# Defense and Nuclear Technologies

*The past few years have seen a major restructuring of the Laboratory's nuclear weapons program to address post-Cold War national security requirements—in particular, to provide for science-based stewardship of the U.S. stockpile, to oversee the dismantlement of retired LLNL-designed weapons and the disposition of weapon materials, and to apply nuclear weapon expertise to the problems of nonproliferation and counterproliferation.*

The national security programs have undergone profound changes as a result of significantly altered U.S. defense needs. The DOE's Office of Defense Programs has shifted its focus to address post-Cold War national security requirements. In concert with DOE and the other national security laboratories, we at Livermore have responded by redirecting our scientific and technical resources to address the highest national priorities. The major activities of LLNL's Defense and Nuclear Technologies directorate are directed toward

- Ensuring the safety, reliability, and security of the U.S. nuclear stockpile.
- Overseeing the dismantlement of LLNL-designed nuclear weapons and the disposition of weapon materials.

*With this new gamma-ray camera, we can obtain more accurate and more informative images of imploding primaries in flash x-ray experiments. In particular, this camera produces images of much higher resolution (at least double that possible with previous instruments) and therefore much greater detail; it can also obtain images at much later stages in the implosion process.*

- Applying our expertise in nuclear weapon science and technology to prevent and counter nuclear proliferation.
- Analyzing current and evolving U.S. military requirements.
- Developing technologies for conventional (non-nuclear) defense.
- Developing and demonstrating technologies for the cleanup and environmental restoration of the nuclear weapons complex.

Our activities benefit not only national security but also civilian science and technology and U.S. industrial competitiveness.

## National Security Priorities

President Clinton has stated that a safe, reliable nuclear deterrent remains a cornerstone of U.S. national security policy. In a speech on July 3, 1994, he said:

"To assure that our nuclear deterrent remains unquestioned under a test ban, we will explore other means of maintaining our confidence in the safety, the reliability, and the performance of our own weapons. We will also refocus much of the talent and resources of our nation's nuclear labs on new technologies to curb the spread of nuclear weapons and verify arms control treaties."

The President has called for the establishment of a stockpile stewardship program and has directed the DOE and the DOD to develop the framework for such a program. Support of the national stockpile stewardship program constitutes the bulk of the efforts of our Defense and Nuclear Technologies directorate.

We are also working with the Laboratory's Nonproliferation, Arms Control, and International Security directorate to respond to the DOD's Counterproliferation Initiative. For

example, we have designed and deployed the only device capable of disabling some terrorist weapons.

In addition, we support DOE's arms control efforts. In 1994, working closely with DOE's Office of Arms Control and National Security, we provided technical assessments of the activities that various countries might conduct under a comprehensive ban on nuclear testing and on the potential arms control and proliferation impacts of building the National Ignition Facility.

In our advanced conventional weapons program, we are supporting DOD efforts to improve its conventional capabilities with new sensors, materials, and munitions.

## Nuclear Weapon Technology Programs

The thrust of the nation's weapons program is no longer weapon development, testing, and production. Today the nuclear weapons issues facing the country and the Laboratory involve responsible stewardship of the U.S. nuclear stockpile and halting the spread of nuclear weapon technology. These issues present major scientific and technical challenges, and our highest priority is to enhance our experimental and computational resources. The science and technology we have developed in the last two years is considerable and presages the advances that will be required in the future. Current programs and recent accomplishments are summarized below.

