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NOTES

Numbers may not add to totals because of rounding.

Unless otherwise noted, budget figures are expressed in current dollars of budget authority. Some historical data, however, are expressed in 1995 dollars of budget authority, as noted.

The Administration does not provide a five-year budget plan for the Department of Energy's nuclear weapons research, development, and testing program. By necessity, therefore, the Administration's plan referred to in this paper reflects the Congressional Budget Office's assumptions.

PREFACE

At four major sites in the western part of the United States, thousands of the country's top scientists spent the Cold War studying and perfecting the science of nuclear weapons in the interest of enhancing U.S. and allied security.

But the Cold War is over, and with it most dimensions of a nuclear arms competition. Further efforts to advance nuclear weapons science may even work at cross-purposes with the goal of rendering these weapons illegitimate in the eyes of the international community.

Against that backdrop, this Congressional Budget Office (CBO) paper describes the Administration's plan for so-called science-based stewardship of the U.S. nuclear arsenal as well as three alternatives that the Congress may wish to consider. It was requested by the Ranking Minority Member of the Energy and Water Development Subcommittee of the Senate Committee on Appropriations.

Michael O'Hanlon and Elizabeth Chambers prepared this paper under the direction of R. William Thomas, Neil M. Singer, and Michael A. Miller; David Mosher and Marvin Smith of CBO provided important assistance. The authors deeply appreciate the thoughtful critiques and suggestions of Richard Garwin, Ray Kidder, Jon Medalia, Marvin Miller, and Christopher Paine. Many individuals at the Department of Energy, the three nuclear weapons laboratories, and the Nevada Test Site also were extraordinarily helpful, and their cooperation is gratefully acknowledged. Of course, the assistance of outside individuals and organizations implies no association on their part with this paper, which remains the responsibility of the authors and CBO.

Sherry Snyder edited the paper, and Chris Spoor provided editorial assistance. Judith Cromwell and Cynthia Cleveland prepared it for publication.

Robert D. Reischauer
Director

July 1994

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SUMMARY

Under the Administration's current policy, the United States plans to maintain a nuclear weapons research program of a scale comparable with that of past decades. But does such an approach make sense at a time when the Cold War has ended, superpowers' nuclear stockpiles are declining to only about one-third of their previous size, development of new warheads has effectively stopped, and many of the world's countries have begun negotiations on a treaty banning nuclear explosive tests?

Some people answer no and argue for deep cuts in the program and in the Department of Energy's (DOE's) budget for research, development, and testing of nuclear weapons. Others oppose such cuts for several reasons: the difficulty of ensuring the ongoing reliability of U.S. nuclear weapons in the absence of testing; the need to maintain substantial nuclear expertise at the weapons laboratories in order to support research on nonproliferation and arms control; and a sense that the safety and security of U.S. nuclear warheads might need to be improved, even if the traditional standards by which nuclear weapons are evaluated (particularly, small size and high explosive power) are now less important.

The Administration's plan for stewardship of the nuclear arsenal is in its final stages of development, though it may be subject to modification arising from the Department of Defense's ongoing review of U.S. nuclear posture. That plan, commonly described as science-based stewardship, places a high premium not only on monitoring and maintaining existing warheads but on furthering the country's understanding of the basic physics and engineering disciplines that are related to nuclear weapons science. For budgetary and policy reasons, however, the Congress may wish to consider alternative approaches to ensuring a viable U.S. nuclear deterrent and promoting nonproliferation.

BUDGETARY SHORTFALLS IN THE ADMINISTRATION'S PLAN ARE POSSIBLE

The Administration's plan for science-based stewardship of the nuclear stockpile places a premium on advancing the state of nuclear weapons physics as well as monitoring and examining scrupulously the weapons in today's arsenal. But the Administration's budget will not necessarily provide funding sufficient to develop the improved tools for stockpile stewardship on the schedules proposed for them. The Department of Energy's laboratories have calculated that meeting those goals will require increased funding for weapons research, development, and testing (RD&T) relative to 1994 levels--an addition of at least $100 million a year, and perhaps $200 million a year or even more. But the 1995 budget request, if adopted, would move funding in just the opposite direction, down to about $1.56 billion from the current level of about $1.7 billion (and the decline would be even more striking if measured in constant, or inflation-adjusted, dollars).

This analysis assumes that under the Administration's plan, the Department of Energy's budget for weapons RD&T will fall in 1995 but regain its 1994 level of $1.7 billion a year thereafter (as measured in current dollars, that is, in dollars not adjusted for inflation). DOE's budget request does not provide detailed information on its plans for the RD&T budget; indeed, those plans are still being formulated. But the assumption of a sustained $1.7 billion funding level is consistent with DOE's overall budget plan for Atomic Energy Defense Activities (of which weapons RD&T is a component, representing some 15 percent of the total). Even if funding for 1996 and beyond returns to the 1994 level, DOE is likely to have significantly less money than it would need to implement the plan. As a consequence, if DOE carried out all plans for new experimental and computational facilities and new RD&T activities, certain basic elements of stockpile stewardship might suffer.

DIFFERENT VIEWS ON NUCLEAR DETERRENCE MAY HAVE IMPLICATIONS FOR THE LABORATORIES AND DOE

As nuclear weapons recede in importance in U.S. military policy--largely a function of the end of the Cold War--requirements to improve the performance and flexibility of the arsenal have declined accordingly. During the Cold War, the huge size of Warsaw Pact armies, coupled with the revolutionary communist dogma of the Soviet state, made the West feel that it needed an unconventional deterrent. But with that era's end, the United States appears to have decided that lessening the likelihood of the proliferation and use of nuclear weapons has become much more important than extracting marginal improvements in their military utility--and perhaps even more important than preserving every capability in the current arsenal. Many analysts would argue that in light of these developments the Administration's nuclear policy, which retains extensive plans for nuclear war, a large nuclear arsenal, and a reluctance to declare that the United States would never be the first to use nuclear weapons in a conflict, has not yet evolved sufficiently.

Given the tremendous destruction that even a small number of modest-yield devices would cause, one can debate the importance of ensuring optimal warheads with extremely high reliability--and thus the need to retain a major laboratory establishment dedicated to advancing nuclear weapons physics. A more sensible and indeed less dangerous policy might be to view nuclear weapons only as a deterrent of the very last resort, what former national security advisor McGeorge Bundy dubbed an "existential deterrent." In that case, targeting and war plans might become more limited in scope, and DOE and its laboratories might not have as demanding a mission. It might be sufficient that they conduct surveillance of U.S. nuclear warheads, test the individual components of warheads to monitor their aging and performance, conduct so-called hydrodynamic experiments on devices that may be similar to actual warheads, and rebuild parts of warheads to identical (or nearly identical) specifications when required.

Having vigorously developed a reliable and highly capable arsenal over 50 years--and in the process conducted more than 1,000 nuclear tests--the United States may no longer need to prove its resolve or its nuclear capabilities through an ambitious program of nuclear testing and the further advancement of nuclear weapons physics. It may be able to do more to buttress the prospects for a comprehensive test ban treaty and further stigmatize nuclear weapons by an example of restraint, without reducing the effectiveness of the U.S. nuclear deterrent for those missions it is truly capable of performing.

What may appear as an already much smaller weapons RD&T budget could seem excessive for a set of missions that was scaled back. Although little money now goes directly to designing new warheads, much of the infrastructure and technical expertise of DOE's laboratories and the Nevada Test Site might be unnecessary if the United States decided to rule out such work in the future.

It would be oversimplistic and unfair to characterize the debate over stewardship as simply one between those who wish to stigmatize and de-emphasize nuclear weapons and those who wish to retain maximum flexibility in the program. Retaining confidence into the indefinite future that each of the 10 warhead types or major modifications likely to remain in the arsenal could produce explosive yields close to specified levels with reliabilities approaching 100 percent would be quite challenging. Accomplishing that goal would take a substantial effort and substantial resources. Without testing, therefore, the cautious weapons physicist would be inclined to pursue several overlapping and independent paths of stewardship in order to be as sure as possible that the arsenal continued to meet existing standards.

But the calculus of the weapons physicist might change somewhat under a more minimalist approach to nuclear deterrence that did not emphasize nuclear warfighting doctrines such as the Single Integrated Operational Plan (SIOP). Warfighting plans such as the SIOP have traditionally formed the basis for the nuclear warhead requirements imposed by the Department of Defense and the President.

Plans such as the SIOP have also been largely driven by the types and numbers of warheads that DOE was able to make available. Precluding any further improvements in those warheads, and perhaps even accepting somewhat lower performance and reliability standards in the existing stockpile over time, might therefore contribute to a change in U.S. nuclear doctrine.

ALTERNATIVE APPROACHES TO STEWARDSHIP: THREE OPTIONS FOR WEAPONS RD&T

This paper analyzes three alternatives to the Administration's plan for stewardship of the nuclear weapons stockpile.

- Option 1 would end nuclear and hydronuclear testing at the Nevada Test Site and increase funding for basic stewardship at the laboratories.

- Option 2 would reduce funding for dual-purpose activities and increase funding for basic stewardship.

- Option 3 would combine the first two options and eliminate the integrated stewardship responsibilities of one of the two major design laboratories.

The first two options would produce only small savings relative to the Administration's plan. Rather than being intended primarily to cut the budget, they would emphasize somewhat different political and technical priorities than would DOE's stockpile stewardship program in its present form. The third option, based on a different philosophy of nuclear deterrence, would make more fundamental changes in the nuclear weapons research, development, and testing work of the Department of Energy.

Neither Option 1 nor Option 2 would differ greatly from the Administration's plan. However, each would cut back on certain programs and mission goals. Doing so would free up more funds for activities considered most important for stockpile stewardship: basic computations, enhanced surveillance, laboratory experiments, and hydrodynamic experiments.

Option 1 would end funding for readiness to conduct nuclear and hydronuclear testing at the Nevada Test Site after 1995. Equipment would go into long-term storage. (If ever deemed necessary, restarting a testing program might take on the order of five years, and perhaps a few more years to restore full proficiency.) This option would preserve other weapons RD&T programs at their requested levels, including those dual-purpose activities that yield benefits in nondefense realms as well as in the nuclear weapons program.

The Congressional Budget Office estimated costs using two levels of increases for basic stewardship activities. Under a variant that phased in a modest increase of $60 million a year (by 1997), the overall level of the 1995 budget would be unchanged, but savings of up to $80 million a year would accrue by 1997 (see Summary Table 1). Under a variant that included a larger increase of $120 million a year, savings would be substantially smaller--and indeed, the program would incur modest net costs during 1995 and 1996.

Option 2, in contrast, would reduce funding for those parts of DOE's stewardship plan that hold out promise for commercial products and nondefense applications, thus refocusing the weapons RD&T program on basic missions related to stewardship of the nuclear stockpile and providing more funds for such activities. In particular, Option 2 would reduce by one-third DOE's funding for activities referred to as technology transfer and dominated by cooperative research and development agreements (CRADAs) with private industry. It would also cancel the proposed construction of the National Ignition Facility, part of the research program on inertial confinement fusion. Option 2 would preserve funding for hydronuclear tests, presumably at the Nevada Test Site. This provision would be consistent with the high importance accorded to hydronuclear tests by some individuals at the laboratories.

