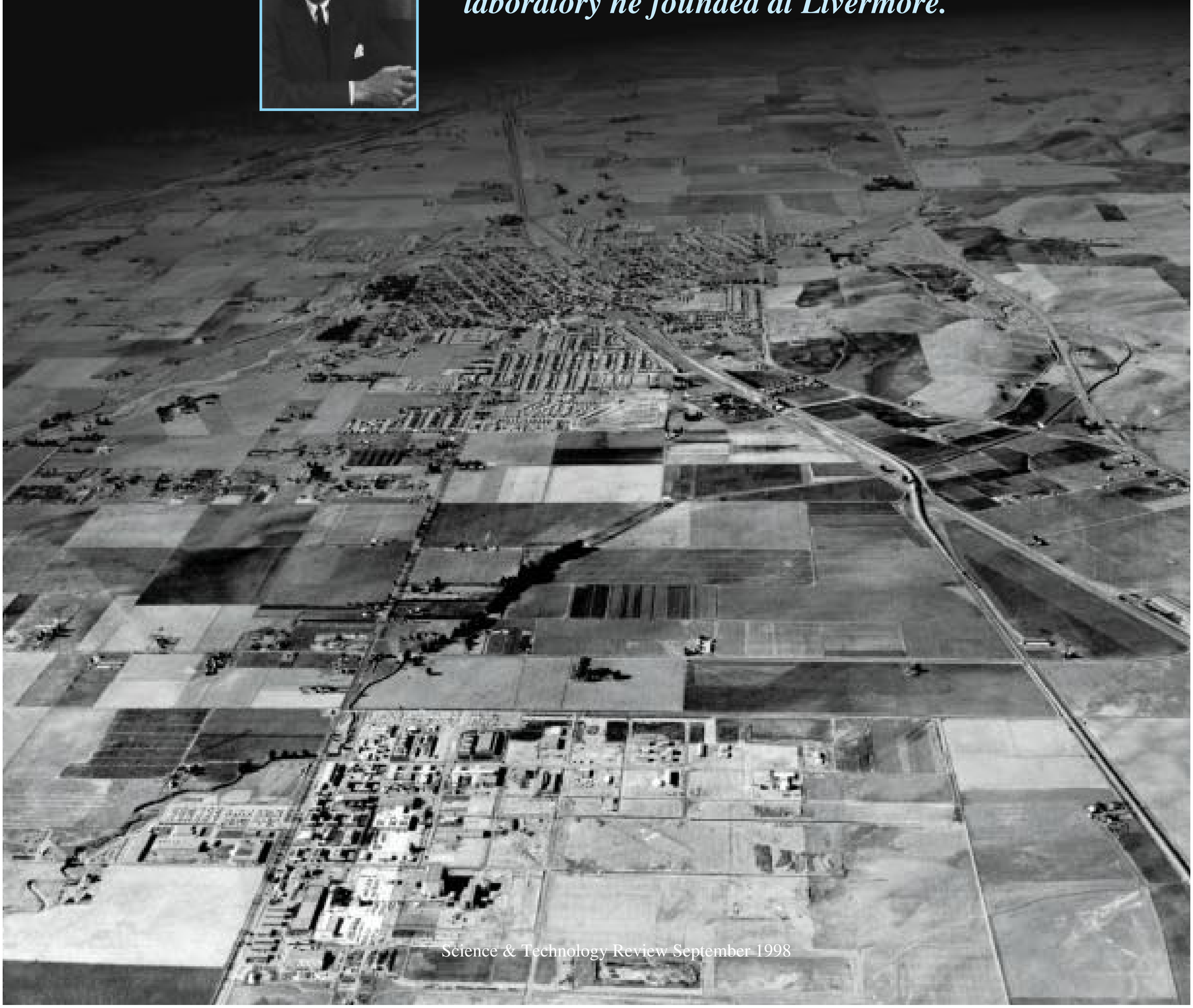
A Short History of the Laboratory at Livermore

