WEAPONEERS OF WASTE

A Critical Look at the Bush Administration Energy Department's Nuclear Weapons Complex and the First Decade of Science-Based Stockpile Stewardship

Principal Author
Christopher E. Paine

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INTRODUCTION

Among the many obstacles littering the road from the end of the Cold War to a less perilous world order, none seems more gratuitous or self-inflicted than the return of bloated U.S. nuclear weapons budgets, particularly when the nation is confronting the twin challenges of international terrorism and record budget deficits.

To the denizens of the Department of Energy's nuclear weapons complex, the sudden disintegration of the Soviet Union in 1991 was disorienting, even demoralizing. From the perspective of 1997, Los Alamos Director Sig Hecker recalled that when nuclear weapons budgets "decreased precipitously" from1990 to 1995, "our people were looking to get out of the nuclear weapons program. The production complex appeared hopelessly broken."[1]

However, in 1996 deliverance arrived for the nuclear weaponeers in the form of a new paradigm, called "science-based stockpile stewardship," which was devised not by anti-communist ideologues, but by centrist technocrats and senior scientific advisers seeking to ensure that the weapons lab offspring of the Cold War would outlive the conflict that spawned and nurtured them.

The old Cold War nuclear doctrine held that a nuclear arms race was necessary to prevent democracies from capitulating to communist totalitarians, whose ruthless leaders could only be "deterred" from "aggression" by nuclear "counterforce" threats of personal (and possibly preemptive) incineration in their underground command bunkers.

While this theory has had a resurgence of late, with Saddam or Osama in the role of the bunkered implacable, the stewardship paradigm for the nuclear weapons complex initially dispensed with the requirement for a credible nuclear target – none being readily at hand in the early-to-mid-1990s – or indeed any tangible intersection with real world conflicts. The quest for new nuclear weapons knowledge had to continue, we were told, because of its intrinsic interest to those charged with maintaining the present base of knowledge.

Without fresh "challenges," the nuclear weapons stewards might lose focus, become bored, and wander off the DOE reservation, and then where would we be? In other words, the nuclear arms race, at least technologically, would have to continue unilaterally, albeit quietly (without nuclear test explosions), so that the United States would always have a qualified cadre of people ready to … resume the arms race.

Portraying this tautological new paradigm as a "prudent hedge" against uncertainty appealed to middle-of-the road Clintonites, who were looking for politically respectable ways to neutralize opposition to the Comprehensive Test Ban Treaty negotiations thrust upon them by the Democratic Congress in 1992. They warmly embraced stewardship, as did many liberal and moderate mainstream supporters of the test ban treaty. Even traditional conservative boosters of the nuclear weapons complex seemed content to play along, using the program to shovel national security pork into their districts while they awaited the arrival of a more propitious political alignment, one in which they could dispense with arms control altogether.

From the low of $3.4 billion in FY 1995, U.S. spending on "nuclear weapons activities" rose steadily, reaching $5.19 billion (including allocated program administration funds) in FY 2001, the last budget prepared by the Clinton administration. Under the Bush administration, the upturn in nuclear weapons spending has continued, to $6.5 billion in FY 2004, far surpassing the $4.2 billion (in FY 2004 dollars) that represents the average yearly Cold War spending on these activities.

As one might imagine, the political changeover in 2000 was relatively seamless for the stewardship program, as the existing paradigm was easily assimilated into the Bush administration "capabilities-based" framework for developing future U.S. military power, unconstrained by plausible intelligence estimates of opposing threats. Indeed, with the election of the Bush administration, the nuclear weapons infrastructure *per se* was assigned a costarring role, along with nuclear-conventional "global-strike" forces and missile defense, as one "leg" in the "new triad" of American military power.

Under the Bush administration, the National Nuclear Security Administration – the quasi-independent agency within the Energy Department that runs the U.S. nuclear weapons complex – launched a "Readiness Campaign" to "revitalize the nuclear weapons manufacturing infrastructure" by improving both its "responsiveness" and its "technology base." Claiming marching orders from the Bush administration's December 2001 Nuclear Posture Review, NNSA asserted that "a truly responsive infrastructure is the cornerstone of the new nuclear defense triad." "To be considered a credible deterrent," NNSA stated, "this infrastructure must include a manufacturing capability with state-of-the-art equipment combined with cutting-edge applications of technology, and an ability to quickly provide modified or enhanced capabilities and products to meet emerging threats."[2]

Apart from its evident self-serving qualities, there are some logical flaws and artificial categorical imperatives lurking in NNSA's new deterrent construct. To be credible, nuclear weapons need not be produced with "state-of-the-art equipment" or "cutting edge technology." Indeed, President Bush professes to have invaded Iraq to forestall development of what clearly would have been a crudely produced nuclear explosive device, the threat of which he nonetheless found to be credible.