Under a variant that phased in an increase of $60 million a year for basic stewardship, this option would save $20 million in 1995 and would generate savings exceeding $100 million a year toward the end of the decade. By

SUMMARY TABLE 1. BUDGETARY IMPLICATIONS OF OPTIONS FOR THE DEPARTMENT OF ENERGY'S WEAPONS RESEARCH, DEVELOPMENT, AND TESTING PROGRAM
(In millions of dollars of budget authority)

	Costs Relative to Administration's 1995 Plan					Five-Year
	1995	1996	1997	1998	1999	Total
Integrated Options						
Option 1: Combine A and E						
Lower increase for stewardship	0	-10	-80	-80	-80	-250
Higher increase	20	30	-20	-20	-20	-10
Option 2: Combine B, C, and E						
Lower increase for stewardship	-20	-65	-70	-125	-125	-405
Higher increase	0	-25	-10	-65	-65	-165
Option 3. Combine A, B, C, D, and E						
Lower increase for stewardship	-60	-155	-270	-345	-365	-1,195
Individual Elements						
A. Eliminate Readiness for Testing and Hydro-nuclear Experiments	-20	-50	-140	-140	-140	-490
B. Cancel National Ignition Facility	-5	-35	-60	-115	-115	-330
C. Reduce DOE Funding for Cooperative Research and Development Agreements	-35	-70	-70	-70	-70	-315
D. Eliminate Integrated Stewardship Capability of One Design Laboratory	-20	-40	-60	-80	-100	-300
E. Increase Funding for Basic Stewardship						
Lower increase	20	40	60	60	60	240
Higher increase	40	80	120	120	120	480

SOURCE: Congressional Budget Office based on the 1995 budget request of the Department of Energy as well as briefings provided by the DOE Nevada Operations Office, Los Alamos National Laboratory, and Lawrence Livermore National Laboratory.

contrast, gradually increasing funding for basic stewardship to $120 million a year would yield no savings in 1995 but would save $65 million annually later in the decade.

Option 3 would reduce the inherent capabilities of the laboratories to make major modifications to existing warheads or design new types of improved-performance warheads, should that ever be required by national policy. Rather than invest large sums of money in advancing the state of nuclear weapons physics and engineering, this option would anticipate rebuilding tried and tested weapons to original specifications--and with identical, or very nearly identical, materials--whenever necessary. To hedge against any imperfections in this scheme for "identical remanufacturing," it would also retain or upgrade most of the basic tools needed for continual monitoring of the U.S. nuclear stockpile and assess any changes that might seem highly desirable for reasons of safety, security, or reliability. Those tools are enhanced surveillance, advanced computations, and laboratory and hydrodynamic experiments. Finally, Option 3 would also provide the technical wherewithal to introduce limited quantities of one or two simple types of warheads that could be expected with very high confidence to detonate without ever having been tested, should such new designs someday be authorized.

Like Option 1, Option 3 would envision an end to readiness for all types of tests at the Nevada Test Site. Like Option 2, it would substantially reduce funding for those activities within weapons RD&T that may have useful civilian and scientific applications but are arguably of secondary importance for nuclear stewardship.

Going beyond the cuts in either Option 1 or 2, Option 3 would also change the basic two-laboratory system, under which both Los Alamos and Lawrence Livermore national laboratories currently function as complete design and stewardship facilities for the so-called "physics package" of a nuclear warhead---the part involving fissile material and other elements that through a sequence of timed events actually produce a nuclear explosion. One of those two laboratories would give up many of its responsibilities for stockpile stewardship and see its budget for weapons RD&T eventually cut by about $100 million a year. (That amount represents about half of its expected budget for weapons RD&T but only about 10 percent of its total funding.) Such a change in the basic philosophy of having two design laboratories would have no budgetary effects on the weapons support and engineering design work performed at Sandia National Laboratories.

After producing savings of $60 million in 1995, this option would allow the weapons RD&T budget to be cut by more than $300 million annually later in the decade.

CHAPTER I

INTRODUCTION

Mirroring the overall downward trend in military spending, the Department of Energy's (DOE's) budget for research, development, and testing of nuclear weapons is declining. From a peak funding level of $2.3 billion in budget authority in 1985, as measured in 1995 dollars, and $2.1 billion in 1993, it has fallen to about $1.7 billion in 1994. The Administration is requesting $1.56 billion for 1995--less than the funding that prevailed in the early years of the Reagan military buildup (see Figure 1).

Despite these cuts, however, the Department of Energy has a rather ambitious technical agenda for ensuring the continued reliability, safety, security, quality, and flexibility of the U.S. nuclear arsenal. Planned levels of funding are not likely to be sufficient for the programs and facilities that DOE plans to support during the rest of the decade.

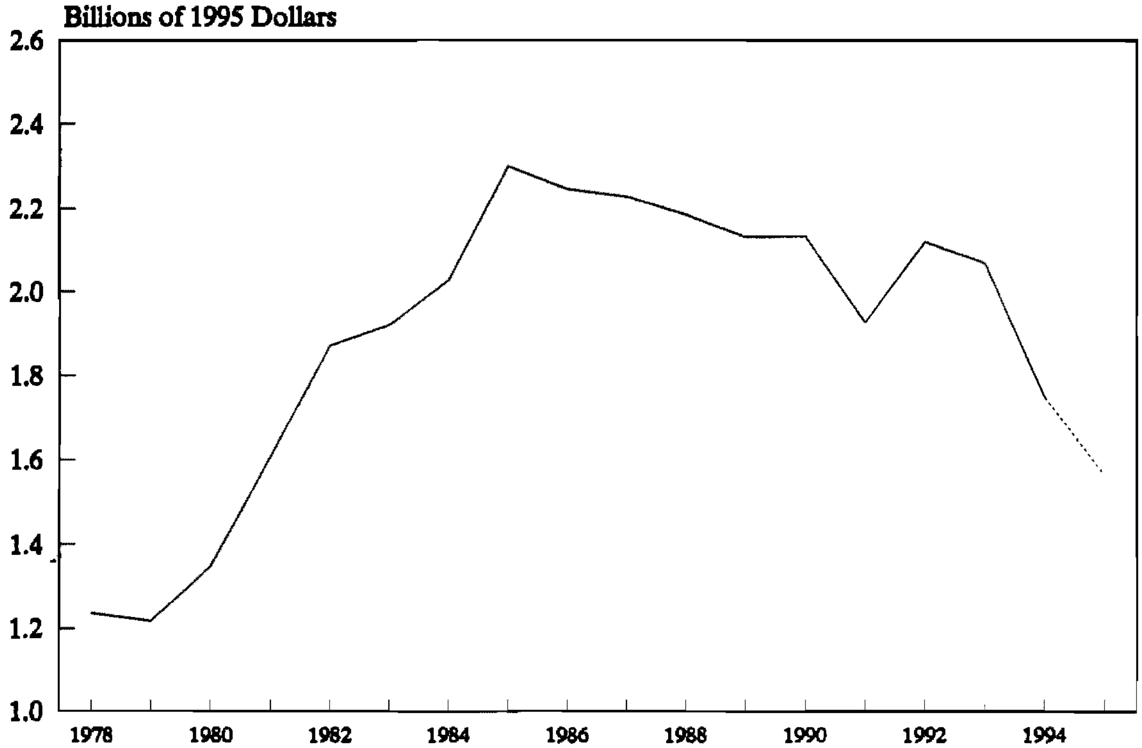
To redress the potential budgetary shortfalls in the Administration's plan--or to underscore a different view of the proper role of nuclear weapons in U.S. security policy--the Congress could pursue programs and funding levels to maintain the U.S. nuclear stockpile that are somewhat different from those reflected in the Administration's plan. That plan, as well as three illustrative approaches that could serve as an alternative, are analyzed in this paper.

BACKGROUND: A COMPREHENSIVE TEST BAN TREATY

This analysis begins from the premise--now widely shared among Administration officials, Congressional policy analysts, and weapons designers--that the United States and other countries have embarked inexorably on a path to end all nuclear testing and conclude an international comprehensive test ban treaty (CTBT). That treaty is now being negotiated under the auspices of the United Nations in Geneva, Switzerland, and has received the active backing of the Administration, which has extended until September 1995 a moratorium on U.S. nuclear testing that is soon to enter its third year.

A CTBT has been a long-standing demand of many leaders and other individuals in countries that do not have nuclear weapons. They object to what in their eyes is a hypocritical attitude on the part of the nuclear powers, which admonish other countries not to develop nuclear weapons even as they

FIGURE 1. DEPARTMENT OF ENERGY'S BUDGET FOR WEAPONS RESEARCH, DEVELOPMENT, AND TESTING, FISCAL YEARS 1978-1995



SOURCE: Congressional Budget Office based on data from the Department of Energy.

continue to improve their own arsenals and accord prominence to nuclear weapons in their military policies. By contrast, many officials and analysts in the United States see this country's possession of nuclear weapons as something of a necessary evil in a world in which knowledge about how to make the bomb is widespread and impossible to eradicate. They believe that it makes sense for the United States--arguably a nonaggressive and responsible country--to continue to possess a viable nuclear deterrent even as it tries to prevent other countries from acquiring weapons of mass destruction.

Although this difference of opinion between the nuclear haves and have-nots probably cannot be entirely bridged, a compromise measure appears to be in the making in regard to the CTBT. Under such a treaty, the United States and other nuclear powers would refrain from further nuclear explosions--and thus from the most visible sign that they were continuing to develop nuclear weapons. Making this commitment would be seen largely as a way to persuade other countries to continue to abide by the 1970 Nuclear Non-Proliferation Treaty (NPT). Under the NPT, those nonnuclear countries agreed not to develop nuclear weapons. In return, the nuclear powers agreed to work toward nuclear disarmament, including an end to nuclear testing, and also to share civilian nuclear technology with nonnuclear countries provided that it be monitored. (In addition, the United States has pledged that it will not attack a nonnuclear country with nuclear weapons under any circumstances unless that country is aided militarily by another that does have nuclear weapons.)

But the NPT, widely seen as a critical element of U.S. policy on nuclear nonproliferation, will require extension in 1995. The combination of a CTBT--preferably completed and signed, but at least nearly completed--and the ongoing process of strategic arms reductions in the United States and the former Soviet Union may well set the stage for a successful extension of the Nuclear Non-Proliferation Treaty. A CTBT should also yield a more direct benefit for nonproliferation policy--making it politically even harder for would-be proliferating countries to test. Without testing, countries would probably not be able to develop advanced weapons such as thermonuclear warheads or warheads suitable for delivery by long-range missile.

A ban on nuclear testing would entail quite significant technical problems for the designer of nuclear weapons. The Department of Energy and its nuclear weapons laboratories argued against such a policy for a number of years. Although they now are generally resigned to it, they are still concerned about how to ensure the long-term viability of the U.S. nuclear arsenal under a CTBT.[1]

Taking a CTBT as a given, this paper examines the Administration's plan for preserving the reliability, safety, security, quality, and flexibility of the U.S. nuclear deterrent--a plan known as science-based stockpile stewardship. It also analyzes alternative approaches to maintaining the effectiveness and safety of the U.S. nuclear arsenal under a policy that prohibits nuclear testing.

SCIENCE-BASED STEWARDSHIP OF THE NUCLEAR STOCKPILE

The Administration's plan for science-based stewardship of the nuclear stockpile proceeds from the premise that, without testing, ensuring the continued reliability of the U.S. nuclear arsenal will be very hard. Materials will deteriorate with age, and new components for today's weapons will sometimes be different, albeit only slightly, from those they replace, thus raising questions about weapons' performance in some cases. Scientists and engineers seasoned by the experience of both successful and unsuccessful tests will retire, passing along the thermonuclear baton to individuals whose knowledge about nuclear weapons will be very extensive but largely theoretical.

