Weapons Labs in a New World

A ban on nuclear weapons testing has left scientists at Los Alamos and Lawrence Livermore with a job nobody wants to think about

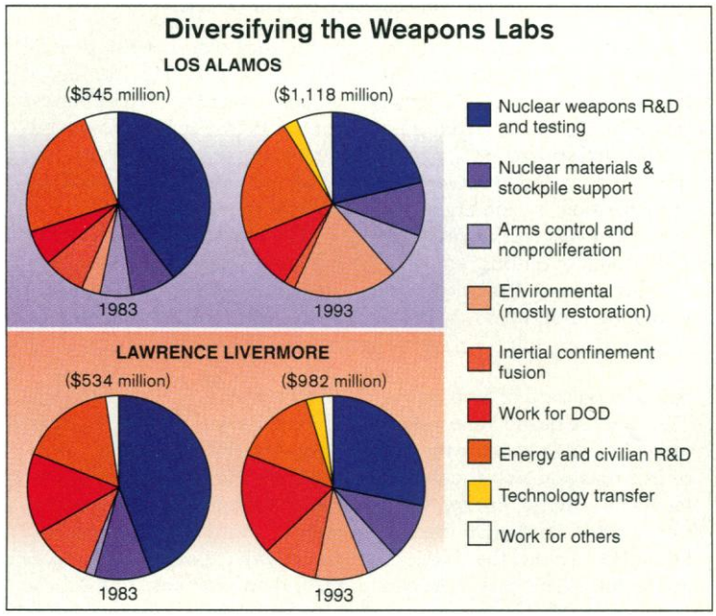
LOS ALAMOS, NEW MEXICO—In a sealed room, past three guards and a code-controlled security door within the Los Alamos National Laboratory, James Mercer-Smith sits and stares out over tinted glasses. The epitome of a nuclear weapons designer, he is an astrophysicist by training, a cold warrior by choice. A 10-year veteran of the lab, he is contemplating a future without new nuclear weapons, and he doesn't like what he sees: "Life is going to be very unpleasant," he predicts.

What has made Mercer-Smith so unhappy is a decision, announced by President Clinton on 3 July, that the United States would extend a year-long moratorium on nuclear weapons testing by another 15 months, with the hope of making the ban permanent. Unless some radical reshuffling of the geopolitical deck generates a wild card akin to a resurrected Soviet Union, the decision could mean that the United States may never again need to build or test nuclear weapons.

But that doesn't mean the scientists in the program will be tossed out onto the streets. Instead, for designers like Mercer-Smith, it portends a trip to the research equivalent of *Through the Looking Glass*—a world where scientists continue to go through the motions of bomb-building, but never actually make a device.

As laboratory officials now envision the next few decades, weapons designers at Los Alamos and its sister Department of Energy (DOE) weapons lab in California, Lawrence Livermore, will continue to design new bombs, mostly on computers. But these weapons will most likely never be tested, and never built. The physicists who write the hydrodynamic algorithms that simulate the behavior of nuclear material during an explosion won't know if their computer codes reflect reality, and the engineers and machinists won't know if the bombs they cut and weld will work. Mercer-Smith and his colleagues will become, in effect, the core of a cloistered nuclear priesthood, practicing the arcane technical rituals of an earlier culture. As depicted in a popular lab cartoon, weapons researchers have been placed in a box that reads, "Break glass in case of nuclear war."

All this has created a pervasive sense of unreality throughout Los Alamos and Lawrence Livermore, the two DOE labs that design and test the nation's nuclear arsenal. (A third facility in New Mexico, Sandia National Laboratory, does mostly engineering in its weapons program.) As Kent Johnson, Livermore's assistant associate director for advanced projects, puts it, "There is a policy decision not to do weapons testing. But the policy decision does not say [not to do] nuclear weapons development. Nor is there a moratorium against thinking about it."



Waning weapons. Spending on weapons research and testing represents a much smaller piece of each lab's budget than it did a decade ago, although absolute levels have stayed about the same.