One is also hard-pressed to see how, absent far-reaching changes in the global security environment, the existence of modern production infrastructure *per se*, rather than actual weapons and forces, would be considered a "deterrent" to armed attack upon the United States or its allies and friends. If this were true, the administration should have no objection to eliminating the entire U.S. nuclear arsenal, and relying on America's fearsome industrial capability to reconstitute the arsenal to discourage cheating on a global nuclear disarmament regime. Of course, the Bush administration harbors no such intention, and its nuclear ideologists are merely throwing out the usual panoply of opportunistic arguments for beefing up U.S. nuclear capabilities.

NNSA seems to be reaching for a novel extension or reinvention of the concept of deterrence, one that is more accurately described as "dissuading" or "discouraging" potential rivals for global preeminence from even seeking to acquire nuclear weapon capabilities commensurate with those of the United States, not through mutual restraint imposed by treaties, but by projecting an aura of overweening permanent military superiority. This approach really has nothing to do with classic deterrence of nuclear attack through an assured survivable capability for nuclear retaliation, nor even with "extended" deterrence of conventional conflict through calibrated "not-incredible" threats to use nuclear weapons first. On the contrary, it is the kind of self-serving ideological claptrap that defense bureaucracies and their contractors have long indulged in to justify their existence whenever strategic irrelevance looms.

The confluence of political interests supporting stockpile stewardship has allowed it to escape serious congressional scrutiny for the better part of a decade. That is beginning, ever so slightly, to change, as members of Congress slowly gain an understanding of the Bush administration's aggressive nuclear program, including its current five-year plan to spend $485 million on development and production of a robust nuclear earth penetrating warhead (RNEP), and its proposal to spend $2 billion to $4 billion over the next 15 years on a Modern Pit Facility to manufacture new weapons.

Congress also may want to take a closer look at the hastily planned, exorbitant crash program to construct and equip nuclear weapons advanced simulation and computing (ASCI) centers at all three weapons laboratories at a cost of nearly $5 billion since FY 1996, with another $4 billion to be added through FY 2009. The original stockpile stewardship master plan was to have these massively parallel supercomputers run new three-dimensional weapon simulation codes, integrating detailed data from a raft of new or recently upgraded experimental facilities.

NNSA would use experiments at these facilities to confirm the predictive capabilities of the enhanced codes, "validating" their use in assessments of stockpiled weapons. Computer simulations would henceforth provide the integrated demonstration of weapon performance formerly provided by nuclear tests. That was the strategy DOE embarked upon in 1995, and it has been guiding the nuclear weapons program for the last decade. Where are the key components of that strategy today?

- The single most expensive component of the strategy is the massive National Ignition Facility (NIF) high-energy fusion laser under construction at Lawrence Livermore National Laboratory in California. DOE sold this mega-project to Congress in 1997 by saying it would be ready to begin the quest for fusion ignition in FY 2005 at a cost of $1.2 billion. In what looks like a classic bait-and-switch operation, NNSA has been trying to run away from the goal of fusion ignition ever since, with good reason. Now it appears that DOE's weapons laboratory scientists vastly overstated their scientific and technical readiness to pursue fusion ignition experiments, and that an ignition-ready NIF project will cost as much as $5 billion to $8 billion by the time of the first ignition demonstration sometime between 2010 and 2014, if it happens at all.

- And then there is the tangled tale of woe surrounding what is the key technological centerpiece of stockpile stewardship, the Dual Axis Radiographic Hydrotest Facility (DARHT), which is supposed to check the performance of the high-explosive driven plutonium primary stages ("primaries") of nuclear weapons. Begun in 1988 at a projected cost of $30 million, the DARHT facility may eventually operate in 2007 after the expenditure of some $500 million, *if* the accelerator technology in the second axis can be made to work, which is by no means certain.

- Most puzzling of all is the 12-year, $2.5 billion effort by Los Alamos National Laboratory to "reconstitute" a capability by 2009 to fabricate and "certify" the performance of a mere 20 plutonium pits per year. How could it possibly cost that much to "restore" a capability for pit fabrication that Los Alamos has had for five decades and never "lost"? Where did all that money go? In this report we call for a full-scale congressional audit of this project.