In this context, the Administration argues, the United States should improve all the other tools, facilities, and techniques that can be used to assess the state of the stockpile--including computers, surveillance techniques, fusion research centers, and hydrodynamic and hydronuclear experiments that study the behavior of materials while they are being compressed, as they are in the early phases of a nuclear detonation. As a consequence, the Administration is considering building a number of new facilities or upgrading existing equipment.

These facilities and techniques might provide an acceptable basis for someday developing new and more specialized types of warheads without nuclear testing. Retaining and perhaps improving such a capability might be viewed as a useful hedge against certain types of unpredictable international events. It could also make possible the introduction of new designs into the stockpile--should they be authorized by the President, acceptable in light of Department of Defense requirements, and consistent with U.S. law.

1. For an example of the past position of the laboratories, see an article by two scientists at the Lawrence Livermore National Laboratory: John D. Immele and Paul S. Brown, "An Exchange on Stockpile Confidence," *International Security* (Summer 1988), pp. 196-210. The rationale for their concern is challenged in that same journal in an accompanying letter by Steve Fetter, an independent scientist.

Perhaps more likely, those capabilities would allow existing warheads to be modified. Such modifications might someday be appropriate if a warhead was to be delivered by a different type of missile, or over a different aircraft flight profile, than originally planned. They might also be appropriate as a means of addressing a problem with safety or reliability that had not been discovered when the warhead was designed and produced. Moreover, they might permit upgrades that would enhance security, perhaps by facilitating the disablement of a weapon that somehow fell into the wrong hands. Sophisticated stewardship techniques would also provide the tools to assess and, if necessary, correct the effects of aging or any defects on existing warheads. These latter missions are the ones that the Department of Energy and its major weapons laboratories most emphasize today.

Adopting the Administration's plan for science-based stewardship would not preclude further arms control or a deepening of the international stigma on nuclear weapons. For example, it would not prejudice decisions about such matters as whether the United States should formally declare that it would never be the first country to use nuclear weapons in a conflict, deeper cuts in nuclear forces, fundamental changes in the targeting of nuclear weapons, or a reduction in the alert levels of deployed forces. But, with the important exception of its support for a CTBT, the Administration's plan would also do little to promote any of these ideas for arms control.

To redress the potential budgetary shortfalls in the Administration's plan or to underscore a different view of the role of nuclear weapons in U.S. security policy, the Congress could pursue different stewardship programs and funding levels than that plan comprises. The following chapters describe the Administration's plan for stewardship and analyze three alternative approaches that reflect different priorities and budgetary options.

Perhaps notable by their absence in the following discussion are two other issues that, though important, will not involve major budgetary resources in the 1990s. One relates to funding for the engineering development of new warhead designs. Although current policy would retain much of the capabilities of today's laboratories, partly as insurance in case new designs are ever desired, funding specifically targeted for such work is quite small today--on the order of a few million dollars at each of the three major laboratories. Work is essentially confined to paper study and computation at this point.

Second is the issue of tritium, used in virtually all current U.S. nuclear weapons. Tritium is intended to increase the explosive yield of the primary--that is, the first of two main parts of a thermonuclear weapon. In the primary, a fission reaction initiates the process of producing nuclear explosive power. Once this process begins, tritium undergoes fusion reactions and produces neutrons that in turn contribute to the explosive power of the fissile material, leading to a much larger explosive power in the primary.

However, tritium decays radioactively with a half-life of about 12 years and thus must be replenished periodically in any warhead. Today the United States has a large surplus of tritium that is being freed up by the ongoing retirement of two-thirds of its nuclear arsenal. But, depending on the future size of the U.S. arsenal, new tritium will need to be produced beginning sometime around 2010. Although this date seems distant, the complexities of building a nuclear reactor or particle accelerator capable of producing tritium may require that construction begin by early in the next century. DOE plans to make a decision in 1996 about the proper technology for producing tritium, with advanced design and construction to follow. This schedule is contentious, however; some people consider it rushed, given the state of research on technologies for producing tritium, and argue that the country should delay decisions and advanced design work for several years. On either schedule, DOE will not incur major costs during this decade.

CHAPTER II

THE ADMINISTRATION'S PROGRAM FOR WEAPONS RD&T

The Administration's basic approach to stewardship of nuclear weapons is to continue to improve understanding and knowledge in a wide range of weapons-related fields and technologies. It is an ambitious approach; indeed, the label "science-based stewardship" emphasizes its wide-ranging and fundamental nature. Under current plans, the Administration would probably build larger research facilities or upgrade existing ones at which scientists would study the basic processes in thermonuclear weapons and examine the mechanical properties of warhead-like devices as they begin to detonate. It would also continue to make substantial improvements in computer facilities and capabilities and would conduct hydronuclear tests, if approved by the President.

DOE'S BUDGET FOR STEWARDSHIP

The budget for stewardship--or weapons research, development, and testing (RD&T)--is found in the budget for the Department of Energy's Atomic Energy Defense Activities (AEDA). That budget, totaling $10.9 billion in 1994, is composed chiefly of three main categories (see Table 1). The largest in dollar terms is for environmental restoration and waste management at sites that formerly produced nuclear weapons and their special nuclear materials. Another, weapons activities, includes $1.7 billion for research, development, and testing of nuclear weapons (see Table 2).

What will the budget for weapons RD&T be in the future? DOE does not submit a five-year budget plan in the detail characteristic of Pentagon budgets. But over the next five years, total funding for DOE's Atomic Energy Defense Activities is expected to remain roughly constant in current-dollar terms. Under the Administration's plan, it would decline from a 1994 level of $10.9 billion to $10.6 billion in 1995 and then climb back to $11.2 billion by 1999. In keeping with such a relatively steady projection for the total AEDA budget, this paper assumes that except for a dip downward in 1995 reflecting the President's current budget request, the budget for weapons RD&T will return to its 1994 level of $1.7 billion in 1996 and remain at that nominal level for the rest of the decade.

TABLE 1. DEPARTMENT OF ENERGY'S BUDGET FOR ATOMIC ENERGY DEFENSE ACTIVITIES (In millions of dollars of budget authority)

	1993	1994	Requested, 1995
Defense Environmental Restoration and Waste Management	4,800	5,200	5,200
Weapons Activities (Research, development, and testing; stockpile support; and program direction)	4,600	3,600	3,300
Materials Support and Other Defense Programs	2,600	2,000	1,900
Defense Nuclear Waste Disposal	100	100	100
Total	12,100	10,900	10,600

SOURCE: Congressional Budget Office based on data from the Department of Energy's budget request for 1995.

TABLE 2. DEPARTMENT OF ENERGY'S BUDGET FOR WEAPONS ACTIVITIES (In millions of dollars)

	1993	1994	Requested, 1995
Obligations			
Research, development, and testing[a]	1,960	1,700	1,560
Stockpile support	2,530	2,060	1,620
Program direction	180	280	170
Subtotal	4,660	4,040	3,350
Use of Prior-Year Balances and Other Adjustments	-100	-440	-80
Total, Budget Authority	4,560	3,600	3,270

SOURCE: Congressional Budget Office based on data from the Department of Energy's budget request for 1995.

a. Includes funding for core research and development, inertial confinement fusion, technology transfer, and testing. See Table 3 for a detailed breakdown of this category.

Current Funding for Weapons RD&T by Program

The nuclear weapons RD&T budget for stewardship, totaling $1.7 billion in 1994, can be broken down by program.

The largest piece, $1.3 billion in 1994, goes to core research, development, and testing. Of that amount, $900 million goes to core research and development and $400 million to testing. The $900 million for core research and development consists of about $725 million for operating expenses--salaries, costs for maintaining facilities, and the like. About $175 million funds capital investment in equipment such as computers as well as construction and maintenance of facilities (see Table 3). Of the $400 million for testing, about two-thirds funds activities at the Nevada Test Site. Nearly all of the rest is spent, in relatively equal amounts, at the three major laboratories.

The remaining $400 million of funding for weapons RD&T is devoted to two programs intended to improve the basic scientific and engineering capabilities of the laboratories. In particular, $220 million funds cooperative research and development agreements (CRADAs)--the chief activity within the weapons program's so-called technology transfer efforts. Those agreements support projects intended to promote collaborative development of technology with industry. The other $185 million supports research on inertial confinement fusion.

Current Funding for Weapons RD&T by Facility

Of the total weapons RD&T budget of $1.7 billion, about 90 percent goes to four major facilities: Lawrence Livermore National Laboratory in California, Los Alamos National Laboratory in New Mexico, Sandia National Laboratories in New Mexico and California, and the Nevada Test Site. Specifically, in 1994, $345 million funds activities at Los Alamos, $400 million at Livermore, $465 million at Sandia, and $315 million at the Nevada Test Site. A remaining sum of $160 million funds work at several smaller facilities working on inertial confinement fusion at the Naval Research Laboratory, the University of Rochester, and elsewhere.

This distribution of funds reflects a philosophy dating back to the creation of the Lawrence Livermore National Laboratory four decades ago--the importance of having independent centers for research and design of warheads at both Livermore and Los Alamos. This approach reflects a desire to retain a competitive dynamic for a matter of great importance to national

TABLE 3. DEPARTMENT OF ENERGY'S BUDGET FOR WEAPONS RESEARCH, DEVELOPMENT, AND TESTING (In millions of dollars of obligations)

	1993	1994	1995
Operating Expenses			
Core Research and Development			
Research and advanced technology	520	315	305
Laboratory stewardship	270	215	195
Special projects, education, and partnerships	95	110	95
Emergency response	35	45	45
Nonproliferation, arms control, and threat assessment	20	10	5
Reconfiguration	15	25	0
Inertial Confinement Fusion	180	170	165
Technology Transfer	140	215	210
Testing	375	370	340
Investment (Capital equipment and construction)			
Core Research and Development	225	175	145
Inertial Confinement Fusion	30	15	10
Technology Transfer	a	5	5
Testing	45	30	35
Total RD&T Budget			
Core Research and Development	1,180	895	790
Inertial Confinement Fusion	210	185	175
Technology Transfer	140	220	215
Testing	420	400	375
Total	1,955	1,700	1,565

SOURCE: Congressional Budget Office based on data from the Department of Energy's budget request for 1995.

a. Less than $1 million.

security that has been very challenging technically (and that remains difficult today).

Nuclear weapons RD&T typically represents about one-third of the laboratories' total budgets in 1994. Although today's funding at each laboratory is comparable with funding before the Reagan military buildup, it represents a real decline of about 30 percent since the peak levels of the 1980s (see Figure 2). Nonetheless, DOE is still able to support independent teams for design, development, and stewardship of nuclear weapons at both Livermore and Los Alamos.