On the fortieth anniversary of E. O. Lawrence's death, **S&TR** ***explores the history of the laboratory he founded at Livermore.***



THE institution now known as Lawrence Livermore National Laboratory formally opened its doors in 1952 as a branch of the University of California Radiation Laboratory (now the Ernest Orlando Lawrence Berkeley National Laboratory). Managed by the University of California under contract with the Atomic Energy Commission (AEC), the new laboratory would soon become what the well-established laboratory at Los Alamos, New Mexico, and home of the World War II Manhattan Project already was: a premier nuclear weapons design laboratory for the United States.

The laboratory lies on a tract of more than one square mile in Livermore, California, about 40 miles southeast of the university's Berkeley campus and its parent laboratory. Although still managed by the university under government contract, it has long since outgrown its origins as a branch laboratory. Today, it serves as a national resource in a broad range of science and engineering research, with national security remaining its core mission.

Creating the Laboratory, 1949–52

Establishing the laboratory at Livermore was a process spanning several years on either side of the formal opening in 1952. Essentially, it began in August 1949, when the Soviet Union tested its first nuclear weapon. Edward Teller, a gifted and sometimes controversial physical scientist highly regarded by his peers and by the AEC, promptly redoubled his efforts to push work on the "Super," a thermonuclear weapon that derived its energy mainly from the fusion of deuterium, an isotope of hydrogen.

So-called hydrogen bombs, or H-bombs, were potentially far more powerful than fission bombs, which drew their energy from splitting atoms

of the heavy elements uranium or plutonium. Fission bombs (atomic bombs, or A-bombs) were developed at Los Alamos during the Manhattan Project. At wartime Los Alamos, Teller had been the chief advocate of thermonuclear weapons development, and he had continued to press his case from a postwar position at the University of Chicago, although without much success. The Soviet A-bomb changed everything.

To Teller (and many others), an American H-bomb seemed the best response to the new Soviet threat. Convinced that not enough was being done, he vigorously lobbied a reluctant AEC for a second nuclear weapons laboratory to compete with the existing Los Alamos laboratory. He also sought other allies. When the Air Force in late 1951 supported a second laboratory, the AEC's resistance began to crumble.

By spring 1952, the AEC had reversed its position, a change greatly furthered by the emergence in California of a viable prospect for a second laboratory. Earlier that year, Ernest Orlando Lawrence—cyclotron inventor, Radiation Laboratory founder, and Nobel Prize winner—had proposed to the AEC establishing a branch of the Radiation Laboratory in Livermore. Acting in response to news of the 1949 Soviet test, Lawrence had secured the former Livermore Naval Air Station for AEC work.

The main project at Livermore was a giant linear accelerator called MTA (ostensibly for Materials Testing Accelerator, a meaningless code name) intended to produce then-scarce plutonium. Figure 1 shows the full-scale working model of the machine's front end under construction. A team from Lawrence's laboratory also used the roomy Livermore site to develop a diagnostic experiment for the 1951 George event in Operation Greenhouse, the first Los Alamos test of thermonuclear principles. In short, Lawrence could back his proposal by pointing to ongoing operations at a proven site. Such arguments coming from a widely admired scientist with other large projects to his credit allayed most AEC doubts.

Figure 1. The first big project at the Livermore site began in 1951, before the laboratory itself was approved. This photo shows the prototype vacuum chamber for the so-called Materials Testing Accelerator under construction. Once development was completed, the full mile-long linear accelerator was constructed near St. Louis.

When Teller accepted a position at Livermore, the last piece fell into place. The AEC and the Regents of the University of California quickly agreed to what would become the second nuclear weapons laboratory. That Lawrence himself would remain in Berkeley and have little part in day-to-day operations scarcely lessened his pervasive influence. His former student and fellow faculty member, Herbert York, largely organized the branch laboratory and became its first on-site director.