Indeed, each lab still devotes about half of its overall budget to defense programs, about half of which is nuclear weapons research, design, and testing. This year DOE as a whole will spend nearly $2 billion on such work, despite the fact that no new bombs have been ordered—or are likely to be ordered for years. Next year the budget is expected to shrink by less than 10%.

The price of peace

Even so, peace has thrown into turmoil the lives of hundreds of physicists, computer scientists, and engineers now in the weapons program. Some will be retained to work on weapons-related projects as a hedge against an uncertain world. Others will seek out civilian-related programs at the labs, often in collaboration with outside companies. An increasing number will move into the rapidly growing fields of nonproliferation—keeping weapons out of the hands of those who don't have them—and counter-proliferation—trying to stamp out weapons programs in countries hostile to the United States. But many will simply leave, forced out either by downsizing or because they feel they can no longer do compelling science at the labs.

The post-cold war era had begun to change the face of the labs long before Clinton extended the testing moratorium. Since reaching a combined peak of about 3600 in 1986, the size of the staff at the two nuclear weapons programs has been halved, to some 900 scientists at each lab today. In the past year alone, funding for the Los Alamos program dropped 17%, and lab officials say they may not have hit bottom yet.

Not all the cuts were in the area of personnel. As much as possible was taken from budgets for hardware and facilities—a task made easier by the absence of tests last year, for the first time since 1961. But the individual weapons divisions within Los Alamos have nevertheless notified between 7% and 20% of their remaining scientists that their jobs are "at risk"—lab jargon for early warning of a layoff.

"Our worst days are with us right now," says John Immele, director of the Los Alamos weapons program. In November, about 800 employees at Los Alamos and another 800 at Lawrence Livermore (not all of them from the weapons programs) are expected to accept what is widely regarded as the "last and final offer" to exit gracefully—a special early retirement invitation for researchers at all the DOE laboratories run by the University of California.

The transition to peace is putting tremendous pressure on lab officials to think in new ways. "The president has made it clear that

Are Two Labs Too Many?

Why does the United States have two laboratories to design and test nuclear weapons? Although official explanations cite the value of competition in science, the real reason is that 40 years ago Edward Teller and Los Alamos National Laboratory founder Robert Oppenheimer had a falling out, and Teller moved to California to create a new weapons lab. His success in persuading the government to back his venture has resulted in decades of healthy rivalry between Los Alamos and Lawrence Livermore National Laboratory. With individual annual budgets of around $1 billion, both do much of the same sort of weapons work, from designing nuclear warheads to getting rid of them, although each has its specialties.

The two labs thrived in the cold war period, but some are now asking whether the duplication is a luxury in the 1990s. Key political figures, from White House science adviser John Gibbons to Representative George Brown (D–CA), chairman of the House science committee, have called for a consolidation of the labs' weapons functions, and Brown has introduced a bill that would do just that. Even those at the labs seem resigned to the end of the days of vigorous, well-funded dual programs.

Livermore officials and some members of the California congressional delegation prefer to keep both operations going, despite the gloomy financial prospects, for a good reason—any merger is likely to leave Livermore the loser. Located half an hour east of the San Francisco Bay area, Livermore has the disadvantage of being situated among environmentally sensitive—and politically active—neighbors who favor less work on weapons. As Kent Johnson, assistant associate director for advanced projects, puts it, "At Livermore we feel pretty confident that if the weapons program were to be consolidated into one laboratory, that laboratory would be Los Alamos."

But lab officials argue that the nation still benefits from the competition between the two labs. "Try as we may, there has been a long history of blunders," says Jeff Kass, a Livermore official who's planning the Department of Energy's (DOE) Complex-21 program to assemble a bomb factory for the future. He offers a self-effacing example: At one point, the labs were worried that if a plane crashed with a bomb aboard, "we might have plutonium melting all over the runway." So Kass and his colleagues came up with a new material to contain the plutonium. However, when Los Alamos scientists reviewed the choice, they found the material was so brittle that it could fracture in a crash. "I thought I had this brilliant alloy," Kass says, "but I had forgotten about impact."