- And let's not forget the new Tritium Extraction Facility at South Carolina's Savannah River Site, originally due to startup at the end of this year at a cost of $391 million. It will now cost at least $506 million, and startup has been pushed back three years, to late 2007. But in a real world sense, this hardly matters, because if the United States adopted a sensible nuclear arms reduction policy, the facility would not be needed for decades.

In short, DOE has failed to meet many of the critical milestones it posted for itself when it set out a decade ago to replace nuclear testing with a grandiose vision of virtual testing via science-based stockpile stewardship, even as it rebuilds an excessive stockpile of high-yield Cold War weapons that now clearly are no longer needed in such numbers, if they ever were.

Despite a compelling record of project mismanagement and technical bungling, or perhaps because of it, for FY 2005 NNSA is requesting $6.81 billion (including allocated administration funds) which, if Congress goes along, would represent a *31 percent increase* in the annual spending level for nuclear weapons over the four years of this administration, and a *doubling* of the appropriated level a decade ago.

After removing the cost of domestic programs to dispose of surplus nuclear weapons materials and develop new proliferation detection technologies, which pump up NNSA's nonproliferation budget, NRDC estimates that the Bush administration is spending *more than 12 times* as much on nuclear weapons research and production activities as it is on urgent global nonproliferation efforts to retrieve, secure and dispose of weapons materials worldwide.

The time has come for both DOE and Congress to recognize that most of NNSA's current and planned nuclear weapons program, and much of its over-nourished nuclear weapons design establishment, are fundamentally irrelevant to the defense and security challenges that confront this nation and the world. Spending billions of dollars, as DOE is currently planning to do, to refurbish and extend the service life of thousands of high-yield Cold War-legacy nuclear weapons, is the height of folly, particularly when the federal government will have to borrow the funds to accomplish this task. NNSA should refurbish at most a few hundred of these weapons, and retire and dismantle the rest.

The body of this report, and the accompanying program cost estimates in the Appendix, explore these issues in considerably greater detail, and suggests that a more modest and better focused stewardship effort, shorn of runaway technical ambitions and layers of duplicative programs, management and infrastructure, would better serve the nation and its taxpayers, and facilitate the global pursuit of more stringent nuclear arms reduction and nonproliferation initiatives.

Eliminating and preventing nuclear threats to national and international security is now the most important NSSA mission, but its budget priorities do not yet reflect that seismic shift in the external environment. While the requirement for a nuclear deterrent persists, to be sure, its scope and importance have sharply diminished, and NNSA can responsibly accomplish the nuclear deterrent mission with a fraction of the resources it is currently consuming.

CHAPTER 1

REAL FUNDING GROWTH FOR NUCLEAR WEAPONS IN A BUDGET BURDENED BY DEFICITS

The National Nuclear Security Administration (NNSA) FY 2005 budget request and five-year projections for its Future Years Nuclear Security Program (FY 20052009) exemplify the Bush administration's penchant for putting nuclear rearmament far ahead of nuclear nonproliferation and arms reduction. The current and planned levels of spending on nuclear weapons now greatly exceed the $4.2 billion annually that represents the average level (in current dollars) for DOE "weapons activities" throughout the Cold War (1948-1991).

After bottoming out at a post-Cold War low of $3.4 billion in FY 1995, U.S. spending on nuclear weapons research, development, testing, production and administration of the nuclear weapons stockpile – funded through DOE's longstanding "weapons activities" account – has risen steadily. By the end of the Clinton administration, in FY 2001, it had reached $5.19 billion (including allocated program administration funds). Under the Bush administration, the upturn in nuclear weapons spending has accelerated, to $6.5 billion in FY 2004.[3]

For FY 2005, the administration is requesting $6.81 billion (including allocated administration funds) that, if Congress goes along, would represent a 31 percent increase in annual spending for nuclear weapons over the four years of this administration, and a doubling of the appropriated level a decade ago. As shown in Table 1, NNSA's Five Year National Security Plan submitted as part of next year's budget request, calls for continuing annual increases to $7.76 billion in FY 2009, a 14 percent increase over the current level, and $2.6 billion more per year for nuclear weapons than when President Clinton left office.