Organizationally, York reported to Lawrence and clearly modeled the new laboratory on what he had learned from Lawrence about running big science programs at Berkeley. Teller, a daily presence at the Livermore Laboratory, played a quite distinct but no less significant role. His imprint was, and remained, especially strong on the laboratory's choice of programs to pursue. The creation and subsequent shaping of the branch laboratory at Livermore and its programs owed much to all three men (Figure 2).

The Formative Years, 1952–58

Like its parent laboratory in Berkeley and future sister laboratory at Los Alamos, the Livermore branch laboratory became an AEC facility under University of California management. Initially, the scope of Project Whitney, the code name assigned to work at Livermore, was quite modest. At the official branch opening on September 2, 1952, the entire staff numbered only 123, many still working in Berkeley, with a projected first-year budget of $600,000. Broadly speaking, Livermore was expected to support Los Alamos with work on aspects of designing and testing thermonuclear weapons.

Weapons, however, never exclusively preoccupied Livermore. Research in controlled fusion soon began. From its first days, Livermore studied such related areas as magnetic fusion. Under the auspices of the AEC's Project Sherwood, several other laboratories were also looking for practical methods of confining a fusion reaction to produce useful energy. Livermore chose to pursue the so-called magnetic mirror approach: magnetic fields would confine ionized gas or plasma within an open-ended cylindrical cavity. Livermore also began its long fascination with high-powered electronic computing and hands-on experimentation: the first UNIVAC arrived in 1953, and the Site 300 high-explosive test facility was opened in mid-1955.

Weapons research nonetheless held center stage, although the first efforts of Livermore's novice bomb designers proved disappointing. Concepts tested during 1953 in Nevada and 1954 at Bikini had yields so far below expectation as to prompt some jeering observers to label them "fizzles" (Figure 3). Disappointed but undismayed, the young scientists and engineers quickly broadened their design approaches and soon turned things around. The breakthrough for fission designs came in 1955 during Operation Teapot at the Nevada Test Site and for thermonuclear designs during Operation Redwing at the Pacific Proving Ground. Satisfactory test results at last allowed the Livermore team to stake a plausible claim as weapon designers, if not yet to quiet all doubts.

Livermore's first weapon assignment, developing the warhead for the Navy's Regulus II missile, came in 1955. Although Regulus II went nowhere, the laboratory's warhead design became part of a gravity bomb for carrier-based aircraft. Livermore also joined forces with the Army to develop nuclear artillery shells. Notwithstanding such modest successes, Livermore remained a relatively marginal player in the nuclear weapon field through the mid-1950s.

Then in June 1957, the Navy decided to entrust the design and development of warheads for its new Polaris missiles to the second laboratory. Meeting the Polaris challenge has often been described as Livermore's coming of age. Two other large development projects also began officially in 1957. One was Project Pluto, an Air Force–backed effort to develop nuclear ramjets for unmanned aircraft. The other was Project Plowshare, aimed at using peaceful nuclear explosions for civil engineering purposes. Livermore clearly had turned the corner.

On March 31, 1958, Herbert York resigned as director of the Livermore laboratory, leaving for Washington to become the first Director of Defense Research and

Figure 2. This 1957 photograph shows the three men most responsible for organizing and shaping the new laboratory at Livermore earlier in the decade—from left to right, Ernest Lawrence, Edward Teller, and Herbert York.

Figure 3. Livermore bomb designers failed their first test. At the Nevada Test Site in 1953, a risky design fizzled, yielding this widely displayed photo of a bent tower.

Engineering. Five months later, on August 27, E. O. Lawrence died. His flourishing laboratory at Berkeley became the Lawrence Radiation Laboratory (LRL) on November 7. Livermore's status as a branch laboratory remained unchanged, although it too flourished. Under the leadership of Lawrence, Teller, and York, it had grown to 3,000 employees with an annual budget of $55 million. Edward Teller, the only one of the original founders who remained at Livermore, succeeded York as director.