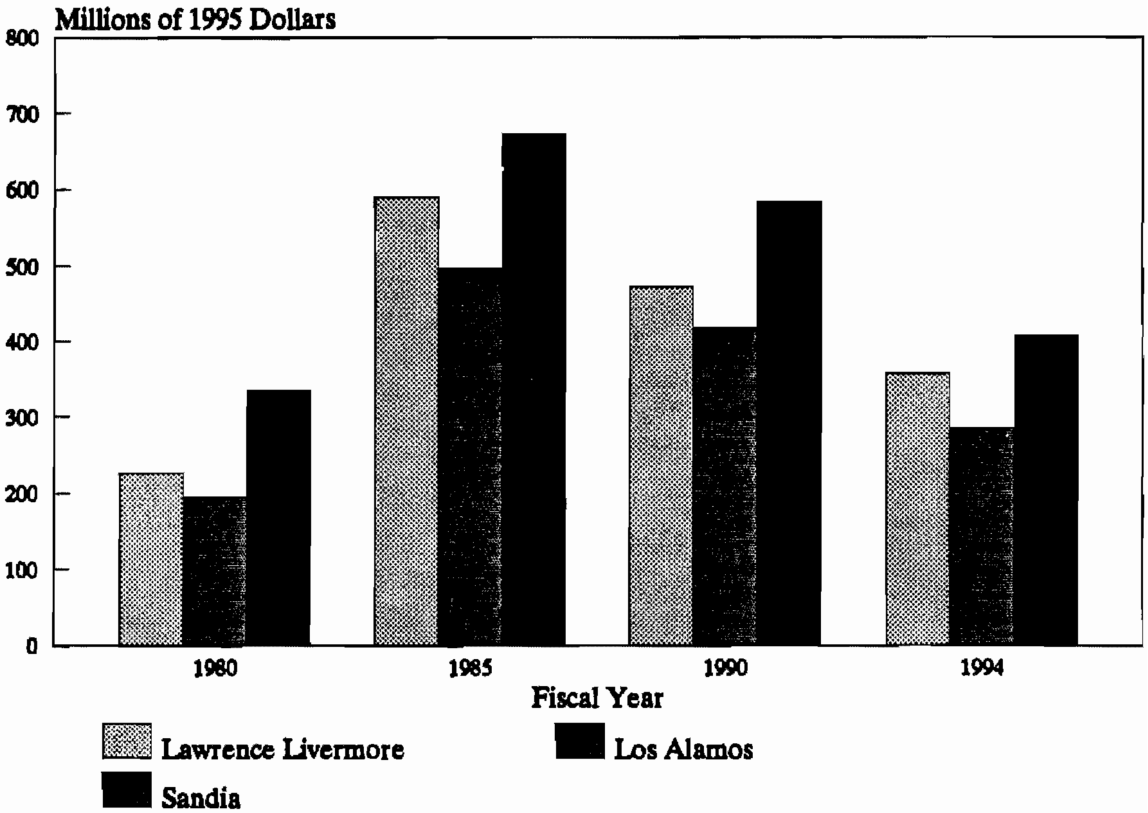
The remaining two-thirds of the laboratories' spending supports activities outside the realm of weapons RD&T (see Table 4). One such activity--research on technologies for environmental restoration and waste management--has seen its funding increase about 50 percent, to over $300 million, since 1992. And further increases for such research may be warranted, as discussed in the Congressional Budget Office's May 1994 study, *Cleaning Up the Department of Energy's Nuclear Weapons Complex*. Another activity encompasses research and development of technologies for verification, arms control, intelligence, and nonproliferation efforts. Total funding for verification and control technology has doubled since 1992 to about $250 million at the three laboratories. Important and interesting research projects remain to be pursued in this area, but current funding levels seem to be sufficient to carry them out.

ACTIVITIES INCLUDED IN THE STEWARDSHIP PROGRAM

What does $1.7 billion a year actually permit DOE to do? Through what specific types of research does the Department of Energy remain vigilant about the state of the nuclear arsenal?

Neither a long-term program strategy, expected from DOE in July 1994, nor the report of an Energy Advisory Board Task Force (also known as the Galvin Panel) due in February 1995, is yet available. But much can be discerned from existing documentation and budget requests. In addition, the Congressional Budget Office received a great deal of useful information from the Department of Energy, the nuclear weapons laboratories, and the Nevada Test Site operations office.

FIGURE 2. DEPARTMENT OF ENERGY'S OPERATING BUDGET FOR WEAPONS RESEARCH, DEVELOPMENT, AND TESTING, BY MAJOR LABORATORY



SOURCE: Congressional Budget Office based on data from the Department of Energy.

NOTE: The operating budget does not include capital equipment and construction.

TABLE 4. FUNDING FOR THE NATIONAL LABORATORIES WITH MAJOR RESPONSIBILITIES FOR NUCLEAR WEAPONS, 1994 (In millions of dollars)

	Los Alamos	Lawrence Livermore	Sandia
Weapons Activities			
Research and development	300	355	430
Testing	45	45	35
Stockpile support and program direction	120	10	165
Total	470	410	630
Work for Others (Non-DOE)[a]	170	210	350
Research on Energy-Related and General Science	140	165	110
Defense Environmental Restoration and Waste Management	185	90	80
Materials Support and Other Defense Programs			
Verification and control technology	85	65	105
Other	15	10	10
Total	100	75	115

SOURCE: Congressional Budget Office based on Department of Energy, "Laboratory Table," Congressional Submission for Fiscal Year 1995 (February 1994).

a. Estimates are taken from the institutional plan of each of the laboratories for 1994 through 1999.

Core Research, Development, and Testing

The highly trained and experienced staffs of these laboratories, heavily weighted with advanced degrees and technical skills, are aided by a vast body of theory and data on nuclear weapons that has been accumulated during the past half century. This information is in various states of accessibility. One current enterprise at the laboratories--and one that would take on special importance for a stewardship philosophy based heavily on the concept of identical remanufacture, as discussed in Chapter 5--is to archive this information more systematically on computers.

In addition to historical data and computational capabilities, weapons designers and engineers have at their disposal a host of high-technology and high-precision laboratories and engineering facilities to study warhead designs and actual warheads. Some of them develop and produce the individual components of weapons. Others test weapons and their components or study their properties through surveillance techniques such as analyzing the scattering of particles that results from bombarding warheads with neutrons. Many of the electrical and mechanical elements of warheads are tested by Sandia; tests intended to examine a device's nuclear design are generally conducted at Los Alamos, Livermore, or the Nevada Test Site.

Computers. DOE's computing capabilities extend far beyond the province of archiving existing data. New computers whose capabilities are orders of magnitude beyond earlier models, not to mention those of the slide rules used by the early bomb designers, are now available to DOE. Their characteristics include three-dimensional computing, so named because their vast "massively parallel" capabilities should allow realistic representations of all three dimensions of an exploding nuclear device. The computers can be calibrated, at least partially, with data from actual nuclear tests, and their codes can then be applied to new problems.

In an era without testing, such predictive capabilities are clearly important. They will help DOE decide when weapons need to be rebuilt and whether a new or modified design is likely to work. They will also inform decisions about whether a defect in a given type of nuclear device can be repaired successfully (or needs to be repaired). DOE has typically discovered such defects at the rate of several per year in the past and expects to uncover them in the future as well.

Laboratory Design, Prototyping, and Experimentation. The laboratories are named as they are, rather than as think tanks or institutes, because they have major engineering and experimental facilities. Some components of weapons in the stockpile are produced at the laboratories today, particularly at Los Alamos and Sandia, and nearly all other components can be made in small numbers at the laboratories when necessary. As DOE's weapons production complex shrinks--with three major facilities ending operations in 1994 alone--the laboratories will take on a much greater role in making weapons components.

These components are diverse. They include timers, switches, detonators, neutron generators, fuzes, conventional explosives, casings for different parts of the weapon, safety devices to ensure that weapons go off only when intended and authorized, and "pits" or spherical shells of plutonium that form the key fissile element of most primaries in the U.S. arsenal today. Many of these components can be and are individually tested and replaced when necessary.

Experiments. The Department of Energy conducts several main types of experiments on nuclear weapons and their components. The first involves tests than can be safely undertaken in a laboratory; those tests are generally on individual weapons components rather than on integrated systems. Another type, largely done by Sandia, uses high-speed kinematic experiments and other approaches to test the effects of movement and impact on certain parts of a warhead.

A third type, bombardment of warheads with neutrons and subsequent analysis of the scattering of those neutrons, is not yet widely employed in stewardship operations. If used for such purposes more often in the future, it could become an important element of stockpile stewardship. This type of experiment would involve the Los Alamos Neutron Scattering Center (commonly called LANSCE), working in conjunction with the Los Alamos Meson Physics Facility, or LAMPF. The properties of the neutrons that emanated from the warhead would reveal information about its characteristics, including the effects of aging on its material components, without destroying the warhead.

A fourth type of experiment uses intense beams of radiation to ensure that military systems--and space systems in particular--could withstand the effects of proximate nuclear bursts. The beams are similar to those emitted by an actual nuclear explosion. DOE uses the existing Saturn facility at Sandia and a number of other facilities such as Los Alamos's Pegasus to generate X-rays and other phenomena characteristic of nuclear explosions. It hopes to build an additional major facility at Sandia, known as Jupiter, to expand its capabilities in these realms.

A fifth class of experiment involves explosive tests of mock nuclear warheads to verify the timing and coordination of different events during an explosion, to learn how a warhead's conventional explosives would compress its fissile material, or to test for safety by simulating accidents and other unplanned events. By studying the propagation of shock waves, the compression of plutonium pits, and the interaction of surfaces of different materials, weapons designers can learn more about whether an actual bomb of similar dimensions would function properly. These experiments are of two types: hydrodynamic and hydronuclear. The former have been done for years; the latter were emphasized during the 1958-1961 nuclear test moratorium but are not currently being conducted.

Hydrodynamic experiments use mock nuclear warheads without the isotopes of fissile material that are in actual bombs. To improve the usefulness of such tests, DOE is constructing a new facility, the Dual-Axis Radiographic Hydrotest (DARHT) facility, at Los Alamos. Conceived by scientists at both Livermore and Los Alamos and scheduled for completion in 1997, it will replace the aging and less capable PHERMEX facility at Los Alamos. DOE also plans to upgrade the Flash X-ray (FXR) facility at Livermore's "Site 300." In several years, DOE may build an Advanced Hydrotest Facility (AHF) intended to take multiple X-ray "snapshots" of an imploding weapon along several axes.

Hydronuclear experiments, by contrast, use mock nuclear warheads with some fissile material. During the 1958-1961 moratorium, at least 35 of the experiments were done at the Los Alamos National Laboratory and the Nevada Test Site.[1] The devices used in such experiments are similar to real bombs. Indeed, they must be, since the purpose of the experiments is to test the start of neutron generation in the fissile material (before the deuterium-tritium boosting would begin in the primary of a real warhead). Such tests might contribute to counterproliferation efforts by helping DOE investigate how certain basic types of nuclear weapons not in the U.S. arsenal might be rendered inoperable.

In hydronuclear experiments, nuclear reactions occur and produce a very small explosive energy, or "yield." But the nuclear yield would be no greater than the energy released by the conventional high explosive in the warhead--no more than a few tens of pounds of TNT equivalent. Such experiments could be done in numerous ways. For example, actual warheads could be modified so that they would not produce substantial amounts of nuclear

1. Robert N. Thorn and Donald R. Westervelt, "Hydronuclear Experiments," Report LA-10902-MS (Los Alamos, N.Mex.: Los Alamos National Laboratory, 1987), p. 6.

yield--even though they might approach or briefly exceed critical mass, in which neutron generation increases through a chain reaction. They might, for example, be injected with an inert gas at the core of the plutonium pit. As the conventional explosive began to cause such a pit to compress, its progress toward high density--and thus its yield--would be limited by the presence of the inert gas.