The administration's future funding profile for Nuclear Weapons Activities (see Appendix, Table A) shows it plans to spend $36.6 billion maintaining and modernizing the nuclear weapons stockpile and laboratory-production complex over the next five years, including $485 million to develop, test, and begin production of the controversial robust nuclear earth penetrating warhead.[4]

Despite the administration's artfully worded denials that it has plans to do anything more than complete a "study" of the earth penetrating warhead, the current budget request for the weapon includes funds for "preparing and conducting hardware demonstration tests for candidate designs. In FY 2005, subsystem tests and a full system test of the proposed design will be completed."[5]

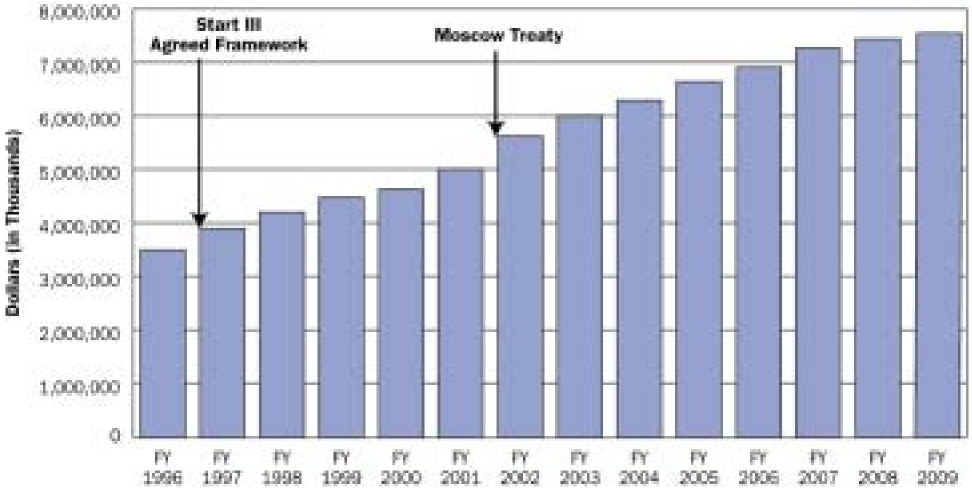

CHART 1. Based on current spending plans and trends, by FY 2007 the United States will have doubled the level of annual spending on nuclear weapons from a decade ago, despite the end of the Cold War. Columns for FY 1996 to FY 2004 represent actual or appropriated levels. Data for FY 2005 to FY 2009 represent requested or planned levels of spending.

Table 1: NNSA Nuclear Weapons Funding FY 2001-2009 (Dollars in Millions)

	FY 01* Actual	**FY 02 Actual**	**FY 03 Actual**	**FY 04 Actual**	**Real Growth FY01-04[a]**	**FY 05 # Request**	**FY 06 FYNSP**	**FY 07 FYNSP**	**FY 08 FYNSP**	**FY 09 FYNSP**	**Projected Growth FY05-09**
NNSA Budget	6,827	7,585	7,940	8,667	21%	9,049	9,405	9,791	9,981	10,167	12.4%
Weapons Program Activities	4,951	5,542	5,895	6,234	20%	6,568	6,681	7,216	7,353	7,492	14%
Weapons Admin istration	237	239	239	242	-2.4%[b]	242	252	256	260	265	9.5%
Weapons Activities TOTAL	5,188	5,781	6,134	6,476	19.3%	6,810	6,933	7,472	7,613	7,757	13.9%

* Last Clinton Budget # "FYNSP" = Bush "Future Years Nuclear Security Program"

[a] Incorporates average inflation adjustment of 1.5% per year for 2001-2004.
[b] Calculated using the same method as described in the preceding footnote.

The current FY 2004 budget provides $1.4 billion for maintenance, refurbishment and modification of nuclear weapons — what NNSA calls "directed stockpile work," which includes $433 million for a budget item called "stockpile research and development"— but only $38 million for "dismantlement/disposal" of nuclear weapons.

In other words, nuclear arms reduction gets *less than one-tenth* of what NNSA openly acknowledges it is spending on nuclear weapons R&D. The actual amount going to nuclear weapons research and development is much higher, because most research under the NNSA's Stockpile Stewardship Program is *generic* in nature. It is not tied to developing a specific nuclear warhead or bomb system, but rather concerned with fundamental improvements in nuclear weapons simulation capabilities for designing or modifying nuclear weapon systems.

Not only is the administration allowing arms reduction to wither, it is significantly shortchanging NNSA's other primary mission – controlling weapons of mass destruction in Russia and other countries. That mission would increase a paltry 1 percent, to $1.35 billion, in the proposed FY 2005 budget. But there is even less here than meets the eye: more than 40 percent ($585 million) of the "nonproliferation" request is actually for disposing of DOE's *own* "surplus" weapon materials, including $368 million for constructing a multi-billion dollar plutonium mixed-oxide (MOX) fuel plant that is not technically required to dispose of surplus weapons materials. These funds not only fail to contribute to reducing nuclear and other proliferation risks abroad, but the MOX plant *itself* represents an environmental and proliferation hazard, and a potential target for terrorist assault.