Moratorium, 1958–61

A moratorium on nuclear weapons testing went into effect on November 1, 1958. It lasted almost three years, until September 1961, during which LRL Livermore saw three directors in rapid succession: Edward Teller (April 1958–June 1960), Harold Brown (July 1960–May 1961), and John Foster (June 1961–September 1965). Despite questions raised about the future of the laboratory—no one could be certain that nuclear testing would ever resume—Livermore continued its rapid growth. Employment increased by a thousand and the annual budget swelled to $78 million by fiscal year 1961.

Although the moratorium barred further testing of the Polaris warhead, deployment proceeded. In July 1960, the Navy accepted delivery of the first 16 warheads, and four months later, USS *George Washington*, the first Polaris submarine, went to sea on its first patrol with 16 armed missiles aboard. After the moratorium, the Polaris missile system provided the only full-scale operational test from launch through detonation ever conducted for a U.S. nuclear missile. On May 6, 1962, a submerged Polaris submarine launched a stockpile Polaris missile to explode a thousand miles away over the open ocean. Figure 4 shows a Polaris missile launch.

Figure 4. Polaris missile launched from a submerged submarine. Livermore came of age with its successful development of the warhead for the Polaris missile.

Polaris designers trusted their work despite changes from the designs field-tested before the moratorium and the implementation of substantial warhead upgrades. A major factor in promoting this trust was computer modeling of the extremely complex physical phenomena involved in nuclear explosions. Stimulated by their concern to understand the physics, bomb designers devised increasingly complex computer codes to model the physical behavior of nuclear weapons. That required state-of-the-art computers—the more powerful the better—one reason that Livermore has consistently pioneered the use of large, high-speed computers.

Computers also played a major role in hydrodynamic experiments at Site 300. Located 15 miles from Livermore across a low range of hills in a rough and thinly peopled corner of the San Joaquin Valley, the new test facility would become a center for nonnuclear experimentation to study warhead safety and reliability. Widening efforts to understand complex phenomena through experiment and computer modeling became a laboratory hallmark.

When the moratorium sharply curtailed nuclear weapons work, Project Pluto assumed a larger place in the Livermore laboratory's activities. It had begun in the mid-1950s as a joint project between the AEC and the Air Force to develop a nuclear ramjet engine. Livermore designed and built two Pluto test reactors—Tory II-A to demonstrate feasibility and Tory II-C as a realistic flight-engine prototype. The first model breezed through its 1961 trials at the Nevada Test Site. Three years later, the prototype engine passed its first tests with flying colors (Figure 5). But the Department of Defense concluded that it had no need for nuclear ramjets and canceled Project Pluto one week later.

Expansion and Change, 1961–71

Events of the 1960s contributed to reshaping Livermore's environment. The public became increasingly concerned about what President Eisenhower in his 1961 farewell address named the military–industrial complex; the 1963 Limited Nuclear Test Ban Treaty ended atmospheric testing; and later in the decade, protests against the war in Vietnam increased dramatically. As the decade progressed, the laboratory became the object of growing criticism from the University of California community and from outside as well. It was also the scene of active demonstrations. Livermore nonetheless sustained its steady growth under the directorships of John Foster and Michael May (October 1965–August 1971), adding another thousand to the workforce and $50 million to the budget.

During the 1960s, Livermore's nuclear weapons design work focused on strategic missiles. To improve the Navy's submarine-launched ballistic missile systems, the laboratory developed warheads for the second-generation Polaris and its successor, Poseidon. While the Air Force continued to rely heavily on Los Alamos for developing bombs and some missile warheads, it increasing assigned warhead development for its intercontinental ballistic missiles, notably Minuteman, to Livermore. By the end of the decade, most warheads in the nation's strategic nuclear weapons stockpile were Livermore designs.