### Stockpile Stewardship

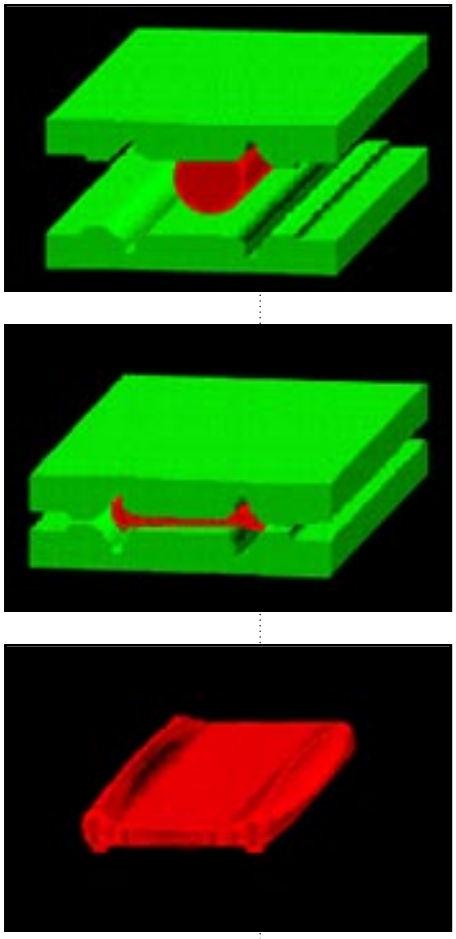
We have taken a leadership role in defining the science-based stockpile stewardship program. In support of this program, we are placing heavy emphasis on developing a fundamental, first-principles understanding of weapon safety, security, and reliability. Even with severe budget constraints, we have increased our efforts to achieve maximum utilization of existing state-of-the art experimental facilities and computers. Together with Los Alamos, we are making heavy use of the Nova facility for weapons-physics experiments. We have developed a gamma-ray camera with which we can obtain higher resolution and more accurate images of imploding primaries in flash x-ray experiments. In addition to upgrading our existing facilities, we are defining the major advances in capabilities, such as the proposed National Ignition Facility, an Advanced Hydrotest Facility, and an advanced massively parallel processing computer facility, which will be needed to resolve future stockpile issues.

### Preventing and Countering Nuclear Proliferation

Dealing with the problems of nuclear proliferation is a high national priority. Whereas the fear of a nuclear war between superpowers is greatly reduced, a new threat, as stated by the Secretary of Defense William Perry, is "a handful of nuclear weapons in the hands of some terrorist organization or terrorist state, perhaps delivered by unconventional means." In such an event, the Nuclear Emergency Search Team (NEST)—created in the early 1970s with strong LLNL

### Highlights for 1994

- Implemented a new strategic plan for the Defense and Nuclear Technologies directorate that is responsive to the changes in U.S. defense needs.
- Refocused the organization on science-based stockpile stewardship and made major contributions to the Stockpile Stewardship and Stockpile Management program plans.
- Continued our vigorous efforts in stockpile surveillance and weapon system safety and performance evaluation.
- Contributed to solving the problem of disposing of weapon materials from dismantled weapons.
- Made major progress in program integration with the Los Alamos and Sandia laboratories to eliminate unnecessary duplication of activities yet ensure adequate peer review.
- Led the development of new nuclear-weapon detection and render-safe capabilities.
- Studied the implications of interdiction of proliferant nuclear activities.
- Confirmed that NIF will be able to access regimes of interest for stockpile stewardship.



*Our ALE3D code is unique in its ability to model complex flows of many different materials. Here, at the start of the forging process, an aluminum billet (red) is positioned in a die (green). After the process, the result is an aluminum part. We have joined with Alcoa Aluminum in a CRADA to investigate the behavior of aluminum as it is formed into complex-shaped parts.*

participation—would be called upon as part of a government-wide response team to deal with the emergency. Many believe the capabilities of NEST should be expanded to meet the new challenges.

Anticipating future needs, we are developing innovative approaches for detecting clandestine nuclear devices and rendering them safe. We have also begun to examine the consequences of interdicting proliferant activities.

### Consolidation of the Nuclear Weapons Complex

The nation's nuclear weapons complex is being downsized, consolidated, and modernized. With no weapons in development or production, various production plants and facilities have been closed. Similarly, the activities and facilities at the national security laboratories—Livermore, Los Alamos, and Sandia—are being examined to eliminate unnecessary duplication of effort and facilities. The goal is to consolidate weapon-related activities around major facilities and capabilities. This consolidation began in the late 1980s with activities related to nuclear testing, and it now covers the full range of efforts in nuclear weapon science and technology.

The first use of the smaller, consolidated complex will be for weapon dismantlement. Thus, activities related to weapon dismantlement and modernization of the weapons complex are intertwined. As a result of the START I and II treaties and unilateral disarmament decisions, thousands of U.S. nuclear weapons are slated for dismantlement. In the future, the modernized complex will be used to support stockpile surveillance and the fabrication or remanufacture of weapon components to resolve safety or performance concerns that may arise.

The national security laboratories have adopted a "lead laboratory" approach to create a single integrated national program. Each institution has lead responsibilities in specific technical areas where they have demonstrated technical strengths, with the other laboratories providing support as necessary. In areas where independent review and judgment are essential (particularly in those areas where there is no industrial or university base of expertise), complementary programs exist at more than one laboratory.