Subtracting the funding for disposing of U.S. surplus weapons materials leaves about $760 million for DOE's real nuclear nonproliferation activities, but that remaining sum still includes $220 million for proliferation detection technology R&D at the DOE labs. Subtract that money and there is only $540 million actually being spent to reduce Russian and global nonproliferation risks in the near term.

In other words, NNSA under the Bush administration is spending *more than 12 times* as much on nuclear weapons research, modification and maintenance activities as it is on urgent global nonproliferation efforts to retrieve, secure and dispose of weapons materials worldwide.

If not on reducing the risk of nuclear proliferation and nuclear terrorism, where is NNSA spending its taxpayer billions? The short answer is *on itself*, building up its technical base and facilities for a new nuclear arms race that will never come, unless, of course, the Bush administration succeeds in its apparent aim of provoking it.

The $1.4 billion request in FY 2005 for directed stockpile work on actual weapons is overmatched by $1.9 billion for a series of so-called "campaigns" bent on resurrecting a modern, highly automated, and networked version of the old Cold War nuclear weapons complex. This effort is premised on accomplishing as much nuclear weapons development as possible without relying on nuclear explosive tests, but never permanently forswearing this possibility by ratifying the Comprehensive Test Ban Treaty, which the Bush administration vehemently opposes, but the rest of the world supports.

A look inside these various NNSA "campaigns" reveals an astonishing world of unaccountable spending, gross mismanagement, and self-indulgent technological excess by a coddled laboratory elite that glibly confuses its own narrow "weaponeering" and "weapons science" interests with those of the nation and its taxpayers.

These campaigns include:

- Improving the capability to predict the performance of nuclear weapons;

- Building integrated electronic micro-machine components to replace current discrete electronic and electro-mechanical components;
- Building supercomputers and software to better simulate nuclear explosions;
- Building a massive laser facility to experiment with fusion ignition and the properties of nuclear weapon materials;
- Restoring the capacity to manufacture plutonium cores ("pits") of nuclear weapons; and
- Restoring the capability to produce and extract tritium, a heavy hydrogen gas that enhances nuclear explosions.

THE SCIENCE CAMPAIGN: SPENDING BILLIONS TO MAKE SURE BOMBS "PERFORM"

Let's begin with the so-called "Science Campaign," which is really a wide array of applied science and technology projects to improve U.S. capabilities for predicting the performance of nuclear weapons. Despite the high-minded title, it includes funding for less intellectual pursuits, such as improving Nevada Test Site readiness to resume underground nuclear test explosions ($30 million in FY 2005), and reviving Livermore's hazardous plutonium Atomic Vapor Laser Isotope Separation (AVLIS) pilot plant, mothballed at the close of the Cold War, to isolate the scarce isotope Pu-242. This isotope is highly prized within the weapons complex because it can be used in full-scale test implosions of nuclear weapon "primary" stages without producing an explosive nuclear chain reaction.[6] Such "hydrodynamic tests," so named because the compressed material behaves like a moving fluid, are a key tool of stockpile stewardship.

By way of background, a primary system typically employs a spherical or ovoid array of high explosives to compress (implode) a plutonium or highly enriched uranium "pit" to a dense "super-critical" configuration that can support an explosive chain reaction with fast neutrons. The primary system's neutron generator must inject a stream of neutrons at the optimum time to initiate the fission chain reaction in the compressed material, while the implosion must generate pressures and temperatures in the compressed material sufficient to ignite fusion reactions in a few grams of heavy hydrogen (deuterium and tritium) gas released into the central core during the weapon's arming sequence. These fusion reactions generate a timely flood of additional neutrons to accelerate ("boost") the fission process to a level that ensures sufficient nuclear energy will be available to ignite the "secondary stage" of the weapon, if one is present.

The likelihood that a specific design for the primary (trigger) stage of a nuclear weapon will achieve the explosive power needed to drive the full weapon to its nominal design yield is often referred to as the "reliability" of a nuclear weapon's primary system, while the likelihood that accidental detonation of the primary's chemical explosive will not result in more than a miniscule nuclear yield is often referred to as its nuclear "safety."