Plowshare and the quest for peaceful nuclear explosions became one of Livermore's major programs in the 1960s. Initially, the program focused on large-scale earth-moving, or nuclear excavation, with the long-term goal of using nuclear explosions to excavate a new Atlantic–Pacific canal through Central America (Figure 6). Development problems, the 1963 test ban treaty, and growing doubts about the economic advantages of nuclear

Figure 5. Project Pluto aimed at developing a ramjet engine for the Air Force. Tory II-C, depicted here, was a prototype flight engine tested successfully in 1964.

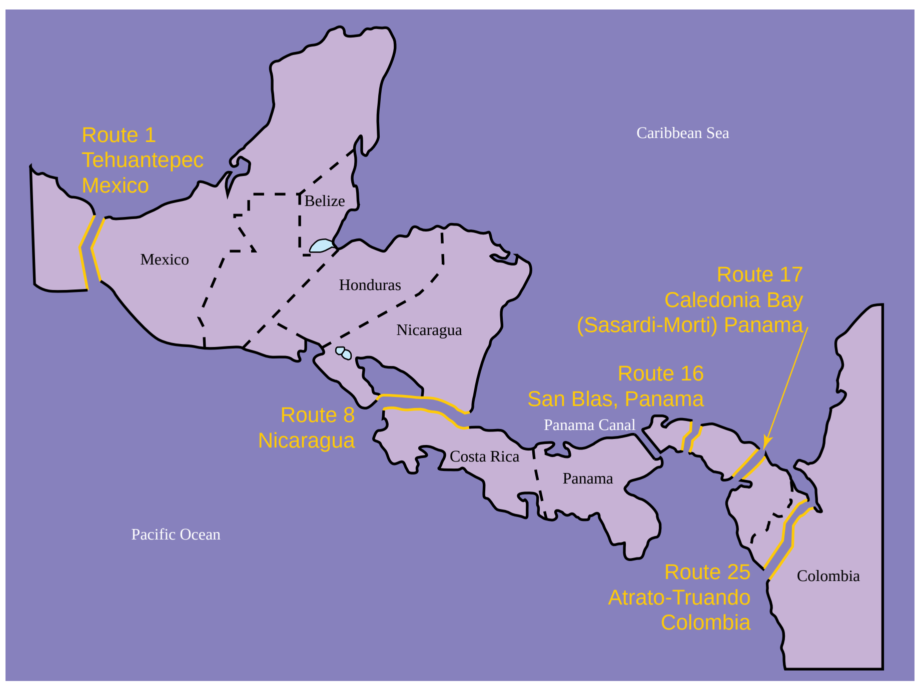


Figure 6. Project Plowshare sought to use peaceful nuclear explosions for civil engineering purposes. One proposal envisioned the nuclear excavation of a new Atlantic–Pacific canal in Central America. Some of the routes considered are shown in this map.

over conventional explosives as well as the lack of public acceptance of such work stifled that plan by the end of the decade.

A reoriented Plowshare program centered on underground engineering, using nuclear explosions to stimulate the flow of natural gas from tight rock formations. Ambiguous experimental results and the environmental legislation of the late 1960s proved obstacles too great to overcome. Like nuclear excavation, underground engineering began to look more costly than it was worth, and Plowshare faded away in the early 1970s.

One of Plowshare's major legacies was Livermore's biomedical research program, created largely in response to concerns about fallout and other radioactive hazards. Fallout had become a major public issue in the mid-1950s with the advent of thermonuclear weapons testing. Plowshare focused interest in the subject because nuclear explosions in populated areas for a variety of routine engineering tasks seemed to pose much more direct threats. The Biomedical Division was established in 1963 to investigate the effects of radionuclides on living systems. Ironically, it became itself a center of controversy when its first director, John Gofman, differed publicly with the AEC on the hazards of radioactive fallout.

The Mature Laboratory, 1971–88

In June 1971, Livermore and Berkeley parted company. Responding in part to campus protest, the Lawrence Radiation Laboratory divided into the Lawrence Berkeley Laboratory and the Lawrence Livermore Laboratory. In December, Roger Batzel became the Laboratory's sixth director, beginning a tenure of unprecedented length and extraordinary growth. From 1971 until 1988, when Batzel retired from the directorship, the Laboratory's budget rose steadily, from $129 million to $896 million, while its workforce climbed from 5,300 to 8,200.