### Weapon Dismantlement and Disposition of Weapon Materials

We are developing safer and faster methods for dismantling retired stockpile weapons and for disposing of their materials. We played a major role in resolving a problem at the Pantex Plant that temporarily halted dismantlement activities. We have built and demonstrated a self-contained apparatus to turn plutonium-containing pits from dismantled weapons into a form suitable for disposition. We are also developing methods to dispose of excess high explosive without open burning.

### Technologies for the Future

The capability to maintain and fabricate weapons in the future will require materials and manufacturing technologies that generate less hazardous waste, improve worker safety, and are environmentally benign. To this end, we have developed a precision die-casting method for producing plutonium components; since this method involves casting within a mold instead of machining, almost no hazardous waste is generated. We also pioneered the concept of reusing plutonium components from retired, dismantled weapons and are developing the facility to implement this idea. Reusing plutonium components obviates the need to manufacture new components to correct safety or performance problems with stockpile weapons. These efforts are integral to the major role we are playing in providing the technical basis for a downsized, consolidated, cost-effective nuclear weapons complex.

### Preserving a Unique Knowledge Base

World-class facilities and important scientific challenges are required if we are to continue to retain, attract, and motivate the top scientific talent essential for addressing future nuclear weapons issues. Declining budgets in the last ten years, together with several voluntary retirement incentive programs, have led to the loss of some of our most experienced weapon scientists and engineers. Demographic projections show that we can expect further dramatic declines in experienced staff in the next ten years. Accordingly, our experienced scientists and engineers are training our newest people. We are analyzing experimental data from the stockpile and from past nuclear tests and are performing new experiments, in the laboratory and on the computer, so we can base our understanding of nuclear weapons on the most up-to-date scientific interpretation. To motivate our people and keep their skills sharp, we are using new tools and working on new challenges. In cooperative R&D partnerships with industry, our people are applying their technological capabilities to improve the nation's economic competitiveness. Our scientists and engineers are also applying their unique technological capabilities to solve important problems in conventional defense.

## Experimental Facilities and Computational Capabilities

Science-based stockpile stewardship requires that we enhance and upgrade existing experimental capabilities and design and construct several new facilities. We must also enhance our computational capabilities; in particular, we must make the move to massively parallel processing in order to increase the accuracy, completeness, and resolution of our simulations.