CHAPTER 2

THE DUAL AXIS RADIOGRAPHIC HYDROTEST FACILITY (DARHT)

DOE Takes 19 years to Deliver its "Highest Priority" Stewardship Capability

A major preoccupation of the Science Campaign in FY 2005 and FY 2006 will be fixing the Los Alamos National Laboratory's Dual Axis Radiographic Hydrotest (DARHT) facility, ostensibly and arguably the most technically important facility in the science-based stockpile stewardship program. The two "axes" of the hydrotest facility contain linear accelerators ("linacs") that are supposed to generate highly penetrating X-ray pulses, providing a capability for "three-dimensional imagery of imploding surrogate primaries with sufficient spatial and temporal resolution to experimentally validate computer simulations of the implosion process."[7]

FIGURE 1: The exterior of Los Alamos' Dual Axis Radiographic Hydrotest facility (DARHT), 16 years in the making, and still not working at more than 10 times its originally proposed cost.

DARHT was born long ago, in the FY 1988 budget request, as a proposed $30 million upgrade of then existing facility, PHERMEX, to a dual-axis machine. Sixteen years later, DARHT is still not finished, but now it costs $327 million, according to a May 2003 assessment by DOE's inspector general.[8] The inspector general predicted then that DARHT "would not be fully operational until June 2004." As the FY 2005 budget request makes clear, even that prediction was wrong. In the bowels of that budget request, NNSA reported that the focus in both FY 2005 *and* FY 2006 will be on finding solutions to "high voltage breakdown problems" on the second axis, and that the "first 2-axis hydro shot in support of stockpile assessment" will not be conducted until *FY 2007*. That would be 19 years after the DARHT project's inception, and 15 years after the United States adopted a nuclear test moratorium, for the startup of a capability that DOE claimed was absolutely critical to the success of its stockpile stewardship strategy.

Concurrent with the delays and technical problems, the inspector general's auditors found that Los Alamos and NNSA managers had quietly changed the completion criteria for the project, offloading costly yet-to-be completed elements – such as a confinement vessel system mandated by court order to contain environmentally hazardous emissions from explosive experiments—to future "non-project operating funds." The managers made a similar shift with second-axis commissioning activities, the auditors reported, and "Los Alamos is now completing commissioning activities using non-project operating funds from the Advanced Radiography Program."

Simultaneously, NNSA and Los Alamos managers quietly "down-scoped" the project, reducing the size and emission capacity of the vessels used to contain detonations by "approximately 50 percent," and the Vessel Preparation Facility to "less than a quarter of its original size," according to the inspector general report. They secretly transferred $17.5 million "saved" by these reductions in capability to other project elements that had overrun their budgets.

So not only will a dual-axis radiographic capability be delivered a decade late. It also will be considerably less capable than planned, thereby conveniently bolstering the argument that NNSA needs an even more powerful and capable radiographic facility. Indeed, unconstrained by concerns that Congress will ever do anything to make them accountable for their technical *hubris* and mismanagement, weapons lab managers have perfected the art of turning costly technical failures into categorical imperatives for the next big machine.

The pending FY 2005 budget request reveals that Los Alamos and NNSA managers are planning in FY 2006 and FY 2007 – *before* DARHT is even up and running – to complete "conceptual plans for future [radiography] facilities" and "prepare [a] mission need document for [a] future radiography facility."[9] This is most likely the billion-dollar plus Advanced Hydrotest Facility – a large multi-axis chamber, with built-in plutonium recycling, for making three-dimensional radiographic movies of full-scale imploding weapons – that nuclear design lab managers have been dreaming about and pushing for since the mid-1990s.

CHAPTER 3

DOES THE NATION REALLY NEED NUKES WITH "MICRO-MACHINES" INSIDE?

Lockheed-Martin Thinks So

While "Science Campaign" projects mainly flow to the two nuclear design laboratories, the so-called "Engineering Campaign" is largely within the purview of Sandia National Laboratory, managed for NNSA by Lockheed-Martin, the nation's largest defense contractor. Sandia is tasked with conducting non-nuclear component engineering and weapons system integration of the nuclear components developed by Los Alamos and Livermore. The centerpiece of Sandia's engineering campaign is the $519 million "Microsystems and Engineering Sciences Application" (MESA) Complex in Albuquerque.

