New Mission for the National Labs

As a testing moratorium takes hold, the future of the weapons laboratories may lie in a $3 billion package of science projects meant to keep the arsenal reliable—and weapons-designing talents sharp

When President Clinton declared an end to all nuclear testing a month ago, he offered the nation's three weapons laboratories an enormous, expensive pacifier—a $3 billion package of scientific projects to replace testing. The labs swallowed hard, choked back their conviction that explosive testing is the best and cheapest means of ensuring the reliability of the nation's nuclear stockpile, and took the bait. The lab directors duly issued statements embracing the test ban—providing the new program materializes.

Now, as the Lawrence Livermore, Los Alamos, and Sandia national laboratories plan the federal Science-Based Stockpile Stewardship Program, scientists inside and outside the government are hailing the effort as a rebirth for basic research at the federal labs. The Department of Energy's (DOE's) request for core nuclear weapons research in fiscal year 1996, now lumped into a single line item dubbed stockpile stewardship, is $1.6 billion. That is $194 million above last year's figure—and would be the first real increase in 4 years, if Congress approves it. With the new investments, "the quality of good scientific thinking at the labs is going to be as high as it's ever been," says Sidney Drell, deputy director of the Stanford Linear Accelerator Center and chair of last year's report on stockpile stewardship by the Jasons, the body of senior scientists who advise the government on defense issues. "I personally see a renaissance in this."

"If 'renaissance' means rising budgets and an expanding laboratory [over the long term], that isn't going to happen," cautions Mike Burns, project leader of Los Alamos's new Dual-Axis Radiographic Hydrotest Facility (DARHT), a stockpile stewardship project that will generate flash x-ray images of shock waves traveling through exploding materials. "But here's a focus. Here's something to do long-term planning around. Here's a new mission. If that's a renaissance, then so be it."

The stockpile stewardship concept has been in the works for 2 years now, the brainchild of Vic Reis, DOE's assistant secretary for defense programs, who was looking for a way to wean the labs from nuclear testing. But it received a major boost last month with President Clinton's test ban announcement and another last week, when the White House identified stockpile stewardship as the rationale for keeping all three nuclear weapons labs open. The program should see its first infusion of funds when the new fiscal year begins next month—if Congress has completed work on the budget by then.

The goal is to replace the trial and error of explosive testing with a more detailed and fundamental understanding of how nuclear weapons work. That knowledge, say planners, should help them predict changes in the weapons' performance and the risk of accidental detonation as they age. But going beyond passive stewardship, the program is also meant to preserve—even refine—the science of weapons design, in case the need for new weapons arises.

"Before the end of nuclear testing, computing and above-ground [experiments] only had to be good enough to get us to the Nevada Test Site with a reasonable chance of success," explains John Immele, the head of nuclear weapons research at Los Alamos. "Now we have to get the right answers without the nuclear tests." Adds Roger Fisher, DOE's deputy assistant secretary for defense research and development, who is coordinating the program, "If indeed we are going to retain confidence in national security devices that are so deeply rooted in and associated with science, we're going to have to increase basic scientific understanding of the weapons."

THE TOOLS OF STOCKPILE STEWARDSHIP

Facility	Site	Cost	Purpose
National Ignition Facility (NIF)	Livermore	$1.1 billion	A 1.8-megajoule, 192-beam laser that would trigger tiny nuclear explosions.
Accelerated Strategic Computing Initiative (ASCI)	Livermore, Los Alamos, Sandia	$910 million	Hardware and software that would boost processing, storage, and communication speed by a million.
Dual-Axis Radiographic Hydrotest Facility (DARHT)	Los Alamos	$123.8 million	An indoor high-explosives facility to simulate the first-stage detonation of a nuclear weapon.
Advanced Hydrotest Facility	Los Alamos	$400 million	A follow-on to DARHT, which would improve the resolution of x-ray flash photos of explosions.
Contained Firing Facility	Livermore	$48.5 million	An upgrade of high-explosives lab at test site near Tracy, California.
Atlas Facility	Los Alamos	$43 million	A pulsed-power machine designed to simulate the implosion of a nuclear weapon trigger.
Jupiter X-Ray Simulation Facility	Sandia	$240 million	A pulsed-power machine designed to study the effects of nuclear explosions on electronics and weapon components.
Los Alamos Neutron Scattering Center (LANSCE)	Los Alamos	$35 million	An upgrade of neutron scattering facility for materials science studies of weapons components.