Few dispute the merits of such outside review in a perfect world, but politics and budget cuts are working against the weapons labs. The Department of Energy (DOE) is already planning to move most of the plutonium processing work at Livermore to Los Alamos (or, if the Nevada congressional delegation gets its way, to the Nevada Test Site), and other weapons manufacturing facilities may follow over the next several years. Jim Courter, the chairman of the federal commission that in July targeted specific military bases for closure, has recommended that a similar commission be assembled for the DOE weapons labs.

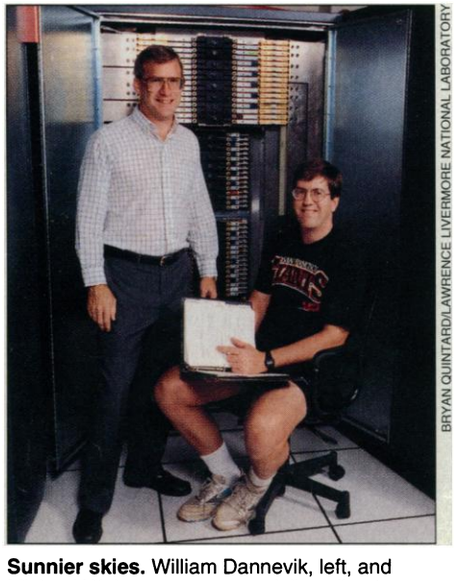
Last month, the Senate approved language similar to Brown's bill that did not require consolidation but that urged the laboratories to move more quickly into nonweapons work. But the trend is clear: With Brown and Gibbons continuing to agitate for the idea and with even greater cuts looming, the end of separate-but-equal weapons labs seems inevitable.

–C.A.

he wants a safe, secure, and reliable deterrent force," says Siegfried Hecker, since 1986 the director of Los Alamos. "But he said do it without testing. How long can we do this? We're not sure, but we're going to give it our best shot. The folks here feel greatly the responsibility of nuclear weapons. We helped put [weapons] here, and they're still our job. We are not done."

For Hecker and John Nuckolls, his counterpart at Livermore, the challenge is to preserve the weapons-related skills of their scientists even though they cannot directly exercise them. "It's harder and more expensive to do our job without testing than it is with testing," explains Hecker. Non-nuclear experiments offer only a glimpse of the energies of a real nuclear explosion, yet they are all that the lab directors can offer their weapons researchers.

This year, the labs are planning to spend $153 million developing alternatives to nuclear testing. A central component of this effort is a program known as Above Ground Experiments (AGEX). AGEX I uses conventional high-explosives to simulate the beginnings of a bomb burst, where a non-nuclear warhead detonates to compress nuclear materials to the point of fission. A companion program, AGEX II, simulates the conditions of fission itself—and, at much higher energies, fusion—by using powerful electric pulses or lasers to compress materials until they act like fluids, much as nuclear materials do as they are imploded in the detonation of a bomb. At Lawrence Livermore, researchers can achieve fusion on a small scale by compressing tiny hydrogen/deuterium pellets with the $300 million Nova laser, briefly bringing a pressure of a billion atmospheres to a millimeter spot, and they can slowly squeeze other materials to millions of atmospheres with the diamond-tipped jaws of a high-tech vise known as a diamond anvil.



BRYAN QUINTARD/LAWRENCE LIVERMORE NATIONAL LABORATORY

Sunnier skies. William Dannevik, left, and Michael Wehner are now modeling climate.

Finding civilian uses

A second group of scientists are officially staying in the weapons programs but shifting their research to non-nuclear projects, funded largely by other lab programs. Lab officials call this "intellectual diversification": If weapons scientists can't work on weapons, let them do something else to retain their skills in case they are needed again for military work.

Los Alamos weapons physicist Rickey Faehl saw the writing on the wall for the nuclear weapons program in 1991. He joined the lab because of the scientific challenge, and he thought improving the nuclear deterrent was the best way to ensure world peace. Repelled by the prospect of simply going through the motions of weapons research, Faehl went to the library to see if industry was doing anything in his specialty—plasma physics—and found companies exploring the use of plasmas to embed ions into materi-

als to make them harder and more resistant to corrosion.