Meanwhile, the Laboratory's federal patron underwent metamorphosis. The AEC split into the Nuclear Regulatory Commission (NRC) and the Energy Research and Development Administration (ERDA) in January 1975. ERDA proved short-lived, becoming within three years part of a new Department of Energy. Livermore's management remained with the University of California, and the Laboratory's growing status received validation of a sort in the 1980 congressional decision to make it a national laboratory. Henceforth, it would be known as Lawrence Livermore National Laboratory.

During the 1970s, Livermore weapons designers lost their near-monopoly on warheads for intercontinental ballistic missiles. Although Livermore was assigned the Air Force's MX/Peacekeeper missile warhead, Los Alamos was designated to develop the warhead for Trident, the third generation of submarine-launched ballistic missiles. By the 1960s, the Army was becoming LLNL's most consistent client, often for politically controversial systems. In 1968, work on

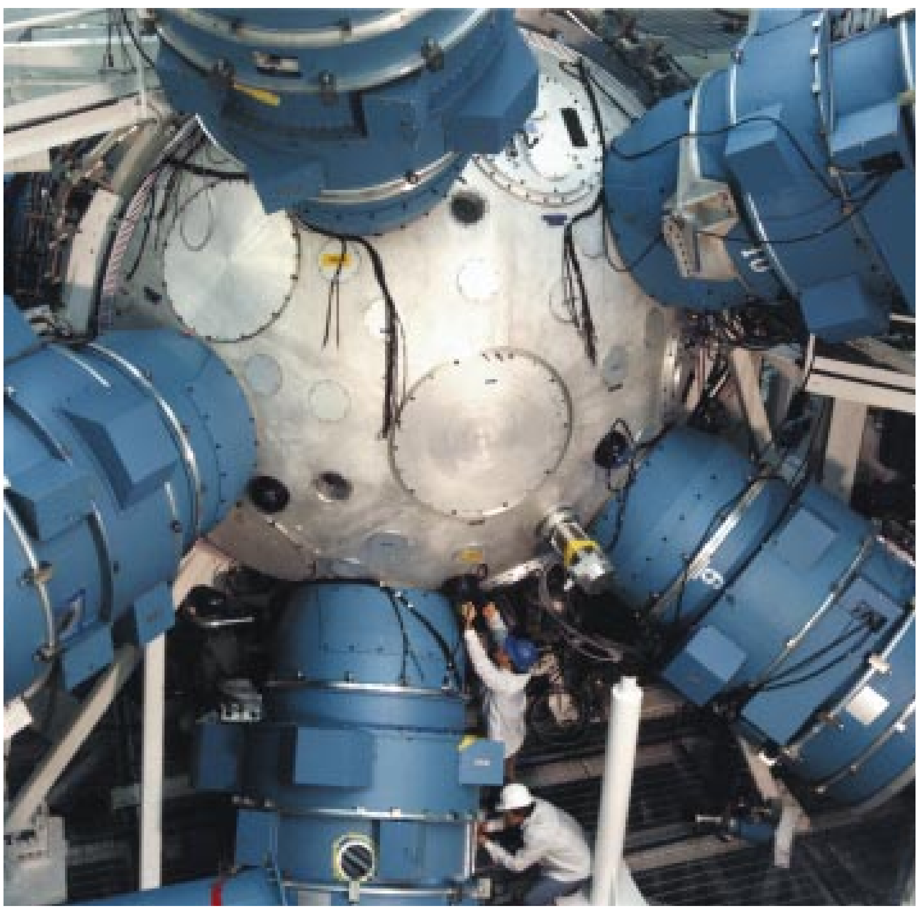


Figure 7. For a decade and a half, the Nova laser has allowed scientists at Livermore to conduct laboratory experiments on laser fusion and weapon physics. This photo shows an external view of the Nova target chamber, a 15-foot-diameter sphere where the system's 10 laser beams converge to heat the tiny experimental package in the center.

the warhead for the Spartan missile embroiled Livermore in the heated debate over antiballistic missile systems. Work in the late 1970s and into the 1980s on the ground-launched cruise missile and enhanced radiation warheads for such tactical weapon systems as the Lance missile and nuclear artillery raised questions about nuclear war fighting and policy.