Walking the line

To that end, Fisher and his colleagues are planning projects as diverse as DARHT at Los Alamos and a similar but smaller Flash X-ray facility at Lawrence Livermore, a $1.1 billion laser fusion project at Livermore called the National Ignition Facility (NIF), an enormous supercomputing project, and an upgraded proton accelerator at Los Alamos, to name a few (see table). Most of these projects have not yet been fully funded, and the House and Senate are at odds over next year's funding levels for several of them, including NIF (*Science*, 29 September, p. 1810). But if the projects do go forward, planners expect to be able to parlay the results of experiments far removed from actual weapons—small, conventional blasts and laser fusion tests—into simulation codes, running on high-performance computers, that can model megaton-sized nuclear blasts.

They are also counting on the program to make sure the laboratories continue to be well supplied with scientific talent, even when they can no longer offer the challenge of designing and fielding new weapons. An unprecedented opportunity to do basic research at the laboratories should provide the lure, say some observers. "During the Cold War, there was always some emergency: You had to get this damned warhead ready for the Poseidon missile; it had to fit; there was a deadline. Science didn't hold center stage," recalls Will Happer, a Princeton University physicist and former head of DOE's office of energy research. "Now they'll get the opportunity to go about their business in a more leisurely, scientific way." Adds Fisher, "It's not unlimited science, but ... it's pretty broad."

Lab managers are also speaking enthusiastically about opening their facilities to outside users, something that was rare to nonexistent during the Cold War. That, they say, will make the labs a more appealing place to work and will boost the quality of the science done there. Explains Phil Goldstone, head of science and technology for Los Alamos's nuclear weapons program, "Interactions with the outside community are how you remain technically vital."

Not everyone is acclaiming the program, however. Some skeptics view it as an end run around the comprehensive test ban treaty currently being negotiated—a way to design new weapons on the sly, something the treaty is designed to stop. And some researchers think the program may have been oversold—either to basic researchers or the military. On the one hand is Grant Mathews, an astrophysicist at Notre Dame University who recently left Livermore. "I think stockpile stewardship doesn't have much of a basic science application," says Mathews. "Everybody is getting hit right now. The national labs are going to have to become leaner and more focused on defense." On the other hand is Seymour Sack, a senior weapons scientist at Livermore, who worries that NIF will be "worse than worthless" for stockpile stewardship, although he does think it will lead to excellent physics.

Such charges are forcing laboratory and DOE officials to walk a tightrope, stressing the value of the program to national defense even as they try to build enthusiasm among basic researchers. "The concern of the DOD [Department of Defense] has been that this is a bunch of expensive facilities that are not really addressing their needs," Immele concedes. "We cannot have a sandbox full of tools that are not really useful to the stockpile." Even Drell, who badly wants a new basic research thrust at the laboratories, agrees. "There would be nothing easier than to build a NIF and have people go out and play, and not contribute to stewardship," he says. "That's a management challenge—to strike that balance."

Dazzling possibilities?

NIF will present that challenge in stark terms. When the laser, the world's biggest, is completed in 2002, it will generate 1.8 megajoules of energy, which its 192 laser beams can deliver to a single tiny target. By heating and compressing pellets of hydrogen isotopes, NIF will trigger pulses of thermonuclear fusion, providing a model system for weapons scientists and energy researchers. But the conditions of intense heat and pressure in these tiny implosions are also reminiscent of

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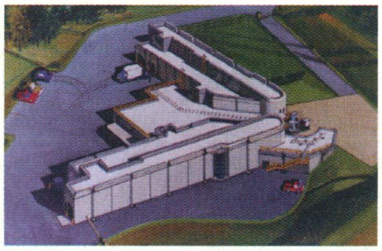

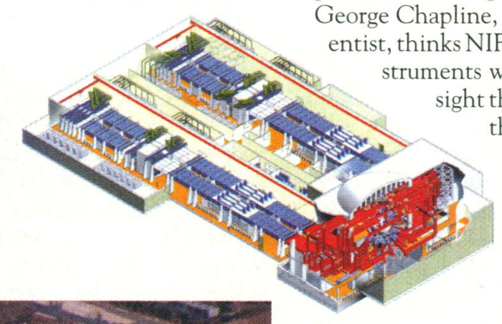

LAWRENCE LIVERMORE NAT'L LAB

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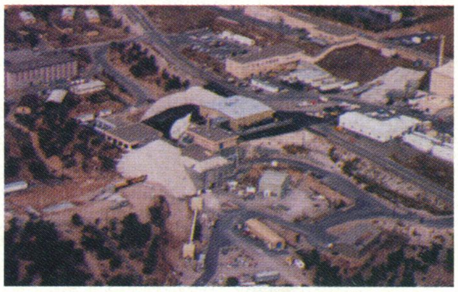


Rich harvest for the labs. Some of the stockpile stewardship facilities, including Los Alamos's LANSCE and DARHT *(above and left)* and Livermore's NIF *(right)*.

those in supernovas and stars, and NIF will be a powerful research tool for astrophysicists, says Joseph Kilkenny, Livermore's program leader for target physics.

