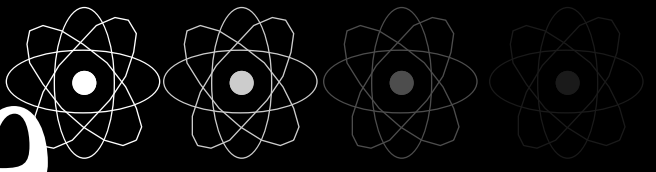
There have been no tests for years, and simulation cannot yet maintain a safe and credible deterrent.

The Decline of the Nuclear Stockpile



By James A. Kitfield

WHEN the Senate last October voted to reject the Comprehensive Test Ban Treaty, it threw into doubt the future of one of the most expensive, ambitious, and misunderstood science projects in the history of the United States.

The debate hardly touched on the Energy Department's multibillion-dollar Stockpile Stewardship Program. However, that mammoth effort was the subtext to the most stinging treaty defeat since the Senate rejected President Woodrow Wilson's League of Nations in 1920. The underlying issues are profound, and whether and how they are resolved will have major implications for the future of America's nuclear deterrent.

Ever since President George Bush declared a moratorium on nuclear testing in 1992, Washington has staked the reliability of its nuclear arsenal on the science-based Stockpile Stewardship Program, which is designed to accurately replicate the complex phenomenon of thermonuclear explosions and testing, using only computer simulations and various subcomponent tests.

Central to the test ban treaty debate was the wild divergence in answers to a fundamental question: Should the US, in its effort to maintain a credible and safe nuclear deterrent well into the future, rely solely on the use of advanced simulations, subcritical tests, and complex experiments—the functions that lie at the core of stockpile stewardship? In rejecting the test ban treaty, a majority of senators—backed by six former Secretaries of Defense and other senior military and civilian officials—seemed to answer with a resounding, "No."

Since 1992, the directors of the nuclear weapons labs have stated that confidence in the stockpile has already declined because of weapons aging, albeit slowly, said James R. Schlesinger, who is both a former Secretary of Defense and former Secretary of Energy and who proved to be an influential opponent of the treaty. "By the time the program reaches fruition around 2010, stockpile stewardship might begin to arrest that decline in confidence, but how far it will have already dropped by that point is a matter of judgment."

Into Purgatory

Although most lawmakers continue to publicly support the moratorium on nuclear testing, the treaty rejection has created a kind of test ban purgatory. The United States doesn't get the insights gained from renewed underground nuclear tests, the stockpile continues to age because no new nuclear weapons are being manufactured, but political support for the $4.5 billion-a-year Stockpile Stewardship Program will almost surely wane. The nuclear weapons lab directors—who have predicted the program will fail without solid, bipartisan support and steady funding—were badly shaken by an attempt by the House to cut $600 million from the program for Fiscal 2000.

"In the near term, I think we'll keep funding stockpile stewardship because almost no one wants to argue for a return to nuclear testing right now, but it's a very good question whether we can maintain long-term funding for an expensive program that has been cast [into] such doubt," said a senior Republican staff member on Capitol Hill. "Once you get beyond the preliminaries of what stockpile stewardship is designed to do, the technological issues just get very murky. That lack of understanding translates into uncertainty and anxiety, which leads to distrust, which translated into opposition to the [test ban treaty]."

After the treaty vote, the Department of Energy conducted a major internal review of the Stockpile Stewardship Program. The review found that while the program is essentially working, DoE needs to place a stronger emphasis on long-term investments in scientific facilities and modernize the infrastructure needed to produce new plutonium pits and refurbish weapons. DoE officials believed that the review may prove their last, best chance to sell the program to a skeptical Congress.

"This [Stockpile Stewardship Program] is very scientifically and technically challenging, and without a thorough grounding in the science, it's clearly very difficult for members of Congress and other observers to reach an independent judgment on the issues raised," said Undersecretary of Energy Ernest J. Moniz, who headed the internal review. "So, while I think we're well on the path to sustaining long-term confidence in our stockpile without testing, it's incumbent on us to articulate more effectively what this program is all about."

To understand what stockpile stewardship is all about, it's necessary to grasp the profound changes that have swept through and reshaped the US nuclear weapons complex.

The Bush Administration's 1989 decision to halt the development and production of new nuclear weapons meant that the US stockpile would progressively age from that moment onward, and it threw into doubt the future careers of the nation's small band of nuclear weapons designers. Now, more than a decade has passed since the US produced a new nuclear weapon. DoE has mothballed or retired much of its capability to produce them.

For instance, of the seven major production facilities that constituted the vast nuclear production complex, only the Pantex Plant in Texas—where US nuclear weapons are being dismantled under the Strategic Arms Reductions treaties—maintains anything close to its Cold War pace of operations. The total nuclear weapons complex is on schedule to shrink from 29.1 million square feet of floor space in 1985 to 6.4 million in 2005.

