens to make the earth a safer place."

Federico Peña
Secretary of Energy
May 29, 1997

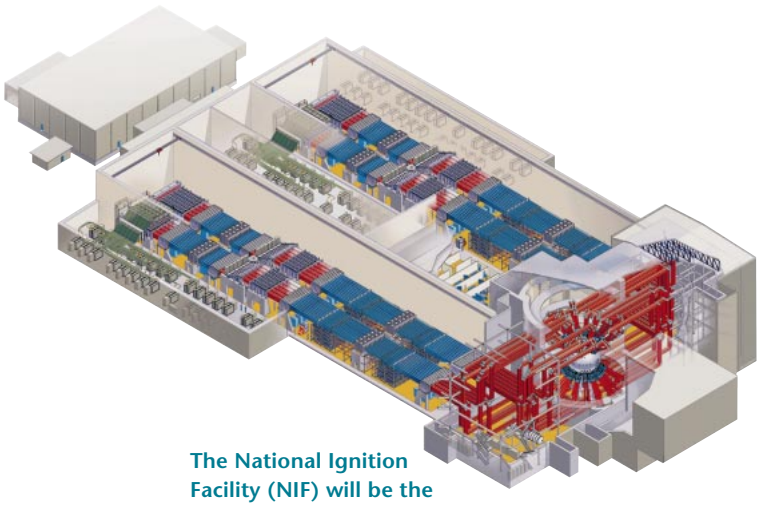
with radiation and the properties of materials at extreme conditions of temperature and pressure. We will combine multiscale modeling with experiments to explore material properties from the quantum level to the atomic level to much larger scales.

• **Thermonuclear Physics Experiments.** Laboratory experiments of weapons physics, including fusion burn, at relevant conditions of temperature and pressure are needed to resolve important stockpile issues and validate computational models. The National Ignition Facility (NIF), which will contain the world's largest laser, is being constructed at Livermore and will provide the only experimental means of studying fusion burn. In addition, the NIF will be a critical next step in the development of inertial confinement fusion as an environmentally attractive energy source and will serve as a user facility for a wide range of fundamental research. The NIF will be invaluable in attracting and training the next generation of stockpile stewards.

• **Improved Hydrodynamic Experiments.** Hydrodynamic experiments provide crucial data on a nuclear weapon's high-explosive detonation and implosion phases. By upgrading the Flash X-Ray Facility to provide full containment of debris from hydrodynamic experiments, we will greatly facilitate the environmental management of these essential experiments. Livermore and Los Alamos will also pursue technology development for a next-generation facility, the Advanced Hydrotest Facility, to obtain multiple views at multiple times during an experiment, a vast improvement over current capabilities.

Manufacturing

Stockpile nuclear weapons must be refurbished periodically, and the replacement parts, materials, and processes must be certified. The development of replacement parts will be integrated with the development of new materials and manufacturing processes. This concurrent engineering approach, with its close collaboration among the laboratories and the nuclear weapons production plants, will reduce costs and increase the efficiency of the production complex. To meet the anticipated refurbishment workload, production facilities—including those for tritium—must be flexible, reliable, highly capable, yet affordable.



The National Ignition Facility (NIF) will be the world's largest laser, housed in a building seven stories high and two football fields long.

• **Advanced Manufacturing Technologies.** We will team with the production plants to develop advanced manufacturing technologies that will reduce defects, improve production yields, and lower costs. We will draw on Livermore's extensive chemistry, materials science, and engineering expertise to develop improved materials and manufacturing technologies for replacement weapons parts. For example, Livermore's ultrashort-pulse laser technology will be incorporated into an extremely precise laser-cutting system that will reduce costs and wasted materials in weapon refurbishment activities.

STEMMING PROLIFERATION OF WEAPONS OF MASS DESTRUCTION

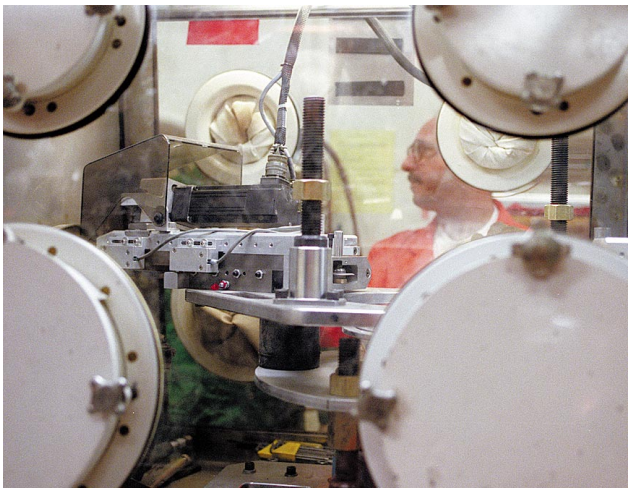
Dealing with the complex and serious threat of weapons proliferation is a critical national priority. Halting the spread and preventing the use of weapons of mass destruction (WMD) require the integration of technology and policy. The national laboratories are working with the various U.S. government agencies that have responsibilities in this area.