Such experiments could raise particular technical and political concerns in the context of a comprehensive test ban treaty. For one thing, they would produce a nuclear yield, albeit a very small one. Also, they would disperse plutonium if conducted underground at the Nevada Test Site (though the laboratories might be able to contain them in the same types of metal shells used in some hydrodynamic experiments). Finally, certain types of hydronuclear experiments could carry a remote risk of producing a substantial nuclear yield if they were not properly undertaken. Thus, they are contentious. Because of their political sensitivity, both domestically and in the context of negotiations toward a CTBT, official U.S. policy on hydronuclear tests is still being debated; it condones them in a broad sense but has not yet authorized specific tests.

The Administration's stewardship program is effectively based on the assumption that a sixth type of experiment--nuclear testing--will not be employed in the future. This assumption is consistent with the current U.S. moratorium on nuclear testing and the Administration's active efforts to negotiate an international comprehensive test ban treaty on all nuclear explosions at the U.N.-sponsored Conference on Disarmament in Geneva, Switzerland. However, the Administration is planning to maintain readiness at the Nevada Test Site to resume testing within two to three years should negotiations fail or other unforeseen developments lead the United States to change its policy.

Another approach to readiness, perhaps dubbed cold readiness, might store equipment at the site without maintaining it in active working order and without maintaining crews to run it. Under this approach, some five years of funded activity might be needed to resume testing, and perhaps several more to regain a high degree of competence.

Inertial Confinement Fusion

Another element of stewardship is research on inertial confinement fusion (ICF). ICF allows study of hot, dense plasmas that bear some similarities to those in thermonuclear weapons. In addition, ICF can provide a useful means of preserving experimental skills and of calibrating and improving codes for weapons design. Eventually, ICF might also produce payoffs in the realm of fusion-derived electrical energy. But the current focus of the program is on weapons applications and will remain so in the short to medium term. Major ICF research facilities are located at Lawrence Livermore National Laboratory (involving the so-called NOVA laser), the University of Rochester, and the Naval Research Laboratory.

According to budget documents from the Department of Energy, the costs of construction and capital investment for ICF will exceed $100 million a year during the late 1990s and in the early years of the next decade; after that, substantial operations costs would be incurred. The chief driver of those increased costs would be the National Ignition Facility, a laboratory that would be much larger than those currently in operation and that is projected to cost roughly $620 million to $830 million. At NIF, scientists would attempt to create a sufficient density and temperature of deuterium-tritium gas such that the atoms in that gas would join together to form helium and release large amounts of energy. In the process of attempting to push these technologies forward, scientists have acquired further insights not only into fusion in nuclear weapons, radiation transport, and implosion but also in the fields of optics, lasers, lithography, and even astrophysics. Livermore's NOVA laser, for example, is a highly effective and state-of-the-art facility for ICF research.

Inertial confinement fusion uses huge lasers to create extremely short and intense bursts of energy aimed at very small enclosed targets of mixed isotopes of hydrogen. For NIF, which would be the country's state-of-the-art ICF facility, the bursts of energy would last on the order of 10^{-10} seconds.

ICF's approach to controlled fusion is different from that of magnetic confinement fusion, in which a much larger but much more diffuse plasma of ionized hydrogen is contained by a magnetic field as it fuses over a longer period (on the order of seconds). In magnetic confinement fusion, plasma densities are on the order of 10^{16} molecules per cubic centimeter, in contrast to roughly 10^{26} in the planned NIF. The characteristics of ICF may make it less promising in the long term as a source of commercial energy, though a recent study by the National Academy of Sciences endorsed NIF because of its value in fusion research.[2]

2. National Research Council, National Academy of Sciences, *Second Review of the Department of Energy's Inertial Confinement Fusion Program, Final Report* (Washington, D.C.: National Academy Press, 1990). See also Fusion Policy Advisory Committee, *Final Report* (Department of Energy, 1990).

Technology Transfer and Cooperative Projects with Private Industry

Cooperative research and development agreements involve a roughly equitable contribution of personnel, facilities, and money between private industry and a DOE laboratory. Since 1991, when the program began, nearly 300 projects have been initiated, representing a total value to date of about $1 billion and an annual DOE budget that now exceeds $200 million. Proposed legislation would allow DOE to use up to 20 percent of its weapons RD&T budget--or more than $300 million a year--for such purposes.

CRADAs are intended to focus on technologies with potential commercial applications that would also yield new insights into weapons science, nuclear physics, or critical technologies. Examples of ongoing CRADAs include projects on the properties of metals, aerodynamics, computer software for secure financial transactions, computer modeling of certain complex physical phenomena, the uses of new types of X-rays to study subjects ranging from explosives to human health, cleanup and final disposition of environmental waste, and the development of flat-panel computer displays.

ALTERNATIVES TO THE ADMINISTRATION'S PLAN

What alternative approaches to stockpile stewardship might the Congress consider, either to redress likely budgetary shortfalls or to help change U.S. military doctrine in a manner that places less emphasis on nuclear weapons? The rest of this paper addresses this question by developing and analyzing three options. The first two would reorient the stewardship program without changing it fundamentally and would result in modest savings after a few years. The third option would represent a program of substantially smaller scope, capability, and cost.

CHAPTER III

OPTION 1: STOP NUCLEAR AND HYDRONUCLEAR TESTING BUT STRENGTHEN BASIC STEWARDSHIP AND RETAIN DUAL-PURPOSE ACTIVITIES

This option would end work related to nuclear weapons at the Nevada Test Site (NTS) over a two-year period. The Department of Energy would not only continue the moratorium on nuclear explosive tests but would also relinquish the ability to resume testing within two to three years. In addition, it would lose the capability to conduct hydronuclear tests at NTS. But the option would increase funding for basic activities within the stockpile stewardship plan--notably those for computation, laboratory experiments on various components of nuclear weapons, hydrodynamic testing, and surveillance of warhead components through techniques ranging from disassembly and visual inspection to neutron bombardment. Finally, the option would continue funding for DOE's weapons-related research programs that also yield or might someday yield commercial benefits (specifically, the National Ignition Facility and cooperative research and development agreements with private industry).

In the first year, this option would continue to sustain a physical infrastructure and a cadre of technical experts capable of readily resuming nuclear tests at the Nevada Test Site. However, by 1996--assuming that a comprehensive test ban treaty enters into force by that point--funding for readiness would end. Any future decision to resume testing, however unlikely that might be, would require that many elements of a testing capability, particularly trained manpower, be reconstituted at that time, and doing so would entail considerable delays and additional, uncertain costs.

BUDGETARY IMPLICATIONS

How much would this approach to stewardship cost? As explained in greater detail below, this option has two variants. One would combine cuts at the Nevada Test Site with an increase in funding for basic stewardship of $20 million in 1995, $40 million in 1996, and $60 million a year thereafter. The other would combine the same cuts at NTS with increases in funding for basic stewardship that were twice as great.

Under the first variant, there would be no net savings in 1995, modest savings of $10 million in 1996, and savings of $80 million a year relative to the Administration's plan thereafter. Under the second, net costs would be incurred in 1995 and 1996, totaling $20 million and $30 million, respectively.

Beginning in 1997, however, savings of $20 million a year would be realized (see Table 5).

Policy Changes That Would Reduce Costs

Savings at NTS would result from canceling readiness for testing, ending funding for hydronuclear experiments, and making modest cuts in funds for infrastructure. Funds for the current readiness program could be eliminated; those funds sustain capabilities in drilling, diagnostics, and other specialized activities related to conducting nuclear explosions and are projected to total about $75 million in 1995. In addition, some $40 million in planned annual expenditures for conducting experiments such as hydronuclear tests at NTS would no longer be needed.

DOE would need to retain most of the infrastructure--roads, electricity, a fire department, and the like--in order to ensure security, provide radiological monitoring, and so on even if nuclear explosions stopped permanently (though at some point these costs might be passed on to other DOE programs, such as the Yucca Mountain repository for radioactive waste from commercial energy production). Thus, at least in the short term, permanently ending hydronuclear and nuclear tests would save DOE only some $25 million out of a total budget for staff and infrastructure of $145 million.

In sum, in 1995, when only hydronuclear tests and some personnel would be affected by this option, about $20 million would be saved. In 1996, although readiness would be ended, separation payments associated with layoffs would limit savings to about $50 million. Beginning in 1997, a total of $140 million a year would be saved at NTS (see Table 5).

Policy Changes That Would Increase Costs

How much would the added funds for basic stewardship total? In view of the lack of detailed information with which to make its calculation, the Congressional Budget Office (CBO) used a high and low estimate based on information obtained from laboratory officials. George Miller, Associate Director for Defense Systems and Nuclear Design of the Lawrence Livermore National Laboratory, estimated that weapons research, development, and testing, if fully funded, would require roughly $1.95 billion a year--some $250 million above the assumed level of $1.7 billion that CBO has taken as the Administration's plan for 1996 and beyond.

TABLE 5. BUDGETARY IMPLICATIONS OF OPTION 1: ELIMINATE READINESS FOR TESTING AND HYDRONUCLEAR EXPERIMENTS AND INCREASE FUNDING FOR BASIC STEWARDSHIP (In millions of dollars of budget authority)

	Costs Relative to Administration's 1995 Plan					Five-Year
	1995	1996	1997	1998	1999	Total
Eliminate Readiness for Testing and Hydro-nuclear Experiments	-20	-50	-140	-140	-140	-490
Increase Funding for Basic Stewardship[a]						
Lower increase	20	40	60	60	60	240
Higher increase	40	80	120	120	120	480
Total Costs						
Lower increase	0	-10	-80	-80	-80	-250
Higher increase	20	30	-20	-20	-20	-10

SOURCE: Congressional Budget Office based on data from the Department of Energy's budget request for 1995 as well as briefings provided by the DOE Nevada Operations Office, Los Alamos National Laboratory, and Lawrence Livermore National Laboratory.

a. Includes advanced computations, surveillance of warheads and their components, laboratory experiments on components, and hydrodynamic testing.

A similar message about the need for more funding, though not necessarily of the same large amount, can be heard elsewhere in the laboratory system. For example, at Los Alamos, CBO analysts were told that the laboratory had calculated its current needs at $60 million above the 1994 level. This price tag provides a reasonable lower estimate of what it might cost to strengthen DOE's basic stewardship activities; in its budget estimates, CBO phases in this funding over three years in equal $20 million increments, so that full funding is achieved by 1997.

However, the $60 million figure is confined to Los Alamos. Do Livermore and Sandia require more money as well? Miller's estimate of a $250 million shortfall for weapons RD&T does not provide a basis for calculating DOE's unmet needs for basic stewardship activities; that amount encompasses not just basic stewardship but also activities and facilities such as the National Ignition Facility and hydronuclear experiments at the Nevada Test Site. Moreover, neither Livermore nor Sandia provided the Congressional Budget Office with estimates about their needs for basic stewardship activities.

In the absence of specific data, this analysis assumes that a reasonable higher bound on the added budgetary requirements for basic stewardship activities might be $120 million a year. Such a funding level would permit DOE to provide additional funding of $60 million a year to Livermore as well as to Los Alamos; alternatively, the funds might be divided between the three laboratories in some manner. In its budget estimates, CBO phases this funding in over three years.

Net Savings

Were the lower amount of $60 million added to basic stewardship, this option would produce net savings of $80 million a year from 1997 on. However, there would be no savings in 1995 and only $10 million in savings in 1996.