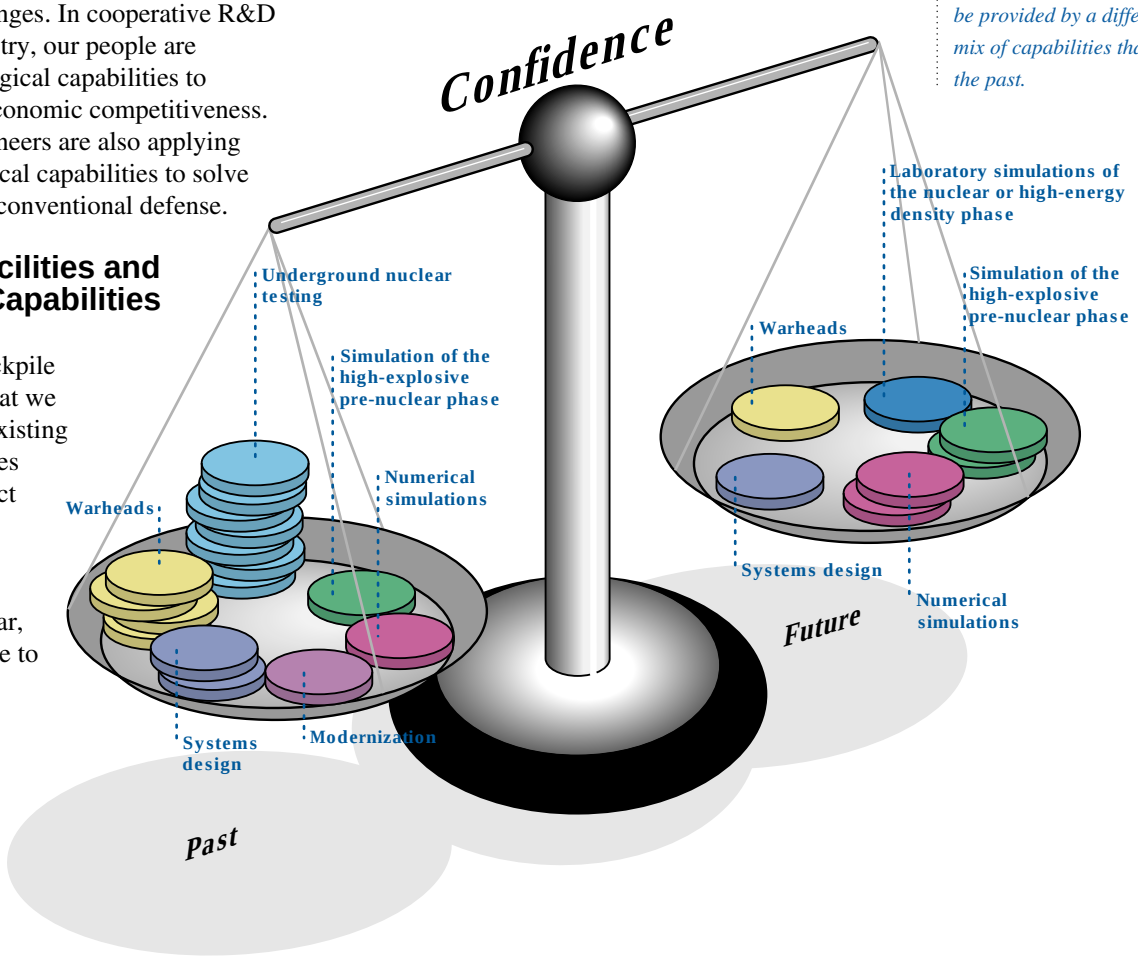
### Flash X-Ray Facility

We are upgrading our Flash X-Ray (FXR) facility, located at Site 300, to provide two pulses, and hence two images, during a hydrodynamics test. These tests, in which mock nuclear material is used in place of the fissile material, are our only non-nuclear means of testing and evaluating the implosion of a nuclear weapon's primary stage. We are also defining a contained firing capability at the FXR to meet future environmental restrictions that might affect open air firings.

### Advanced Hydrotest Facility

The double-pulse FXR data will be critical in defining an Advanced Hydrotest facility. We are working with a team of Livermore, Los Alamos, Sandia, EG&G, and AWE (Atomic Weapons Establishment, U.K.) researchers to develop plans for the Advanced Hydrotest Facility. This facility will provide multiple beams and multiple pulses

*Confidence in the safety, security, and reliability of the nuclear stockpile will be provided by a different mix of capabilities than in the past.*



of x rays and, hence, three-dimensional CAT-scan-like movies of the interior of an imploding device.

### High Explosives Application Facility

Our High Explosives Application Facility will continue to play a major role in developing safer high explosives and in conducting studies to characterize other energetic materials. We are improving existing processes and operations and developing new methods for formulating and handling energetic materials to reduce costs, minimize waste, enhance worker safety, and remain in compliance with increasingly strict ES&H regulations.

*Much of the special expertise developed for nuclear weapons is finding application in conventional (non-nuclear) defense such as the Patriot Missile.*

### National Ignition Facility

With the proposed National Ignition Facility, we will be able to address a wide range of high-energy-density phenomena beyond the capabilities of current facilities. Like LLNL's Nova laser facility, where the Livermore and Los Alamos weapons programs conduct one-third of all the experiments carried out, the National Ignition Facility will be used for weapons physics work as well as for many other scientific investigations. Currently, we are studying the arms-control implications of building the National Ignition Facility, in particular, the impacts on nonproliferation and on achievement of a comprehensive test ban.

### Secure Computing Facility

The Defense and Nuclear Technologies directorate supports more than 90% of the operating costs of the Laboratory's Secure Computing Facility and 100% of the costs for acquisition of new equipment. The state-of-the-art computing capabilities at this facility benefit virtually all Laboratory programs.

In the past year, we acquired the Meiko CS-2 computer. This massively parallel processor (MPP) consists of 256 nodes, with each node containing 16 million words of memory. The first and second halves of the machine were delivered and recently installed. We are in the process of learning to use the MPP to take full advantage of its capabilities; we are transferring our application codes onto this new machine and are integrating it into the Secure Computing Facility.