At Livermore, we are applying nuclear expertise and other capabilities to the challenge of nuclear nonproliferation. In response to recent legislation calling for enhanced U.S. capabilities against proliferation of all types of WMD, we are also developing the technologies, analysis tools, and expertise needed to help stem the proliferation of chemical and biological weapons. Livermore's program in nonproliferation, arms control, and international security is tackling WMD proliferation across the entire spectrum of the threat—prevention, reversal, response, and avoiding surprise.

Proliferation Prevention and Arms Control

Prevention is the first level of defense against WMD proliferation. Livermore has a long history of policy analysis and support for U.S. arms control activities, dating back to the atmospheric test ban negotiations and the Strategic Arms Limitation Treaty talks of the 1960s. Currently, we are conducting research and development on technologies for monitoring the Comprehensive Test Ban Treaty and the Chemical Weapons Convention. We will provide technical and analytical support to U.S. negotiators for the START III talks, which are aimed at further reducing U.S. and Russian nuclear arsenals. We will also continue to be extensively involved in activities to safeguard nuclear materials worldwide.

We developed a waste-free means of cutting open weapon pits (left) that are excess to national security needs. As the next step leading to permanent disposal, the plutonium is then extracted and converted to an oxide using the Livermore-developed hydride/oxidation (HYDOX) process (right).



We will provide U.S. decision makers with capabilities for analyzing proliferation activities and evaluating the consequences of possible interdiction options.

• **Support for the Comprehensive Test Ban Treaty.** We will continue to assist the U.S. effort to implement the Comprehensive Test Ban Treaty by providing personnel to support the negotiations preparing for entry into force of the treaty and by pursuing research to improve treaty compliance monitoring. We will develop the data and databases needed to compute regional seismological corrections and monitor with high confidence specific regions of interest for low-yield nuclear tests. We will also investigate the use of alternatives to seismic signatures to detect evasively conducted nuclear tests.

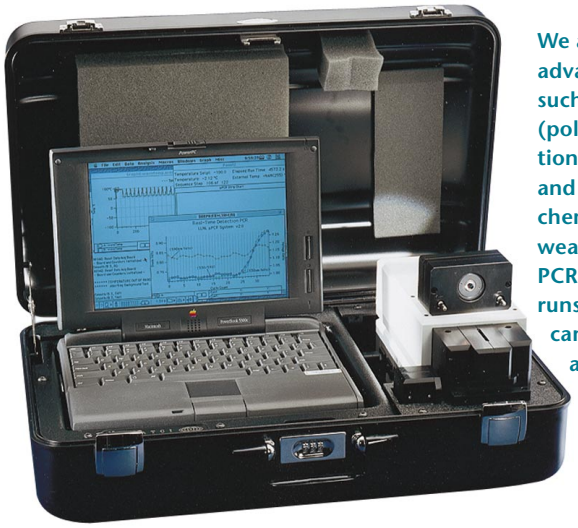
• **Nuclear Material Protection and Control.** We will expand Livermore's collaborations with facilities in Russia and the other Newly Independent States to improve the protection, control, and accounting of nuclear materials. Researchers will also work with Russian counterparts to reduce the inventories of nuclear weapons materials of both countries, including the development and validation of methods to confirm that inspected fissile material originated from the dismantled nuclear weapons.

• **Fissile Material Disposition.** The dismantlement of thousands of nuclear weapons by both the U.S. and Russia will require the disposition of large quantities of weapons materials. Technical options for the permanent disposition of plutonium are being investigated at Livermore, the other national laboratories, and counterpart institutions in Russia. Livermore will focus on developing technologies to embed plutonium in glass or ceramic materials.

• **Integration of Policy and Technology for Global Security.** We recently formed the Center for Global Security Research to bring together scientists, technologists, and the policy community to examine the ways in which technology can enhance international security. Through collaborative projects, the Center will study such topics as the security implications of emerging technologies, technical options for bolstering security, implications of a START III agreement, and the future role of military forces.

Proliferation Detection and Defense Systems

The nation must be able to detect weapons-related activities and evaluate options for stopping potential proliferants from successfully acquiring WMD. We will build on the Laboratory's broad base of relevant expertise—including genomics, microfabrication, sensors and remote monitoring, lasers, atmospheric science, computational modeling, intelligence analysis, and emergency response—to develop needed capabilities and technologies.



We are developing advanced instrumentation, such as this mini-PCR (polymerase chain reaction), for on-site detection and identification of chemical and biological weapons agents. Our mini-PCR fits inside a suitcase, runs on batteries, and can be used for *in situ* analyses.

• **Proliferation Detection Technologies.** We will develop sensitive, long-range standoff sensors for measuring trace amounts of airborne effluents that are indicative of specific processes occurring within suspect weapons production facilities. We will also develop local sensors for long-term continuous monitoring of inherently short-range signatures (e.g., radiation). In addition, we will develop networks of sensors to protect critical areas, such as military bases, from ground-delivered nuclear devices and biological weapons.