All the Others Still Test

A number of observers consider the virtual shutting down of US production as a weak link in stockpile stewardship. Except for the United States, all the other nuclear states that endorsed the test ban treaty continue to manufacture new nuclear weapons, largely relieving them of concerns produced by an aging stockpile. DoE is reconstituting the ability to manufacture a limited number of replacement plutonium pits at Los Alamos National Laboratory in New Mexico, but some scientists note that defects in weapons were often created in the transition from the laboratory to the assembly line.

"At some point we're going to have to remanufacture—if not new weapons then major components using new, modern processes," said a senior weapons designer at Lawrence Livermore National Laboratory in California, a lab that shares stewardship of the nuclear weapons stockpile with Los Alamos and Sandia Laboratories in New Mexico. "Not being able to test at that point could drive us out of our comfort zone into the red zone."

The change that prompted the most concern at the national weapons labs, by far, was the halt of all nuclear tests in 1992. Testing was viewed as the essential experiment that gave nuclear scientists confidence in their calculations. Nuclear tests were also used as the crucial audition period for all nuclear weapons designers.

"Careers were made and broken at the [Nevada] Test Site," said George H. Miller, associate director for national security at Livermore. "Weapons designers, including myself, were promoted based on our ability to conduct successful tests. So the organization we evolved to efficiently design, produce, test, and field new weapons, along with our entire reward system, was all swept away at the end of the Cold War."

The anxiety expressed by some of those nuclear scientists reflects the view that testing with a full nuclear explosion had unique advantages. The flaws that would show up from time to time during testing of a new warhead or weapon design, for example, would reveal fundamental gaps in the science of nuclear fission. With the nuclear stockpile now aging without new testing, some experts fear those gaps aren't being detected.

One Los Alamos expert in thermonuclear fusion likened the present challenge to walking an obstacle course in the dark when your last glimpse of light was a flash of lightning back in 1992. "Knowing that we won't be able to open our eyes again and take a peek with a nuclear test, and that there are obstacles and errors out there in the dark, makes you very nervous as a designer," said the scientist. "Nuclear tests proved the inaccuracies and uncertainties in our base of knowledge."

Test Site to Laboratories

Instead of being able to rely on underground nuclear tests at the Nevada Test Site, nuclear scientists now must look to the science-based program, which is centered on the premise of deconstructing into its component parts the extraordinarily complex phenomenon of a nuclear chain reaction—high-explosive-induced implosion, nuclear fission, tritium boosting, and thermonuclear fusion.

To spotlight each component of the nuclear chain reaction, the Energy Department is funding construction of a series of very expensive experimental facilities that, taken together, represent one of the largest projects in the world.

The $1.2 billion National Ignition Facility now under construction at Livermore will attempt to achieve fusion ignition at the microscopic tip of giant lasers. The first axis of two enormous X-rays—comprising the dual-axis radiographic hydrodynamic test facility—is now running at Los Alamos. When the second phase is complete in 2002, the total cost is estimated at nearly $260 million. The X-rays will provide freeze-frame, detailed photos of materials imploding at speeds of more than 10,000 miles per hour. The program also envisions construction of a multibillion-dollar production facility for tritium, an essential ingredient of modern nuclear weapons with a relatively short half-life of 12 years.

Eventually, data from the experimental facilities will be fed into a developmental supercomputer that (in theory, at least) will operate 100 times faster (100 trillion calculations per second) than today's most advanced computer. The idea is that the data will allow the computer to accurately simulate a nuclear explosion.

Many experts maintain that, for sheer scope, magnitude, scientific complexity, and challenge, the science-based program is rivaled by just two other 20th century endeavors—the World War II Manhattan Project to rapidly develop the atomic bomb and the 1960s-era Apollo program to land a man on the moon.

"I think this is pretty close to the moon shot in terms of difficulty, because we're requiring increases in computing speed which have never been seen since the invention of the microprocessor," said David M. Cooper, associate director for computation at Livermore and an Apollo program veteran with 30 years supercomputing experience at NASA. "I'm an optimist, so I think we can pull this off, but when you compare trying to simulate an aging nuclear stockpile on a computer to some of the computing problems I worked on at NASA, they were a slam dunk. This is a half-court shot."

The construction of the experimental facilities that are at the heart of stockpile stewardship serves another important function: Weapons lab officials say they are imperative in attracting a new generation of top scientists to the nuclear weapons program and validating their work.

"The way we validated people in the past has disappeared," said C. Bruce Tarter, director of Lawrence Livermore. "Even with the new facilities, the question remains whether we can keep from fooling ourselves about how good we are. I think we can. Without these facilities, my own judgment is there's not a chance in hell we can."

An Aging Stockpile

Perhaps the greatest challenge confronting the labs is the collection of uncertainties produced by an aging stockpile.

Many weapons are already beyond their anticipated design lives of roughly 13 years. To better understand how that process is affecting the stockpile, the labs have instituted the enhanced surveillance regimen, which involves dismantling representative samples of the stockpile each year. While no major problems have yet been identified, experts say the inspections have already led to modifications of some weapons in the stockpile.