MESA's purpose is to develop new microelectronic machine ("microsystem") components to meet a postulated need for "continual advances in technologies" to improve nuclear weapon "surety" – the weaponeer's shorthand for the built-in technical features ensuring against unauthorized and accidental detonations. The complex also will endeavor to produce modern highly integrated miniaturized replacement parts for the larger number of discrete non-nuclear components currently used in nuclear weapons, to meet the needs of NNSA's large "refurbishment" programs for enduring stockpile warheads. According to the NNSA's budget request:

> The microsystems that will be developed in MESA will have the ability to sense, think, act, and communicate within a wide range of environments. They will employ a technology base that spans photonics, mechanics, and radiation-hardened microelectronics on size and integration scales that have not been previously achieved…. MESA will employ state-of-the art visualization technologies … includ[ing] a [classified] Visual Interactive Environment for Weapons Simulation (VIEWS) Corridor, a visualization lab, primarily electrical and laser light- laboratories, and workspace to support approximately 274 personnel [in the classified portion of MESA's "Weapons Integration Facility"].[10]

FIGURE 2: Sandia's new $519 million MESA Complex will comprise some 391,000 square feet of laboratory and office space and house some 650 engineers working on new ultra-miniaturized components for nuclear weapons.

The unclassified portion of the MESA Complex Weapons Integration Facility (WIF-U) will house another 100 personnel, including "partners from industry and academia" to encourage "two-way transfer of information" – generally not a good idea when the transferred information involves nuclear weapons design.

A second new building within the MESA Complex will be a "Microsystems Laboratory" (MicroLab) to conduct research, development, rapid prototyping and testing of microsystem components. It will house 274 microsystems researchers and engineers, including "a small group of MESA external partners." A third new building, already under construction, is the "Microsystems Fabrication" (MicroFab) facility. It will replace the Compound Semiconductor Research Laboratory built in the late 1980s, provide new clean rooms, and replace approximately 80 percent of the tools in the existing facility.

The fourth major building project in the MESA Complex is upgrading and retooling the existing Microelectronics Development Laboratory (MDL) "to allow R&D to progress during construction of the full MESA project … [and] to produce qualified war reserve (WR) radiation-hardened integrated circuits" to replace "commercial vendors" who "soon will cease to exist, leaving Sandia as the only supplier for these key weapons components."

All in all, the MESA complex will comprise approximately 391,000 square feet and house some 650 engineers working on new microcomponents for nuclear weapons. How much of this is minimally necessary in order to extend the service life of existing weapons, and how much is self-serving taxpayer gouging and technological empirebuilding by Sandia and corporate parent Lockheed-Martin, is difficult for outside observers to gauge.

However, we do know that prior to the conjunction of the Bush White House and Republican control of the Senate, this project consisted only of a proposed $51 million upgrade for retooling the existing Microelectronics Development Laboratory (MDL). One may therefore surmise that much of the additional work – such as the new “Weapons Integration Facility” with state-of-the art “visualization” facilities for designing new weapon components – is a gold-plated pork barrel add-on that is not strictly required to sustain the U.S. nuclear weapons stockpile.[11]

CHAPTER 4

ADVANCED SIMULATION AND COMPUTING INITIATIVE (ASCI) CAMPAIGN

Bombs, FLOPs and Big Screens, Coming to a (Classified) Theater Near You

In NNSA's FY 2005 request, the Bush administration reveals that it intends to spend $740 million next year, $19.9 million more than the current level, on nuclear weapons simulation and computing, and an astonishing $4.031 billion through FY 2009 – an average of $806 million per year just on nuclear weapons computing alone. Each of the four nuclear weapons laboratories now has a new supercomputing center under construction or recently completed. NNSA is midway through a program to equip them with the second generation of advanced simulation and computing initiative (ASCI) supercomputing systems.[12]

- Installation of the DEC/Compaq/HP 20 trillion of operations per second (teraOPS) ASCI "Q" machine at the new Los Alamos Strategic Computing Complex was completed in FY 2003, and the machine will ostensibly continue to operate as a "tri-lab resource" in FY 2005.
- At Sandia Albuquerque, Cray Computer's 40 teraOPS "Red Storm," now being delivered to the new Joint Computational Engineering Laboratory, will begin its "integration and acceptance" phase in the coming year.
- At Livermore the FY 05 focus will be continuing construction of the 253,000 square foot Terascale Simulation Facility and full delivery and installation of the 100 teraOPS ASCI "Purple" machine.
- Finally, at Sandia California (across the street from Livermore), the new Distributed Information Systems Laboratory will "concentrate on secure networking, high performance distributed and distance computing, and visualization and collaboration technologies that do not exist today, yet need development to help create design and manufacturing productivity environments for the future Nuclear Weapons Complex (NWC)."[13]

As shown in Table D in the Appendix to this report, over the five-year period 2002 to 2006, NNSA will have added some 656,000 square feet of floor space dedicated to nuclear weapons supercomputing at a cost of $263 million just for the empty buildings and utility support systems. The bill for equipping these centers with supercomputer hardware and advanced display technology through the end of the current Five Year National Security Plan (in FY 2009) comes to $1.71 billion, and operating them costs another $1.35 billion. So by the end of 2009, all this redundant supercomputing will have cost U.S. taxpayers at least $3.3 billion, just for the buildings and computer hardware!