Savings would be lower if $120 million a year was added to basic stewardship activities. If the laboratories were accorded a full $120 million a year in added funds for these purposes, phased in by 1997, savings would be $20 million a year into the indefinite future. In 1995, added costs would total $20 million, and in 1996 they would reach $30 million before savings began to accrue the next year (see Table 5).

PROS AND CONS OF ENDING NUCLEAR AND HYDRONUCLEAR READINESS AT THE NEVADA TEST SITE

Eliminating the readiness to resume testing and the ability to conduct hydronuclear experiments at the Nevada Test Site might be a viable policy option for the Congress to consider.

Arguments for Ending Readiness

The United States has determined that pursuing a comprehensive test ban treaty is a useful way to improve the diplomatic prospects of renewing the Nuclear Non-Proliferation Treaty and to raise the technical and political obstacles that any country wishing to develop nuclear weapons would need to overcome. As such, it has observed a moratorium on nuclear testing since September 1992 and plans to continue to do so through September 1995. As the world's preeminent conventional military superpower, the United States arguably has much more to lose from nuclear weapons and their further development than it has to gain from them. If adopting Option 1 and making a firm decision to stop all forms of hydronuclear and high-yield nuclear testing at NTS reinforced existing policies--even if only for its symbolic and diplomatic benefits--it might be a prudent policy.

With a large and diverse stockpile that can be certified as quite reliable through means not involving nuclear explosions, moreover, the United States may not need the ability to resume testing quickly in order to retain a strong deterrent even if CTBT negotiations languish or fail. And it has such a large body of experience with testing that other countries may feel they are being asked to give up much more than is the United States by abandoning nuclear testing at this particular point in history.

Under this approach, the U.S. nuclear arsenal would be kept dependable not through testing but through other activities such as surveillance, computation, and above-ground experiments on components of weapons. DOE documents suggest that these activities ultimately are more critical than hydronuclear testing for the basic purposes of stewardship.[1] Hydronuclear tests have important limitations--for example, they do not permit direct study of deuterium-tritium boosting, one of the more complicated processes designed to occur in warheads in the U.S. nuclear arsenal. Boosting typically

1. See Department of Energy, "Summary of Nuclear Weapons Stockpile Stewardship Conference," held January 31-February 2, 1994, at Sandia National Laboratories, Albuquerque, New Mexico, organized by DOE's Office of the Assistant Secretary for Defense Programs (March 1994), p. 4.

increases the yield of a primary by an order of magnitude; without it, the primaries in most of today's U.S. nuclear warheads would not produce sufficient X-ray energy to ignite the secondary of the weapon, and the resulting fission explosions would produce nuclear yields well below those of the Hiroshima and Nagasaki devices (which produced yields of roughly 12.5 kilotons and 22.0 kilotons, respectively).

Moreover, a number of weapons experts within and outside the laboratories argue that certain types of fission devices are quite simple to build and do not require testing to provide a high-confidence deterrent. They tend to make this argument most forcefully in regard to so-called gun-assembled weapons using uranium 235 (of the type used on Hiroshima), but they also believe that so-called solid-pack (of the type tested in the Trinity test and dropped on Nagasaki) and even levitated-pit devices might be built with quite high confidence in their reliability without testing.[2] This judgment is bad news for the cause of nuclear nonproliferation since other countries might be able to develop fission weapons without ever conducting nuclear tests. But it is strong evidence that the United States need not doubt its ability to retain indefinitely some kind of nuclear deterrent even under a comprehensive test ban.

Whatever contributions hydronuclear testing could make to improving the safety of the U.S. arsenal or understanding how to counter the fledgling nuclear arsenals of proliferating countries would be sacrificed under Option 1. However, today's U.S. nuclear arsenal is smaller, safer, and generally on a lower state of alert than those of past years. Thus, further improving its safety may not be a pressing priority. Also, if the United States hoped to use the knowledge gained from hydronuclear testing to counter proliferation of nuclear weapons, it would need to locate the nuclear weapon or weapons in question--generally assumed to be an extremely difficult proposition.

What about the need to hedge against violations of a CTBT by other countries? Even if the United States abandoned active readiness and put its equipment in long-term storage, it probably would retain the ability to resume nuclear tests within a half-decade or so. Significant obstacles would need to be overcome--the need to rejuvenate equipment, rehire and retrain technicians, and, perhaps most of all, comply with increasingly strict environmental laws before being allowed to resume underground nuclear explosions. During

2. In gun-assembled devices, high explosives propel a hemisphere of uranium into contact with another similar hemisphere to produce a critical mass. In solid-pack devices, explosives compress a spherically symmetric body of fissile material, which then reaches critical mass. In levitated-pit devices, a space is maintained between the fissile pit and the high explosive before detonation. When the high explosive is fired, it propels a tamper that achieves a substantial speed before striking the pit--increasing the efficiency with which the pit is compressed.

this period of preparation, budgetary costs would be substantial and rather unpredictable, quite likely exceeding their current levels. But the process of restoring a capability to conduct nuclear tests, though lengthy, would probably not pose intractable problems.

Arguments for Retaining the Capability to Conduct Tests and Hydronuclear Experiments

A permanent end to testing that involves both nuclear detonations and hydronuclear techniques would not be without critics. Whether or not the ability to resume testing quickly can strongly influence countries' decisions to accept a CTBT, it arguably is a relatively inexpensive and benign precaution. At a time of general downturn in U.S. military spending, moreover, remaining military policies may take on a special symbolic importance beyond their technical merits. Retaining readiness also may be preferable to the United Kingdom, since it has relied on NTS for its nuclear tests. Even if no further U.K. or U.S. tests were conducted at NTS, there might be diplomatic benefits to retaining readiness for a time until testing doctrine has a chance to change more fundamentally in London.

Moreover, conducting hydronuclear tests might also serve as an important, if imperfect and limited, proxy for more traditional nuclear testing. This role of hydronuclear testing could be especially important in the period before completion of the Dual-Axis Radiographic Hydrotest facility and its likely successor, the Advanced Hydrotest Facility. A DOE conference on stockpile stewardship held in early 1994 confirmed this judgment, indicating that hydronuclear tests, though perhaps not as critical as computations and above-ground experiments, could be significant, particularly in the next few years. For example, they may be able to demonstrate that a certain type of accident would not cause a given warhead to detonate. If by contrast it was determined that such an accident would cause the warhead to detonate, remedial steps could be taken. Such steps might include rebuilding the warhead, temporarily modifying the warhead to render it incapable of exploding during normal day-to-day operations (which was once done for a nuclear artillery shell, according to a weapons physicist currently working at Livermore), and changing operational and handling procedures (as was done for the W88 warhead on the Trident II submarine-launched missile).

Despite DOE's judgment that hydronuclear testing is probably not among the top priorities within the stewardship program, some weapons physicists and bomb designers, particularly at Los Alamos, attribute substantial importance to this technique. Because many of the defects found in warheads have been systemic--involving the interaction of different materials such as high explosives and plutonium--realistic testing was needed to assess their importance. Hydronuclear testing is one such realistic tool, among the best (short of full nuclear explosions) for diagnosing certain types of problems.

Hydronuclear testing could be valuable, for example, in assessing the chemical high explosive that would compress the plutonium pit in the primary of a warhead. DOE has discovered major problems with the high explosives in warheads in the past and may encounter such problems again. In one scenario, DOE might use a new type of high explosive to modify or rebuild a warhead in the future. The explosive might be more environmentally sound but might also have slightly different characteristics than existing types (such as particulate "grain size"). Such differences might not be allowable under the concept of identical remanufacture but might not be totally unavoidable either (even if DOE could obtain a waiver, based on national security considerations, from any environmental and worker safety laws that applied). Yet those differences could cause concerns about a warhead's performance. To avoid or at least delay this type of risk, the laboratories might elect to keep the original high explosive in a warhead as long as possible. Doing so, however, could raise concerns about safety and reliability as well, and hydronuclear testing might be useful in investigating them.

Addressing such potential scenarios with complete confidence requires a nuclear test, since it is only under those conditions of temperature, pressure, and radiation that certain phenomena occur. As recently as two years ago, DOE flatly stated that the United States would require some nuclear testing as long as it retained a nuclear arsenal. Although this conclusion has been reconsidered, apparently in light of the political priority of negotiating a comprehensive test ban treaty, it underscores the need for highly realistic testing. Hydronuclear tests, though certainly not a perfect technical substitute for actual explosions, can allow scientists to observe the initiation of certain processes that are so critical to the actual functioning of a nuclear weapon.

PROS AND CONS OF INCREASING FUNDING FOR BASIC STEWARDSHIP

The weapons laboratories are no longer designing new weapons. For the indefinite future, they will focus primarily on monitoring and responding to the effects of aging and any possible small changes in the Department of Defense's requirements on existing warhead types. Those efforts are important but may be considerably less difficult than figuring out ways to make new bombs smaller, more powerful, more specialized in their effects, or more capable of new missions such as driving X-ray lasers or penetrating the ground before they detonate.

However, the end to testing of nuclear weapons in the kiloton-range has removed an important tool from the bomb designer. DOE can no longer carry out the ultimate assessment of a nuclear weapon. Although most nuclear tests were not used to ensure the reliability of existing warheads, they sometimes were used to investigate safety or to understand the effects of any defects that arose or were suspected several years after a bomb had entered the U.S. inventory. As such, eliminating nuclear tests substantially increases pressure on other types of tests. Yet recent budget cuts have already pushed at least one laboratory--Los Alamos--below the minimum level of employees it has established for fulfilling its responsibilities for such elements of stockpile stewardship under current policy.

Some people argue that a number of these potential problems could be alleviated by using simpler bomb designs. But at present, Presidential direction and the Department of Defense have not substantially relaxed their demands on DOE; requirements for high-yield, low-weight, and small-volume warheads remain in place. At least some of today's designs seem likely to remain in the arsenal indefinitely. Under all these assumptions, it seems reasonable to consider increased funding for the laboratories' core stewardship activities.

CHAPTER IV

OPTION 2: CURB DUAL-PURPOSE ACTIVITIES BUT STRENGTHEN BASIC STEWARDSHIP AND RETAIN CAPABILITY FOR HYDRONUCLEAR TESTING

Like Option 1, Option 2 would provide greater funding for basic stewardship activities--advanced computations, surveillance of warheads and their components, laboratory experiments on components, and hydrodynamic testing. But its philosophy would depart from that of Option 1 in that its budgetary resources would, as their next priority, fund other activities directly focused on the existing arsenal of warheads. Notably, hydronuclear tests at the Nevada Test Site would be fully funded under this option but would not be conducted until the President authorized them.

This option would place a lower priority on dual-purpose activities--those of general relevance to nuclear weapons physics that are also being pursued for their commercial and scientific benefits. In particular, this option would cancel the National Ignition Facility and would reduce by one-third today's budget of about $220 million a year for cooperative research and development agreements. In order not to break any existing contracts, money would be reduced incrementally over a two-year period. The cut in funding might be realized either by keeping the current cost-sharing formula between industry and the Department of Energy but reducing the number of projects (or their size) or by changing the cost-sharing formula. Business, and particularly large businesses and consortia, might, for example, be asked to pay two-thirds of all costs rather than one-half (although DOE might retain the right to relax this formula for projects that appeared to be particularly important to the nuclear weapons program).

BUDGETARY IMPLICATIONS

The technical and budgetary dimensions of canceling the National Ignition Facility are quite straightforward. The facility would simply not be built, with no need for a substitute facility or any shutdown procedures for existing facilities. Savings would be small in 1995 but would become substantial in 1996 and reach an annual level of as much as $115 million later in the decade (see Table 6). They would remain nearly as large through the first several years of the next decade. In addition, operating savings could be expected thereafter.