The concern is that, with far fewer weapons in the stockpile today (seven essential weapons types vs. 24 at the height of the Cold War), any common-mode failure discovered in the future would involve a much larger portion

of the US stockpile than in the past. "Essentially, we have fewer eggs in far fewer baskets," said one weapons designer.

Nuclear weapons contain plastic high explosives, metal components, and materials that constantly emit high levels of radiation. In fact, to describe what happens to an aging nuclear weapon, experts draw an analogy between the bomb and a car that sits in the sun for years. Over time, the glue on the windshield will pull away, the upholstery will become more brittle, and the dashboard will crack.

"A similar phenomenon occurs inside a weapon, and we really don't know in what time frame that becomes a problem," said one weapons scientist at Los Alamos. "We don't know, for instance, if the sensitivity of high explosives to impact will stay the same despite aging. That's why we're in a race against time to get the data we need from our experiments before any major problem arises in the stockpile or the most experienced designers retire or die."

In an effort to buy time, the weapons labs have begun an aggressive archiving effort as part of stockpile stewardship. Minute data from more than 1,000 nuclear tests going back four decades are being updated and entered into computer data banks. If future experiments and computer simulations are accurate enough to one day explain anomalies in past weapons tests, experts believe that will go a long way toward validating the Stockpile Stewardship Program.

Also troubling the US is the specter of a rapidly aging and surprisingly small fraternity of critical US nuclear weapons designers. Almost since J. Robert Oppenheimer established the supersecret Manhattan Project of the 1940s on a series of isolated mesas at Los Alamos, US nuclear scientists and engineers have moved mountains to keep the United States pre-eminent in nuclear weaponry.

Lab managers are only now beginning to understand how heavily the labs relied on the gut instincts of a small core of very experienced weapons experts. As befits a culture far more analogous to a college campus than a federal bureaucracy, knowledge at the three nuclear labs was often passed along in relatively informal apprenticeships. Now those lessons are being passed to a new generation of scientists—scientists who likely won't ever design a weapon or conduct a nuclear test, yet who must monitor a rapidly aging stockpile.

As part of stockpile stewardship, archivists are thus conducting extensive videotaped interviews in an attempt to preserve the knowledge of the older generation of weapons designers and engineers. "While we always recognized that much of the expertise in this business resided inside people's heads, we've been surprised at how many of the details existed almost in the realm of folklore that was passed along from one generation to the next," said an archivist at Los Alamos. "So we're trying to lay down the foundation of information that will smooth the path if we ever have to go back to testing."

Raising a Red Flag

Almost from the beginning, Pentagon officials were most concerned that, even if the Stockpile Stewardship Program identified a potential problem in the arsenal, Washington would lack the political will to withdraw from a test ban accord and conduct the necessary testing. Largely to assuage those concerns, the Presidential directive establishing the program also called for a new, annual certification procedure for the nuclear stockpile.

Each year, the Secretaries of Defense and Energy would receive formal assessments from directors of the three weapons labs, the commander in chief of US Strategic Command, members of the Joint Chiefs of Staff, and a Nuclear Weapons Council composed of Congressional representatives. These individuals would have to certify the safety and reliability of the stockpile. The President has pledged that, if that certification is not given, he will invoke a "supreme national interest" clause and resume nuclear testing. Should a problem arise in the stockpile, the process would, in theory, create an internal dynamic to overcome any outside political pressures against resuming testing.

"From the beginning of stockpile stewardship, the nub of the issue was, if a problem was identified in the stockpile by the annual certification process, would the political pressure not to test override technical and military judgments," said Victor Reis, who until recently was the Department of Energy's assistant secretary for defense programs and a chief architect of stockpile stewardship. Reis said he felt "comfortable" that the annual review process—outlined in treaty addenda called "safeguards"—would succeed in bringing any serious problems with the stockpile to the attention of the senior officials in the Administration and Congress. "But the safeguards and the treaty were never debated as a single package," said Reis. "Whether the Administration or Congress is to blame for that, I think that's why the treaty was defeated."

In terms of the DoE's internal review of stockpile stewardship, officials say it will likely point to some setbacks as well as significant achievements. Because of ineffective management and unforeseen technical problems, for instance, the National Ignition Facility is nearly two years behind schedule and more than $200 million over budget. On the other hand, progress in the program has given the lab directors and Secretaries of Energy and Defense enough confidence to certify unequivocally, for the fourth year in a row, that the nuclear stockpile is safe and reliable. In a signature success for stockpile stewardship, the weapons labs were even able last year to adapt and deploy an old nuclear warhead on a new delivery system—the B61 Mod 11 deep earth-penetrating bomb—without nuclear testing.

"Our tools under stockpile stewardship are working so well today that we are not only able to certify safety and reliability after giving a complete physical to every single weapon system in our arsenal, but we are also able to meet new military requirements," said Energy's Moniz. "So our review will look at whether stockpile stewardship needs retooling, not whether it's working. It's already working." ▪

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