A year later, he and a team of other Los Alamos weapons and nonweapons researchers struck a deal with General Motors (GM) to use a mothballed chamber from a canceled lab fusion experiment to investigate a technique the automaker could use to fabricate ultrahard manufacturing tools. Los Alamos had equipment that was bigger and more expensive than anything a company would consider on its own, says Joe Mantese, head of the materials section in GM's electrical and electronic research department, and the lab's researchers could pursue research leads that wouldn't normally fit with the company's focus on its bottom line. "They happened to have this off-the-shelf machine that could do stuff that would be really costly for us to do," he says. "Everything just clicked." The technology still hasn't made it to the production line, but GM likes it well enough to keep the money flowing.


LOS ALAMOS

On target. Merri Wood is sticking with designing weapons.

Lawrence Livermore physicists Michael Wehner and William Dannevik have also made an in-house switch to the civilian sector. Two years ago Wehner was designing the fission bombs that set off the main fusion cores in a hydrogen bomb and Dannevik was designing the fusion cores themselves. Today, although they are still officially in the weapons program, the two scientists spend their time collaborating on a global climate modeling project. They say that, improbable as it may seem, modeling nuclear explosions uses many of the same scientific skills as modeling the climate—hydrodynamics, turbulent flow, and radiative transfer. "They're surprisingly similar problems," Wehner says. "Both are multidisciplinary, and both require a stable computing environment."

No one knows, however, if working on climate change research will really keep their bomb-building skills alive. "We're faced with the question of how we'll feed this [climate modeling] knowledge back into the weapons community," says Dannevik. Adds Wehner, "It's not an easy thing to do—you're really trying to balance two very different careers."

Some weapons researchers are downright skeptical about the whole notion of intellectual diversification. "From a hard-core design standpoint, it's hard to much more than shake your head over this," says Los Alamos weapons designer Merri Wood, who's sticking with weapons research. "It's a double-edged sword. There's not much about secondary [the fusion part of a warhead] design in particular that has much to do with anything in industry, really." Likewise, she says, industrial research isn't likely to keep her weapons skills sharp. "If I were, for example, working in the oil recovery technology program, I'd know how to run a hydrodynamic computer program, but it has nothing to do with nuclear weapons."

Antiproliferation proliferates

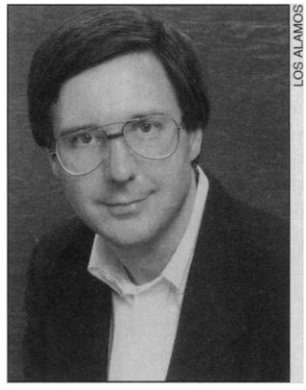
There is one area for which the weapons researchers' skills are particularly well-suited: ensuring that other people don't make weapons. Nonproliferation and counter-proliferation together now account for about 10% of each lab's billion-dollar budget, and the percentage is expected to rise to as much as 25% over the next few years.

The programs cover everything from intelligence to high technology. Weapons lab scientists helped to inspect what were thought to be weapons factories in Iraq—some had even raised the issue in the first place. Some lab researchers have developed sensing equipment to detect the chemical or radioactive signature of weapons remotely—even, perhaps, from space. Still others are paid just to think.

"Ameena Iqbal" is a young weapons designer at Los Alamos who asks that her real name not be used. She comes from a developing Asian country, and she is afraid that if those in her country who seek nuclear weapons were to know that she designs them at Los Alamos, she or her family might be in danger. At Los Alamos, designers like Iqbal are paid essentially to pretend to be Third World nuclear scientists. Provided with intelligence and import-export data on certain suspect countries, they are asked how they would build a bomb, what type it would be, and what traces it would leave. "I know how important it is for a lot of these countries to have a device—a bomb—of their own," she says. "It's a matter of national pride."