TABLE 6. BUDGETARY IMPLICATIONS OF OPTION 2: CANCEL NATIONAL IGNITION FACILITY, REDUCE FUNDING FOR COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENTS, AND INCREASE FUNDING FOR BASIC STEWARDSHIP
(In millions of dollars of budget authority)

	Costs Relative to Administration's 1995 Plan					Five-Year
	1995	1996	1997	1998	1999	Total
Cancel National Ignition Facility	-5	-35	-60	-115	-115	-330
Reduce Funding for Cooperative Research and Development Agreements with Private Industry	-35	-70	-70	-70	-70	-315
Increase Funding for Basic Stewardship[a]						
Lower increase	20	40	60	60	60	240
Higher increase	40	80	120	120	120	480
Total Costs						
Lower increase	-20	-65	-70	-125	-125	-405
Higher increase	0	-25	-10	-65	-65	-165

SOURCE: Congressional Budget Office based on the 1995 budget request of the Department of Energy as well as briefings provided by the DOE Nevada Operations Office, Los Alamos National Laboratory, and Lawrence Livermore National Laboratory.

a. Includes advanced computations, surveillance of warheads and their components, laboratory experiments on components, and hydrodynamic testing.

These budget estimates are based on the assumption that NIF would cost about $725 million to build--the halfway point between the $620 million figure quoted by DOE in the past and the $830 million estimate that Lawrence Livermore National Laboratory recently conveyed to the Congressional Budget Office. Given the uncertainty surrounding these cost estimates, NIF's total price tag--as well as the year-by-year funding stream for its construction--clearly could vary from what CBO has assumed.

Savings from curbing CRADA activities under the technology transfer program would be equally straightforward to calculate. In order not to disrupt any existing contractual obligations, the savings might be phased in over the next two years in two equal increments. Relative to the Administration's current plan, savings would total $35 million in 1995 and $70 million a year from 1996 onward.

Canceling the NIF and reducing the program for cooperative research and development agreements together would save about $40 million in 1995, $105 million in 1996, $130 million in 1997, and $185 million in both 1998 and 1999. But these gross savings would be partly canceled out by increased funding for basic stewardship. When combined with the higher range of the added costs for basic stewardship discussed in Option 1, they would not produce substantial net budgetary savings until 1998. But when combined with the lower range of that added funding level--$60 million annually from 1997 on--they would result in net savings of $65 million in 1996, $70 million in 1997, and then $125 million in both 1998 and 1999.

PROS AND CONS OF CANCELING THE NATIONAL IGNITION FACILITY

Canceling the National Ignition Facility may permit significant budgetary savings in the stockpile stewardship program without disturbing the basic programs of greatest importance for ensuring the reliability of today's nuclear inventory.[1] NIF would provide a less direct means of ensuring reliability than do hydrodynamic testing, computations, and basic laboratory experiments. Inertial confinement fusion can produce insights into fusion processes in a thermonuclear weapon, but its ability to do so is indirect and, ultimately, rather limited.

Hundreds of thermonuclear tests have been conducted under the U.S. test program, and a variety of thermonuclear weapons have entered the

1. For a discussion of the pros and cons of increasing funding for basic stewardship, see pages 28-29.

stockpile. In very few cases have fusion processes caused unexpected trouble in weapons.

By departing somewhat from the concept of identical remanufacture, it might be possible to gain even more confidence in the performance of weapons' primaries. Some primaries might be modified slightly to have more plutonium than is required in existing thermonuclear weapons. However, doing so might, in some cases, reduce safety against unintended detonations. Moreover, not all weapons physicists concur that this approach would, in the absence of nuclear testing, have the effect of increasing confidence in the arsenal; some believe such changes could even lower confidence.

Perhaps more usefully, simpler designs might be added to the arsenal as insurance against major problems that might develop in existing warheads. Some of those designs might weigh more than existing warhead types, but they still could be deployed on existing delivery vehicles if each vehicle carried fewer warheads (a trend that is expected to occur as a result of the strategic arms reduction treaties).

Without the National Ignition Facility, the nuclear weapons program might lose some of its appeal and be less able to attract highly qualified scientists and keep them sharp and creative. But a host of other missions would remain: CRADAs; ICF research at existing facilities, at least for a time; and remaining parts of the nuclear weapons research, development, and testing program such as advanced computations and research on explosives. In addition, in the short term, laboratory experts could archive experimental data and perhaps do some paper design work on simple and robust warhead designs in case the United States someday decides to add one or more new types of warheads to a post-testing arsenal. In perhaps a decade, they could begin work on an Advanced Hydrotest Facility at which hydrodynamic and perhaps hydronuclear experiments could be carried out.

In addition to those important tasks that bear directly on the nuclear arsenal and nuclear weapons physics, laboratory personnel could perform research in other areas of physics and technology. Perhaps most important from a national security perspective would be work on nonproliferation, intelligence, verification, and arms control.

Important caveats accompany any suggestion to cancel the National Ignition Facility, however. Doing so would significantly impinge on the basic scientific character of work done at the laboratories. The Administration's science-based stewardship approach places a high premium on retaining top-notch physicists by providing them with challenging work within the nuclear weapons program. Rather than take an alternative approach, in which part-time bomb designers might do other physics that helps to keep their weapons skills sharp, the Administration's plan has a number of research projects funded within nuclear weapons RD&T. Arguably, offering scientists state-of-the-art experimental work on physics problems with substantial relevance to the behavior of secondaries would increase their propensity to remain within DOE's weapons program. In the process, NIF would allow improvement and calibration of certain nuclear weapons computer codes used to understand the physical processes in existing, modified, or new warhead designs.

Performing important research on subjects such as nonproliferation, arms control, and intelligence may keep very good physicists within the laboratories and DOE's Atomic Energy Defense Activities program. But these tasks may also require a somewhat different set of skills and thus may not keep scientists as sharp in nuclear weapons physics. Although the skills and expertise for designing nuclear weapons are indispensable in nonproliferation research, the knowledge required in laser technology, sensors such as synthetic-aperture radars and multispectral imaging systems, "chemical forensics," and satellite technology may pose even greater challenges to researchers.

Not only might findings from NIF be highly relevant to a better understanding of the physics of thermonuclear weapons, but civilian technology could reap substantial benefits. Expectations of using nuclear fusion as a near-term energy source are no more optimistic now than in the past, and even NIF would remain several technological generations short of what would be required to produce commercial nuclear energy. Nonetheless, any success in this area would be of monumental importance for the economy and the environment. Research on inertial confinement fusion may thus deserve support irrespective of the insights it may provide about weapons physics--if indeed the scientific community believes that this research holds out a reasonable long-term prospect of success, as the previously noted report from the National Academy of Sciences suggests it does. And in the meantime, such research can contribute to progress in laser technology, optics, and other related fields, as the ICF program has already done.

PROS AND CONS OF REDUCING FUNDING FOR CRADAs

By returning funding for cooperative research and development agreements to roughly the 1993 level, a program that has grown very rapidly from zero to a substantial share of the nuclear RD&T budget would undergo a pruning that may yield useful economies without harming the most promising avenues of research. It would also place firm limits on growth in a program that, if not carefully watched, could weaken the weapons program and cause at least some deleterious effects in the private sector by aiding some firms to the competitive detriment of others.

Given the relatively modest size of its budgetary cuts, this option would probably not have major negative consequences for stewardship of the stockpile. CRADAs could still help to maintain the competencies of the core weapons RD&T program in ways that yield good benefits for the dollar. Two-thirds of today's dedicated funding for CRADAs would continue, allowing the laboratories to help produce commercial benefits for the economy using technologies, knowledge, and institutions developed at an earlier time at taxpayers' expense. The resulting level of $140 million in annual funding would equal the level attained in the budget for 1993, the last budget passed during the Bush Administration.

Technology transfer between the laboratories and the private sector is not a new phenomenon and does not depend exclusively on a dedicated CRADA process. Indeed, the nuclear weapons program continues to support certain collaborative efforts with industry out of its own core budget--albeit at a level measured in the millions or tens of millions of dollars a year, in contrast to the CRADA figure of over $200 million. Such efforts, when seen as being clearly in the interest of core competencies of the nuclear weapons program, would be unaffected by this option.

The CRADA program would be recognized first and foremost as a nonweapons effort. Any further support for technology transfer would have to come from other sources and be justified on its nonweapons merits. But even as a nonweapons effort, CRADAs have some problems. A certain amount of unintended disruption to the market seems inevitable--particularly, perhaps, for small businesses, which do not always have the organizational abilities or market incentives to pool resources and stay apprised of ongoing work at the laboratories. Several firms have made this case, opposing CRADAs because of the risks posed to their businesses by projects that aid their competitors.

Any decision to reduce funding for CRADAs, however, would buck what seems to be an accelerating trend. Technology transfer is generally popular today within DOE and much of industry. DOE receives considerably more applications from industry than it can accept. Thus, the laboratories must rank the candidates based on the technical promise of their projects and their potential helpfulness to the weapons program. (The labs then send lists to Washington for official DOE approval and selection--a process that can be lengthier and more cumbersome than many people at the laboratories and in industry would prefer.)

Such an "industrial policy" intrinsically carries risks of political favoritism and disruption of the marketplace. However, reports from the laboratories suggest promising initial returns from the program and a high degree of professionalism on the part of those involved in choosing and carrying out the projects. Moreover, the laboratories reportedly are encouraging larger corporations to team with each other and form consortia in order to make more effective and fairer use of the CRADA process.

CHAPTER V

OPTION 3: CHANGE NUCLEAR DOCTRINE AND FOCUS A CORE STEWARDSHIP PROGRAM ON ONE DESIGN LABORATORY AND SANDIA

This option would combine the changes in laboratory missions and associated budget cuts discussed in Options 1 and 2. Thus, it would end all weapons-related activities at the Nevada Test Site; cancel the National Ignition Facility, which is intended to push the frontiers of nuclear weapons science; and reduce funding for cooperative research and development agreements with industry. It would also change the basic two-laboratory system under which the Los Alamos and Lawrence Livermore national laboratories have represented largely independent and complete nuclear weapons laboratories for most of the nuclear era. Like the other options, it would increase funding for basic stewardship, though only by the lower amount ($60 million a year).

Taken together, the changes under Option 3 are probably too major to be viewed as simply the sum of individual budget cuts and program terminations. They represent an approach to nuclear weapons stewardship that is substantially different from that of the Administration's plan. As described in this analysis, they derive from two main premises. At the broad strategic level, these changes presume that Presidential and Department of Defense requirements for the nuclear weapons arsenal will become no more challenging, and perhaps less challenging militarily, over time. At the technical level of stewardship, they draw heavily on the concept of identical remanufacture, which would have the weapons laboratories rebuild today's warhead types to the same technical specifications and with the same materials that were used in their original production. The option would allow certain deviations from a strict interpretation of identical remanufacture, but the basic precept would be simply to rebuild existing types of warheads as aging required it. Improvements in the warheads' performance, and in many types of safety features, would not be pursued.

DETAILS OF THE PROGRAM

Even a minimalist approach to stewardship would entail substantial numbers of physicists, engineers, machinists, chemists, and other specialists. They would need to maintain manufacturing capabilities and to ensure that all warhead specifications remained identical--which to the technician means within the same tolerances for error and imprecision that were allowed in the construction of the original devices.[1] Moreover, this option would retain the capability to make certain changes to warheads if absolutely necessary, driving up requirements for funding and personnel even further.