Livermore entered still more controversial waters in the 1980s, when Laboratory studies suggested the feasibility of nuclear-powered x-ray lasers. Theoretically, such lasers could destroy ballistic missiles in flight and might thus become the backbone of a reliable defense, as Edward Teller and others vigorously argued. In 1983, President Reagan launched his so-called Star Wars program, the Strategic Defense Initiative, that committed the United States to developing the technology for such a defensive system. Although only one of many institutions studying directed-energy weapons and other potential antimissile and antisatellite weaponry under the program's aegis, Livermore remained closely identified with Star Wars, even after the end of the Cold War.

Magnetic fusion research at Livermore began to produce results by the mid-1970s. An experimental magnetic mirror machine (2XII-B) created a stably confined plasma at temperatures, densities, and times approximating those a power plant might need. Although not the most favored approach in the fusion research community, the magnetic mirror then stood second only to the tokamak concept of power generation through fusion. The AEC approved a large-scale scientific feasibility test of the magnetic mirror approach, the so-called Mirror Fusion Test Facility, but changing priorities scuttled the $350-million experiment, canceled in 1987 before ever operating and sold for scrap a decade later.

The invention of the laser offered another avenue toward the goal of controlled fusion. Beginning in the early 1970s, the Laboratory developed a series of neodymium-glass lasers, each more powerful than its predecessor, culminating in 1984 with the Nova system. For a decade and a half, Nova has provided unrivaled facilities to pursue the goal of practical laser fusion. For Livermore, high-power lasers had an additional advantage: the thermonuclear microexplosions they could generate allowed scientists to study weapon physics in the laboratory under controlled conditions (Figure 7). Nova's successor, the National Ignition Facility now under construction, promises to greatly expand both areas of research.

Lasers also offered a powerful new tool for isotope separation. Precisely tuned light can ionize a specific isotope in a mixture of vaporized isotopes, allowing it to be easily separated from the rest. Livermore's development of the process for atomic vapor laser isotope separation, more commonly known by its acronym, AVLIS, promised to provide a safe, cost-effective, and environmentally responsible means of producing uranium-235. The AVLIS process is currently undergoing commercialization.

Biomedical research at Livermore expanded greatly during the 1970s and 1980s. Carcinogenic and mutagenic chemicals were included with radionuclides as subjects of study, and the research program increasingly focused on understanding basic biological processes at every level from cell to organism. Livermore-devised instruments, notably the flow cytometer, made the Laboratory a world center for analytic cytology (Figure 8). When the Department of Energy, the AEC's successor, decided to support a massive effort to map the human genome and establish the sequence of every gene on human chromosomes, Livermore was well placed to develop the automated techniques that would make the project feasible.

Environmental research complemented biological studies. Precise sampling techniques and sophisticated computer modeling have allowed Livermore to play a growing role in environmental assessment, while other research has contributed to make cleanup techniques more effective.

Project Plowshare had included studies of several techniques for using nuclear explosions to extract oil or minerals from underground deposits too costly to reach by other means.