The experience we are gaining with the Meiko MPP will be extremely valuable in defining the DOE's Accelerated Super Computing Initiative (ASCI). The DOE laboratories and industry are working together to define the ASCI. As currently envisioned, it will involve three elements: (1) collaborating with manufacturers to develop new supercomputer technologies, (2) developing software to take maximum advantage of new machine architectures, and (3) providing the infrastructure to manage supercomputing resources (e.g., compilers, graphics capabilities, data-management and data-storage devices).

### National Storage Laboratory

We are also working with 20 other laboratories and universities on the National Storage Laboratory (NSL), located at LLNL's National Energy Research Supercomputer Center. LLNL is playing a major role in developing the NSL capability for advanced storage of archival information; this effort involves writing the software to access a variety of storage media. The NSL is based on the Unitree storage capability that we developed initially for our weapons work.

## Summary

Fulfilling our national security and stockpile stewardship responsibilities requires tremendous scientific and technical breadth: from esoteric theoretical physics and computational modeling to materials science and precision engineering. Because there exists no broad industrial or university base from which to draw expertise in nuclear weapon science and technology, we rely heavily on formal peer reviews and informal exchanges with our sister laboratory at Los Alamos. Our relationship with the University of California and the challenging nature of our work have enabled us to recruit and retain top scientific and engineering talent, and we are committed to attracting such talent in the future.

LLNL has an important, long-term role in the nation's nuclear weapons program. We are responsible for four of the ten weapon systems in the enduring U.S. stockpile (three of nine after 2002), including the only systems that incorporate all modern safety features. For years to come, we will be responsible for these weapons and for the problems that will inevitably arise. Our nuclear expertise will also play a crucial role as the U.S. attempts to deal effectively with the threat of nuclear proliferation.

This past year brought the culmination of our response to profound changes in the nation's defense needs as we restructured and refocused our activities to address the Administration's goal of reducing global nuclear danger. We made major contributions to important national security issues in spite of severe fiscal constraints.

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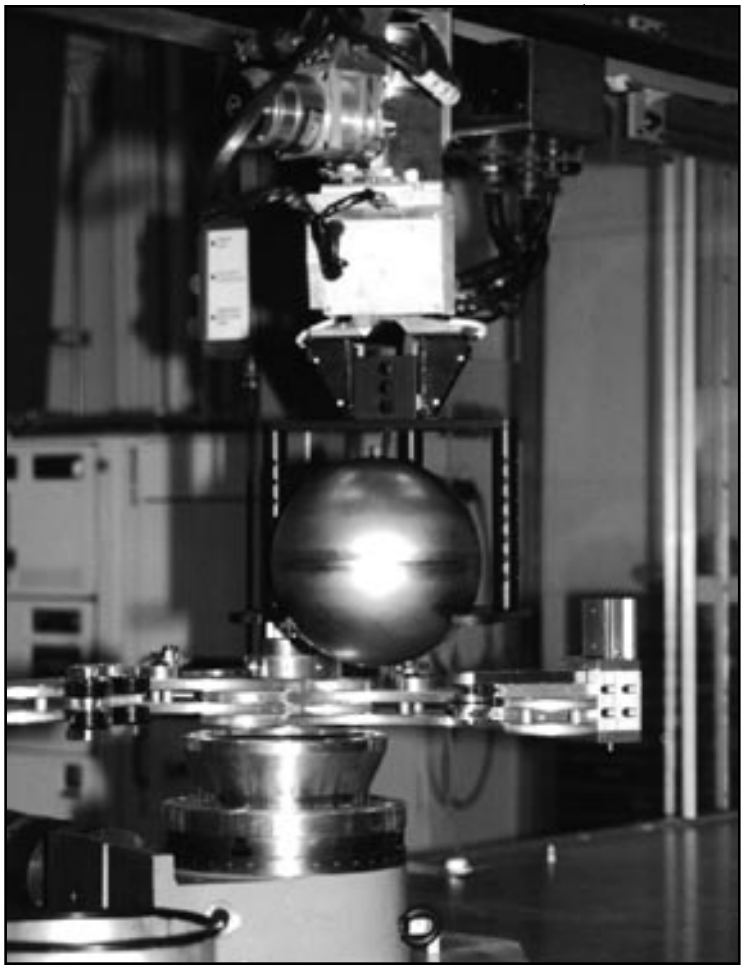

*Disassembly of nuclear weapons and the disposition of their materials continue to be important national issues. The Laboratory has developed an innovative, automated technique to disassemble weapons and remove material by a hydride/dehydride process. The spherical unclassified mock object above was used to develop this technique.*