This approach to stewardship would retain most calculations and experiments. Warhead surveillance, various computer simulations, laboratory experiments on weapons components, and small explosive experiments would provide additional confidence that the reliability of the arsenal had not suffered. At the extreme, the concept of identical remanufacture would preclude all improvements in safety, but pragmatically speaking this option might allow certain types of changes under exceptional circumstances if they were deemed necessary.

The question remains whether one could ever assure remanufacture that was for all intents and purposes identical. Small changes in some characteristics of materials are nearly inevitable, even if one undertakes to rebuild a warhead exactly to specification. Because of this concern, many weapons physicists do not support the concept of identical remanufacture. Even if not adopted literally, however, that concept could be a useful conceptual pillar in an alternative stewardship plan. Especially for those elements of a warhead most difficult to make work properly, such as the high explosive and the plutonium pit, it might be sensible to assume that changes generally would not be made except in the most extreme circumstances.

Such a stewardship plan might, as an insurance policy of sorts, introduce one or two simple new designs to the arsenal (joining several existing types) to help ensure a basic retaliatory capability. Most bomb designers seem confident that it is possible to design simple, reliable fission bombs without testing them. Designing such weapons might further reduce the chances for a "common-mode" failure in which a key component found in all types of today's U.S. warheads might develop problems (most of these kinds of failures could be detected by nonnuclear experiments, but some might not be). If the President decided to proceed along this path, it might be wise to begin actual work on simple and highly reliable or robust designs soon, perhaps within the next decade or so. The process could then benefit from the experience of the current generation of weapons designers before they retired.

Unlike some proposals for consolidating the laboratories, Option 3 would not entail moving facilities from one site to another. Perhaps better viewed as streamlining rather than consolidating laboratories, it would retain

1. See the proposal by Ray Kidder and Richard Garwin, as described in Jonathan E. Medalia, "Nuclear Weapons Stockpile Stewardship," Report 94-418F (Congressional Research Service, 1994), pp. 52-56.

computational capabilities at the design laboratory whose mission was changing (and of course at the other laboratory as well). It also would keep peer review teams of weapons physicists who are able to provide independent assessments of the weaponry remaining in the stockpile and to contribute to research on verification, intelligence, nonproliferation, and counterproliferation.

Moreover, the option would sustain funding in the short term to allow completion of some useful experiments at the design laboratory being streamlined. Funding would also be provided at that laboratory to close facilities that were not needed and to clean up the sites at which they were located. The facilities needed for nonnuclear work--for example, research on high explosives--eventually would have to be funded out of different accounts if their likely benefit was deemed worthwhile. The option would also sustain current funding for Sandia's engineering and support work on nonnuclear parts of U.S. nuclear weapons.

Practically speaking, although both Los Alamos and Livermore are excellent weapons design laboratories, it would probably be simpler and cheaper to retain Los Alamos as the integrated design and stewardship laboratory. Los Alamos has a larger and more capable facility for processing plutonium, and upgrading the Livermore facility would be especially contentious in suburban northern California. Los Alamos also has more expansive grounds for various types of explosive experiments. Perhaps even more to the point, Los Alamos designed and remains responsible for most of the weapons in the enduring U.S. stockpile (8 of 10 main types or modifications and 80 percent of total warheads in the anticipated stockpile under the second Strategic Arms Reduction Talks Treaty).[2] By 1997, it will have the country's best hydrodynamic test facility, on which construction has recently begun. Also, some of its engineering and prototyping work uses facilities that will also be part of DOE's weapons production complex of the future, whereas Livermore will be less heavily involved in production work.

BUDGETARY IMPLICATIONS

Combining the elements of Options 1 and 2 would save $140 million a year at NTS, and $185 million a year in the NIF and CRADA programs by 1999. Further savings would result from the decision to scale back one of the two major design laboratories--roughly $100 million a year by the end of the decade. Total gross savings would thus reach $425 million a year by 1999.

2. Medalia, "Nuclear Weapons Stockpile Stewardship," p. 52.

But they would be phased in incrementally, and in addition would be partly canceled out by increased costs of about $60 million a year in order to fully fund basic stewardship activities. Thus, net savings from this option would be $60 million in 1995, $155 million in 1996, $270 million in 1997, $345 million in 1998, and $365 million annually from 1999 on (see Table 7).

To understand the savings involved in changing the mission of one of the two major design laboratories, take the case in which the Lawrence Livermore National Laboratory would no longer play the role of a full-fledged facility for nuclear weapons design and stewardship. How much of its planned $200 million annual budget for core weapons research, development, and testing activities could be cut under these assumptions? It would still need about $70 million in fixed costs just to maintain basic facilities. Several million dollars a year would be required for the individuals making up peer review and computational teams who would also provide in-house support to researchers on nonproliferation, arms control, and intelligence activities. Additional funds would support the designers who would move to Los Alamos. Those individuals would provide technical expertise for Livermore's B83 bomb and W87 missile warheads, which will remain in the U.S. arsenal. Thus, annual costs at Livermore and for former Livermore personnel could remain as high as $100 million even after this option was fully phased in. In other words, of a base of $200 million a year, DOE would eventually save about $100 million by curtailing the basic weapons mission of Livermore.

Such a policy should probably be put in place gradually. As noted, some ongoing experimental work might be well worth finishing at this point. In addition, preparing for an orderly transition to Los Alamos would take some time. Finally, a gradual process would facilitate stability at Livermore, which would remain highly important to the country for both defense and non-defense purposes under this approach, and would allow time for scientists to change career orientations or find jobs elsewhere.

Designating Livermore rather than Los Alamos the integrated stewardship laboratory would substantially reduce savings. A larger team of scientists would need to relocate from Los Alamos to Livermore than the reverse, given Los Alamos's disproportionately large share of the enduring arsenal. The Department of Energy would need a substitute site for plutonium work, perhaps at the Nevada Test Site. The Dual-Axis Radiographic Hydrotest facility, construction of which recently began at Los Alamos, would need to be started over at Livermore (though it might be canceled, with a successor to Livermore's existing Flash X-ray facility deferred until the Advanced Hydrotest facility could be built later in the decade). All told, savings might

TABLE 7. BUDGETARY IMPLICATIONS OF OPTION 3: FOCUS A CORE STEWARDSHIP PROGRAM AT ONE DESIGN LABORATORY AND SANDIA (In millions of dollars of budget authority)

	Costs Relative to Administration's 1995 Plan					Five-Year
	1995	1996	1997	1998	1999	Total
Eliminate Readiness for Testing and Hydronuclear Experiments	-20	-50	-140	-140	-140	-490
Cancel National Ignition Facility	-5	-35	-60	-115	-115	-330
Reduce Funding for Cooperative Research and Development Agreements with Private Industry	-35	-70	-70	-70	-70	-315
Eliminate Integrated Stewardship Capability of One Design Laboratory	-20	-40	-60	-80	-100	-300
Increase Funding for Basic Stewardship[a] (Lower increase)	20	40	60	60	60	240
Total Costs	-60	-155	-270	-345	-365	-1,195

SOURCE: Congressional Budget Office based on the 1995 budget request of the Department of Energy as well as briefings provided by the DOE Nevada Operations Office, Los Alamos National Laboratory, and Lawrence Livermore National Laboratory.

a. Includes advanced computations, surveillance of warheads and their components, laboratory experiments on components, and hydrodynamic testing.

be considerably less under such an approach. But moving the stewardship mission to Livermore should not be dismissed if DOE has reasons to think that Livermore can perform the stewardship function more effectively than Los Alamos.

PROS AND CONS OF RETAINING ONLY ONE DESIGN LABORATORY

Having only one of the two major laboratories acting as the custodian of the U.S. nuclear arsenal may now be acceptable. Only that laboratory would expend resources to research and build prototype warheads and test their physics packages on a component-by-component basis; Sandia National Laboratories would retain responsibility for many other parts of the warhead. The remaining design laboratory--operating in conjunction with Sandia--would become responsible for surveillance, component testing, computer simulation, and hydrodynamic testing of all warheads remaining in the arsenal regardless of whether they had been designed at Los Alamos or Livermore.

All three labs would, however, remain the principal repositories of the country's nuclear expertise. The laboratory that ceased to pursue design and integrated stewardship work would retain peer review teams and computational capabilities and would continue ongoing research on nonproliferation, nuclear safety, and verification. These activities together with CRADA projects might well be enough to retain excellent intellectual vitality at the laboratory whose mission had changed.

Moreover, by reducing the capabilities of the laboratories and lowering the priority placed on progress in nuclear weapons science, this option might promote arms control and reduce the role of nuclear weapons in U.S. military policy. Reducing the latent capacity to develop new types of warheads might enable U.S. nuclear weapons to be seen more clearly as a deterrent of last resort and less as a potential tool of warfighting.

The quality and reliability of U.S. nuclear weapons would be unlikely to suffer substantially under Option 3.[3] Although the approach would represent a significant change in DOE's plan for stewardship and in the basic functioning of the laboratories, it would retain the basic elements of stewardship and peer review. The peer review process might be enhanced by a vibrant two-laboratory system but may not require it. After all, Sandia has provided internal peer review for its contributions to U.S. nuclear weapons systems over

3. For a discussion of other pros and cons associated with this option, see pages 25-29 and 33-37.

the years; Los Alamos or Livermore might well be capable of doing more along those lines for the physics package of nuclear warheads. Under this option's fairly cautious approach to adopting a plan for stewardship that relied on only one design laboratory, however, the second design laboratory would continue to provide some peer review as well.

Even though the physics of nuclear weaponry is much better understood now, challenges remain, and any discussion of this type of option must recognize that. Most of the warhead designs now in the inventory have only a modest margin for error or degradation, since they are optimized to provide maximum explosive force in a given shape and at a given weight. Thus, it may be a useful insurance policy to have two independent teams of physicists and technicians together deciding which types of warheads should be retained, how any modifications dictated by safety or security concerns should be addressed, or which of the more reliable types of warheads--if any--should be built without testing in the future.

Moreover, even though the stewardship mission represents only about one-third of either laboratory's total budget and expenditure of effort, it is the main unifying mission at both Livermore and Los Alamos. A sense of coherence and integration at the laboratories has been critical since their inception early in the nuclear age and remains perhaps their chief defining characteristic. Their thousands of scientists are able to remain in close contact, working together on projects that require cooperation and interaction. Although it arguably would be desirable to have another mission of significant technical challenge and importance to unify and integrate one of the laboratories of the future, that mission is not yet clearly defined. Without it, the quality and integrity of either laboratory could suffer quite substantially. For the good of both the weapons stockpile and the laboratory system, some bomb designers place a high priority on retaining two design laboratories.

Finally, the laboratories already have made substantial progress in reducing overlap. They have not only substantially cut overall nuclear weapons RD&T budgets but have also begun to use the so-called lead lab concept. Under this approach, the processing of plutonium and uranium, detonator technology, reuse of plutonium pits, new inertial confinement fusion and hydrodynamic facilities, and a host of other activities and capabilities are now emphasized by only one laboratory or the other. That being the case, any decision to reduce the country's future investment in nuclear weapons technology would require more finesse than simply taking a knife to the weapons RD&T budget of one of the laboratories. It also would be likely to yield lower savings than such an approach would imply.