University of Arizona astronomer David Arnett got a foretaste of that last year, when he modeled exploding stars on the Nova laser, NIF's predecessor at Livermore. Physicists at the laboratory had read Arnett's astrophysics papers on the fluidlike flows of matter within supernovas; realizing he was tackling the same kinds of problems they were facing in nuclear weapons design, they invited him to experiment on Nova. There he and a doctoral student, Jave Kane, are creating conditions similar to those in a supernova in a target material.

The subject matter of the experiment isn't its only pioneering aspect. "It's an interesting challenge from the sociology-of-science perspective," Arnett notes. "In the past, [lab managers] ... have made it fairly difficult to do basic research. They've talked about it as long as I can remember, but when it came down to the crunch, it was the exception rather than the rule when it worked well. But they're restructuring now." Livermore officials say they have been encouraging other outside scientists to follow in Arnett's footsteps, hoping to build up interest in NIF. This year, almost 10% of Nova's 1200 to 1400 laser shots will be conducted by universities.

But lab scientists differ over whether NIF will be as valuable to weaponeers as to basic researchers. A study on stockpile surveillance put together by the labs declares that NIF's tiny fusion bursts will be vital to studying how the performance of a bomb's hydrogen isotope–filled "secondary"—its fusion powerhouse—degrades as it ages. Indeed, George Chapline, a Livermore weapons scientist, thinks NIF's advanced diagnostic instruments will yield such detailed insight that the laser "will be better than testing." Others aren't so sure. Ray Kidder, a Livermore scientist who was a pioneer in laser fusion, says NIF will benefit the weapons program indirectly, "by providing a challenging facility for research in the kind of physics that happens to be the physics of nuclear weapons." But for stockpile stewardship, says Kidder, "it's been heavily oversold."

ASCIng for speed

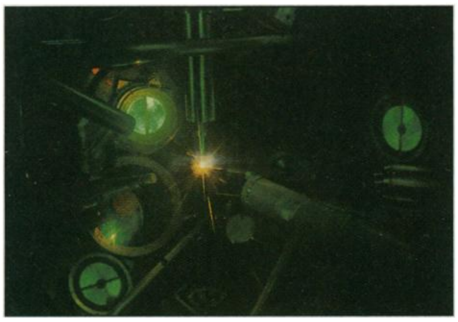
Either way, extrapolating from experiments like those on NIF to full-scale weapons will take copious computing power, and that's where another project in the stockpile stewardship pantheon, the Accelerated Strategic Computing Initiative (ASCI), comes in. ASCI kicked off on 7 September, when DOE announced a 1-year, $45 million collaboration with Intel Corp. to build a supercomputer 10 times faster than any in existence by linking 9000 of Intel's forthcoming P6 or Pentium Pro microprocessors. But that will be only the first step. If Congress approves DOE's request, ASCI would spend $910 million by 2002 in pursuit of computers that will surpass today's systems by a factor of a million in processing speed and in storage capacity.

All three labs will work on operating systems and applications software. And a full quarter of ASCI funds will be dedicated to the Superlab program, an effort to build a computer network with data transfer rates a million times higher than those of the fastest existing networks to link Livermore, Los Alamos, and Sandia into a "virtual laboratory." The object is to store, share, and analyze the vast quantities of data collected from the 1027 nuclear tests conducted since 1945, from 50 years of research at the labs, and from the new experiments conducted under the guise of stockpile stewardship. All this data and processing power, say planners, should enable scientists to create virtual nuclear explosions that will model the performance of stored, aging weapons.

Outside the laboratories, the project will also provide a spur to technological development, says David Nowak, ASCI's leader at Livermore, who notes that the hardware and software will be developed with universities as well as industry. Sidney Karin, director of the San Diego Supercomputing Center, one of four civilian supercomputing centers funded by the National Science Foundation, thinks ASCI's sheer size guarantees that it will shape cutting-edge computer technologies, among them the massively parallel computing that the NSF centers have pursued. "When something as large as the ASCI program comes along and says, 'We need this technology,' that's an enormous endorsement of the activities of our center," says Karin. "This will be significant over time, very, very significant."

Drell adds that the computer databases will offer basic researchers a "treasure-trove" of data on such topics as how metals like plutonium behave under the extreme conditions of heat and density generated in a nuclear blast. Just how much of the data they will be able to examine is still in question, however; a classification review of the nuclear weapons databases is now under way.