• **Counterproliferation Analysis and Planning.** We will apply our expertise in country-specific analysis of proliferation activities, weapons development, and computational modeling to provide U.S. decision makers with enhanced capabilities for analyzing weapons proliferation activities and the consequences of possible interdiction options. We will develop versatile and powerful tools for assessing the proliferation activities of foreign countries, ascertaining the specific function and location of major production sites, and identifying critical production activities that, if interdicted, would halt the proliferation effort.

Counterterrorism and Incident Response

We are augmenting Livermore's long-standing capabilities in nuclear emergency response with similar capabilities for chemical and biological weapon emergencies. The Laboratory's efforts are integrated with those of the other laboratories and government agencies that would respond to a WMD incident. We will continue to devise strategies for dealing with the threat of WMD terrorism and develop improved techniques for detecting and disabling WMD devices. We will also pursue an initiative to counter nuclear smuggling to prevent nuclear weapons and nuclear materials from falling into the wrong hands.

• **Responding to the Proliferation of Chemical and Biological Weapons.** We will develop detectors and sensor systems for remote monitoring and characterization of chemical and biological proliferation activities as well as field-portable instrumentation for on-site analysis in the event of a chemical or biological weapon attack.

• **Counter-Nuclear-Smuggling.** Livermore has unique resources for dealing with actual or alleged cases of nuclear smuggling. For example, we have available the instrumentation and expertise for characterizing virtually any compound and identifying nuclear, chemical, or biological signatures of WMD activity. In addition, we developed and now staff the Department of Energy's Threat Credibility Assessment Center, located at Livermore. The Laboratory's strengths in sensor systems, remote monitoring, and information analysis will be used as part of a collaborative national initiative to identify and interdict nuclear smuggling.

Highly interactive simulation models are used for military training and security analysis at Livermore's Conflict Simulation Laboratory.

We will build on the scientific and technical capabilities developed for the Laboratory's stockpile stewardship and nonproliferation missions to pursue advanced technologies for the Department of Defense.

Avoiding Surprise

The nation must avoid being surprised by foreign WMD activities. For decades, Livermore has used its technical knowledge about the design and testing of nuclear explosive devices to assess foreign nuclear weapons programs and nuclear proliferation risks. We will continue to integrate this knowledge with specifics about each country's nuclear capabilities and with our understanding of the nontechnical issues that motivate nuclear programs. Livermore's analyses will support the U.S. intelligence and policy communities, providing valuable technical assistance to policy makers and diplomats as they develop strategies for the U.S. response to international activities.

MEETING NEW MILITARY REQUIREMENTS

The Department of Defense must define and implement the military strategy, force structure, modernization programs, and defense infrastructure to meet ever-shifting future threats to U.S. national security. Recent studies have defined a U.S. "military of the future" that is technologically superior and dominant enough to win quickly, decisively, and with minimum casualties. Consistent with national budget constraints, the technologies that provide this dominance must be cost effective and available in a timely manner.

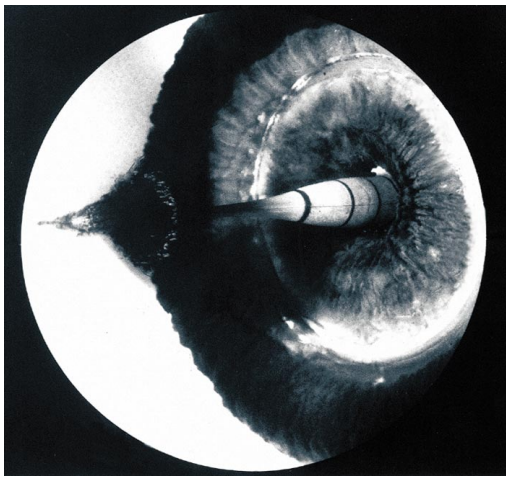
We will build on the scientific and technical capabilities developed for the Laboratory's stockpile stewardship and nonproliferation missions to pursue advanced technologies for the Department of Defense. We will focus on areas where Livermore's special skills match identified needs.

• **Quick and Decisive Military Operations.** The U.S. military's ability to conduct operations quickly and decisively will depend heavily on advanced sensors, information technologies, and predictive meteorology capabilities. Livermore will use its demonstrated strengths and capabilities to pursue innovations in each of these areas.

• **Precision Weapons Systems.** Livermore will contribute its expertise in energetic materials, advanced conventional munitions, laser and electro-optics systems, conflict simulation models, and consequence analyses to the development of precision weapons systems that will allow the U.S. military to destroy adversary targets while minimizing collateral casualties.

• **Effective Protection of U.S. Forces.** The Laboratory will pursue technologies pertinent to theater ballistic missile defense and the detection of chemical and biological agents in order to protect U.S. forces against chemical and biological weapons.

• **Efficient Operations.** Livermore's conflict simulation capabilities will be applied to logistics issues to investigate means for efficient supply of equipment to U.S. forces, which can make a decisive difference early in a military operation and dramatically reduce overall costs.



An explosively formed jet of metal (10 centimeters long) speeds to the left at 8 kilometers per second as it is recorded by a streak camera. At Site 300, we are demonstrating shaped-charge technology for use against very hard targets.