Putting weapons to bed

The end of the cold war may have even expanded opportunities for one group of weapons scientists: those who must dispose of the plutonium cores of obsolete bombs and ensure that the weapons remaining in the stockpile will work if they are ever needed. Among the esoteric technologies Los Alamos is exploring to get rid of unneeded plutonium is accelerator-based transmutation—using powerful particle beams to turn plutonium into some less dangerous element. Evoking the alchemist's dream, the technique is intended to make plutonium safe for disposal, perhaps generating some energy in the process. It's still considered a long shot—critics point out, for example, that a proposal to burn the transmuted material in commercial reactors would require a whole new class of reactor—but alternatives are in short supply.


LOS ALAMOS

Cold warrior. James Mercer-Smith dislikes what he sees.

As a Los Alamos plutonium chemist, Joe Martz is thriving on peacetime work. A second-generation lab scientist—his father was a statistician—he's a believer who plans to stay. "It's something of a paradox—there's this assumption that with the end of the cold war our responsibilities are declining," he says. "In fact, the reverse is true."

One of Martz's jobs is thinking up ways to find out if the weapons in the stockpile will still work half a century after they were built. "There's no better job security than in the storage of plutonium," he says. "Its half-life is 25,000 years."

The closing of plutonium fabrication facilities at the Rocky Flats production plant in Colorado has meant more work for Los Alamos and Lawrence Livermore. Although there is no need for more plutonium, some weapons may eventually require remanufacturing (to fit new delivery devices, for example), and DOE officials are reluctant to shut down plutonium processing facilities and lose the skills they spawned. Instead, they're planning a much smaller plutonium bomb factory complex with the possibility of centering much of the production at one of the two large defense labs.

Testers without tests

Perhaps the group of scientists most directly affected by the cessation of nuclear testing are those who conduct the tests themselves. Some of them will be involved in putting the testing program on stand-by: DOE's proposed budget for fiscal year 1994 includes $150 million to "maintain the infrastructure" at the Nevada Test Site, and $125 million to "maintain the capability to quickly resume testing." But without any actual tests, prospects are limited for the engineers, technicians, and scientists who designed the sensors that take a brief snapshot of a nuclear explosion before being vaporized. "I'm in charge of the *Titanic*," says Lawrence Livermore associate director Dick Fortner, who runs the testing program. "Now I have to steer it into open waters." Some of these scientists are now designing sensors for above-ground tests, and others are working on space-borne nuclear explosion detectors

for arms control. Fortner is confident that some of his group's skills can be applied in fields ranging from optical electronics to environmental clean-up. Nevertheless, "I basically told 15% of my group that their job this year was to find a new job," he says.

"Now we're being told, no thank you, we don't need you anymore."

—Merri Wood

At Los Alamos, some of the engineers and scientists in the testing program are hoping for a future in environmental monitoring. They are converting monitors once placed downwind of an explosion at the Nevada Test Site into what they hope will be a web of unattended environmental sensors around the world. The proposed network, known as GEONET, would connect thousands of the lunar lander-like sensors by satellite. "We need to be doing exciting work like this to keep people interested," says Jake Pera, testing group leader. "If we're not moving out and distributing these things around over the next 4 years, the program will die."

But not every manager will succeed in saving his or her program. Alan Spero had been a weapons designer and the deputy director of Lawrence Livermore's "A" division, which designs H-bombs, until he left in July to become a division leader in the analysis division, focusing on proliferation issues. Spero divides his former fellow designers into two categories: those who are "product-oriented" (there to build bombs), and those who are interested in physics. "Product-oriented people tend to feel the loss, and they're moving out," he says. "People are clearly getting the message that nobody cares anymore about what they did."

For Wood, the government's decision to stop testing has left her with a feeling of betrayal. "I, and others who have been here a lot longer than I have, have committed our lives to supporting national defense," she says. "Now we're being told, 'No thank you, we don't need you anymore.'" Many scientists say that the real effect of Clinton's decision won't be felt for many years. "In 10 years the nation won't have anybody with direct experience anymore," Spero says. And that can't be good for the program, adds Mercer-Smith: "Any discipline that stops doing advanced development is dead. The question is, 'How much does it have to stink before you bury it?'"