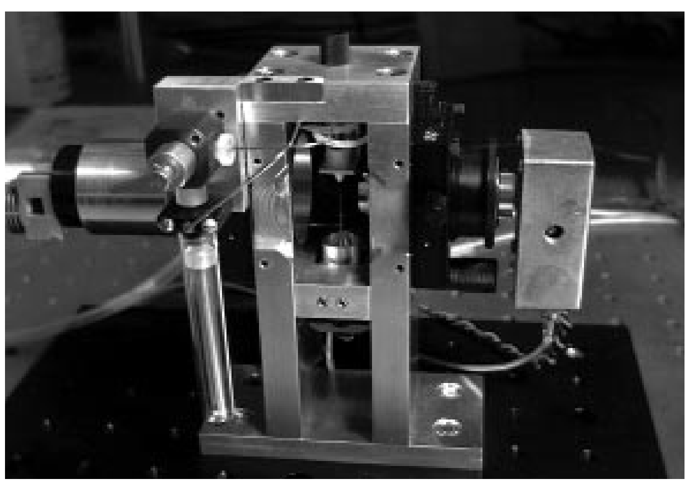


Figure 8. A demonstration model of Livermore's miniature flow cytometer. The pattern created by laser light reflected from a cell passing through the laser beam of this instrument reveals the cell's size and internal structure.

Although merely paper studies, they assumed new importance when the oil embargo of the early 1970s generated public concerns about the nation's dependence on foreign sources of energy. Nonnuclear energy became a major subject of Livermore study. In situ retorting of oil shale and coal gasification assumed a prominent part in Livermore's newly initiated and wide-ranging energy research program. Once again, however, changing national priorities brought the efforts to a standstill.

Era of Transition, 1988–Present

As an institution created to sustain and promote American science and technology for the Cold War, Lawrence Livermore faced a new world when the Cold War ended. Few foresaw that end as imminent when John Nuckolls became Livermore's seventh director in 1988. Average annual employment hovered around 8,000 into the early 1990s. The budget Nuckolls inherited in 1988, just under $900 million, rose to over $1 billion in fiscal year 1991. Both budget and workforce had declined significantly from those peak levels by April 1994, when Bruce Tarter succeeded Nuckolls as director.

In the immediate post–Cold War world, Livermore confronted a congressionally mandated moratorium on nuclear weapons testing, a vanishing Strategic Defense Initiative, and shrinking Department of Defense and DOE budgets. In response to the changing nature of perceived threats to national security, the Laboratory formed a new multidisciplinary directorate in 1992—Nonproliferation, Arms Control, and International Security.

Dismantling retired nuclear weapons and ensuring the safety and reliability of the remaining U.S. nuclear stockpile without nuclear testing displaced designing new weapons as the major national need of applied weapons experience and expertise. Testing or not, the Laboratory was still obliged to help preserve a viable nuclear weapons stockpile. As a key participant (along with Los Alamos and Sandia) in DOE's Stockpile Stewardship Program, Livermore is making major investments in advanced computation and nonnuclear testing. It is part of the Accelerated Strategic Computing Initiative to increase massively parallel computational power for virtual analysis of the aging stockpile verified by past nuclear test data and nonnuclear experiments. The National Ignition Facility is a keystone experimental facility in the Stockpile Stewardship Program, offering a means to obtain vitally needed data, maintain competence in weapon physics, and pursue inertial confinement fusion. Groundbreaking for this advanced laser program took place in 1997 (Figure 9).

After a period of uncertainty and reevaluation, Livermore has reaffirmed its central role as "a premiere applied-science national security laboratory." As further stated in the Laboratory's recently published strategic plan, *Creating the Laboratory's Future*, the Livermore's "primary mission is to ensure that the nation's nuclear weapons remain safe, secure, and reliable and to prevent the spread and use of nuclear weapons worldwide."

—Bart Hacker

Figure 9. On May 29, 1997, Secretary of Energy Federico Peña (center) joined Laboratory Director Bruce Tarter and Congresswoman Ellen Tauscher in breaking ground for the National Ignition Facility.

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Editor's Note: Bart Hacker recently left the staff of S&TR *to become the curator of Armed Forces History at the Smithsonian Institution in Washington, D.C. He did the research for this article while serving as Lawrence Livermore National Laboratory Historian, 1992–1996.*