Nondefense users will also be able to unleash the computing power developed under ASCI on their own data sets, promises Hassan Dayem, director of computing at Los Alamos, in applications ranging from predicting the spread of forest fires to modeling the spread of AIDS or influenza to designing new drugs. "The only way you know something like this works is when it works on a wide class of problems," explains Nowak. "And if that is the case, it'll work on the [nuclear] stockpile."



LAWRENCE LIVERMORE NAT'L LAB

Bomb in microcosm? Laser beams implode a target at the Nova laser, NIF's predecessor.

But William Dannevik, leader of Livermore's climate system modeling group, isn't sure there will be much time for nondefense work in the computing program. His group's complex models of global warming could be used to "put the [ASCI] machines through their paces," he says. But Dannevik doesn't expect to get enough computer time to refine his models. "ASCI will be extremely focused on moving stockpile stewardship from a test-center program to a computing-centered program," he says. "I just don't think there will be time for unrelated activities."

Other facilities under the stockpile stewardship banner will have to walk the same fine line between basic research and defense work. Los Alamos will spend $35 million to upgrade the Los Alamos Neutron Scattering Center (LANSCE), which harnesses the beam from a proton accelerator to produce a shower of neutrons. The neutron flux will let defense scientists look into aging nuclear weapon components without destroying them. Los Alamos's Goldstone expects the upgraded neutron source to be available as well to outside researchers who want to examine anything from automobile parts to biomolecules.

LANSCE has done double duty in the past, and critics have complained that civilian and defense researchers had to joust for machine time. But Drell thinks that as new weapons development ends, straight weapons research will take up less time. At that point, he says, "bringing in the outside community will be essential for LANSCE. ... Nothing would be worse than building a machine that nobody wants."

Even the hydrotest facilities at Los Alamos and at Livermore's test site in California's San Joaquin Valley could have nondefense spin-offs, say their managers. Hydrotests explode model warheads, made of high explosives wrapped around a core of a heavy metal like depleted uranium, to simulate the implosion that is the first step in triggering a nuclear explosion. Flash x-ray machines then capture images of the implosion in three dimensions. That imaging capability could also be put to use in industrial research—studying the response of a jet engine that has ingested birds, for example. And the control systems being developed for the Los Alamos facility's electron beams, which create the pulses of x-rays that image the explosion, might be adapted to other accelerators, says Burns.

To Happer, though, the labs' efforts to create a new focus for basic science may be self-defeating. He worries that although DOE may be able to sell the program for the next few years, as money gets even tighter, stewardship will fall prey to charges that it is sheer indulgence. "If it begins to look to Congress like support for National Public Radio and the New York symphony, it's going to be funded at the same level they are," he warns.

But Drell is confident that the money will be there if Congress is convinced that nuclear weapons maintenance is the main purpose of the program. He thinks legislators will accept the rationale that without new nuclear weapons to design and test, the laboratories need another way to retain a cadre of first-rate scientists. "What was driving the labs in the past? Building better weapons," he says. "Now we have to provide a new impetus, a challenge by different means."

–Jonathan Weisman

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NATIONAL ACADEMY OF SCIENCES

NRC Pledges Faster Delivery On Reports to Government

You are the chief of a federal agency, and one of your science programs is beset by technical problems. Rival factions are battling over the design of the project, and the fight attracts the unwelcome attention of Congress. So you turn to the National Academy of Sciences (NAS) and order up an impartial and thorough review. Eighteen months later and $250,000 poorer, your agency gets an answer in the form of a 200-page report recommending changes in the program. In the meantime, however, Congress has come to its own conclusions and canceled it.

An unlikely scenario? Not according to some NAS officials and their government clients, who worry that the academy's deliberate pace risks making some of its studies moot even before they are completed. So the academy is trying to speed up its act—as carried out through its operating arm, the National Research Council (NRC)—by negotiating contracts more quickly, appointing committee members faster, and reducing the number of reviewers of draft reports. "Agency heads say we need to move faster—it's a pretty standard refrain—and they are reluctant to request a report that takes too long to produce," says NAS Executive Officer William Colglazier. The academy has already shown its ability to move more quickly by taking only 5 months to issue a report on the National Aeronautics and Space Administration's (NASA's) Earth Observing System program (*Science*, 22 September, p. 1665).

The quicker pace could help the academy fill some of the gap to be left by the demise of the Office of Technology Assessment (OTA), which Congress abolished this week in part because its slow pace seemed out of synch with the frenetic legislative agenda. This new emphasis on timeliness is also prompted by a decline in income from studies and workshops conducted for the federal government, which is the customer for 80% of the reports done for the academy, the National Academy of Engineering, and the Institute of Medicine (IOM). Revenues peaked at $192 million in 1993 and 1994, says Archie Turner, NAS's chief financial officer. They are now at $176 million and are