Joe Greene doesn't want to find out. Greene, 57, spent 30 years at Los Alamos in various parts of the weapons testing program, but the prospect of ending his career amid increased bureaucracy and declining quality was too much to bear. He's taking the early retirement offer in November, before the full implications of the lab's forced non-nuclear approach to nuclear weapons research hits home. "Many of my friends in the testing program are going through hell, trying to maintain a sense of validity and their professional standards," he says. Another who is leaving is Stephen Kiergan, a 53-year-old Lawrence Livermore designer who hopes to fulfill a lifelong dream of teaching high school physics. Weapons designers "are facing a lot of turmoil" in the next few years, he says. "I had to ask myself if I wanted to go through all that, only to retire a few years later."

A future without bombs

Indeed, the turmoil facing the weapons program seems likely to persist for several years. "I can't imagine a scenario that could get us back into testing," says Lawrence Livermore weapons designer Joe Sefcik. "I'm pretty much resigned to ending my career without testing."

Working on that assumption, lab officials are frantically trying to preserve knowledge of how to design a nuclear weapon before any more researchers like Greene and Kiergan retire or walk away. Unfortunately, little documentation exists on how to design, make, and test nuclear weapons. "Most of the critical information is transmitted by oral tradition," says Mercer-Smith. As a result, he and some of his colleagues may be spending the next few years madly typing as they try to record how to build bombs before they forget.

Why don't they just lock their desks and walk away? The answer lies deep in the psyches of those who have devoted their lives to what they believe is a noble calling. "Sure nuclear war is lousy," says Wood, "but so is conventional war. We have shown considerable restraint over the past 40 years. Why should people hypothesize that we'll show no restraint in the future?"

In the end, says Mercer-Smith, a moratorium on testing doesn't change the reason he came to Los Alamos. "If you really think you're here to save the world, it doesn't matter if you're having a good time or not," he says. "I know we're going to have a bad time, but we will still be here to save the world."

–Christopher Anderson

SUPERCONDUCTING SUPER COLLIDER

Senate Vote Lifts Prospects for SSC

Scientists and workers at the site of the partially completed Superconducting Super Collider (SSC) clustered around television sets last week, watching the Senate decide the fate of their project. They let out a big cheer when the final vote came in: 57 to 42 to keep the project alive for at least another year. The vote overturned a death sentence imposed by the House of Representatives in June. And the relatively large margin of victory gives the project a good chance of surviving the congressional budget-cutting this year when members of the House and Senate meet in conference to iron out their differences on the SSC and other Department of Energy (DOE) projects.

Most construction remains halted at the Waxahachie, Texas, site of the SSC, however, and it is not likely to resume until the project's 1994 funding is assured, SSC officials say. Hundreds of lab employees were laid off and tunnel-digging suspended (*Science*, 30 July, p. 539) after the House voted earlier this year to kill the project, and the Texas legislature decided to withhold its annual $79 million contribution until the political picture cleared. Texas has still not released those funds, and does not plan to revisit the issue until a meeting on 20 October of the Texas National Accelerator Laboratory Commission. "At the moment, we're still in a holding pattern," says lab spokesman Russ Wylie. Lab officials estimate that the delay could cost several million dollars.

The project's fate now rests in the hands of a House-Senate conference committee, which will be made up of the congressional leadership and members of the appropriations committee—a group that favors building the SSC. Representative Jim Slattery (D–KS), a vocal opponent, circulated a letter last month calling for the conference committee to include members opposed to the SSC, but his petition was signed by fewer than half of the 280 representatives who voted no in June.

Congressional staffers say that the conference committee could meet as early as this week, although no final decision had been made at press time. DOE officials expect the project to emerge from the conference committee with the amount—$640 million—the president requested and the Senate approved. Slattery and other House opponents such as Representative Sherwood Boehlert (R–NY) are not yet willing to call it quits, however. They will attempt to defeat the entire $22 billion energy and water appropriations bill (which includes the SSC) when it is brought to the House floor after the conference. "We want to keep the pressure on the Speaker [of the House] to abide by the House's position" on the SSC, as reflected by its June vote, says Slattery aide Joel Shapiro. He concedes, however, that it may be difficult to get a majority of the House to reject the bill simply to kill the SSC.

–Christopher Anderson