Developing the three-dimensional weapons simulation codes (applications software) to take advantage of the vastly increased computational power will cost billions more, but regardless of the amount expended, this effort by its very nature is unlikely to yield comprehensive, definitive results that can be confidently employed to "certify" the performance of new nuclear weapons designs without testing.

The design of nuclear weapons has always been based primarily on computations and subsequently computer simulations. These simulations are based on the known laws of physics and properties of matter, but they also make use of simplified physical models and numerical approximations to capture processes that are too complex to allow precise description on first principles alone. (To take an example from everyday life, imagine trying to predict accurately the random splatter pattern a tomato makes when you throw it against the wall.)

These models contain parameters that are adjusted to provide a best fit between computed and observed results in nuclear explosive, subcritical and hydrodynamic tests, resulting in a "calibrated" code for each particular class of nuclear explosive device. Nuclear weapon simulations therefore are partly based on "first-principles" and partly on empirical observations.

Since the United States is no longer conducting nuclear explosive tests under the prevailing informal test moratorium, and such tests would be permanently banned under the unratified Comprehensive Test Ban Treaty, DOE no longer can carry out experimental studies of the "boosting" process,[14] the primary explosion, energy transfer to the second stage, the secondary implosion, and secondary explosion. Meanwhile, experiments at the $5-billion National Ignition Facility (NIF) will have marginal and possibly inconsequential value if ignition and capsule gain are not achieved – in improving computer simulation of these aspects of thermonuclear weapons.

DOE still can do hydrodynamic studies of the implosion phase of the (usually plutonium) primary stage, however, and potentially can use the information obtained to extend and improve computer simulation of primary implosions. This fact has led NNSA to invest heavily in a program of expensive underground "subcritical experiments" at the Nevada Test Site to glean further data regarding the hydrodynamic properties of plutonium.

From the inception of the ASCI program in FY 1996 through FY 2004, DOE has spent at least $4.75 billion on nuclear weapons computing.[15] That sum does not include all the costs involved in setting up and gathering data from experiments designed to refine the physics models embedded in the various linked modules of code that attempt to simulate each stage of the implosion-explosion process. From FY 2005 to FY 2009, NNSA plans to spend another $4 billion on more ASCI hardware and software development, for a total of $8.75 billion, or an average of $2.92 billion to equip each weapons laboratory with "state of the art" simulation capabilities.

With such a massive investment, one might expect the most powerful supercomputer in the world to be a DOE ASCI machine. But for the last two years, that honor has gone to NEC Corp.'s Earth Simulator supercomputer at the Japan Marine Science and Technology Center in Yokohama, which in April 2002 achieved the world's highest performance of 35.61 TeraFLOPS, nearly triple the benchmark performance of the leading ASCI supercomputer, the Los Alamos Q machine.[16]

In an era when "the network is the computer," apparently no one in government (save perhaps the General Accounting Office) thought to ask why NNSA weapons labs could not make do with networked access to a single center for "massively parallel" computing, rather than constructing and equipping three such centers, particularly in view of the GAO's findings in the late 1990s that DOE's existing supercomputer resources were seriously underutilized: "In 1997, for example, less than 5 percent of the jobs run on the largest supercomputers used more than one-half of the machines' capabilities."[17]

FIGURE 3: An architect's computer rendering of the Terascale Simulation Facility under construction at Lawrence Livermore National Laboratory in Livermore, California, one of three such facilities recently constructed at the NNSA weapon laboratories. The facility can accommodate 288 nuclear weapons researchers and some 200 trillion operations per second of computing power.

Indeed, why did NNSA not focus its effort, first and foremost, on emerging high-speed networking techniques to link its existing, and future commercially available off-the-shelf computing systems into a "virtual" supercomputer? And instead of rushing out and engaging in a frenzy of supercomputer procurement, why did NNSA not first direct more modest sums into R&D on innovative architectures that would enable quantum reductions in the footprint, power consumption, and cost per teraOPS of scientific supercomputing systems? IBM did, and the results, cited below, have been spectacular.

NSSA's overstuffed supercomputing effort will force taxpayers to pick up the computer support staff costs, maintenance, security, and utility charges (including massive electric bills) for four separate computing centers, each having numerous unique support requirements.

HASTE MAKES WASTE: A TALE OF TWO MACHINES

The case of Los Alamos' recently "completed" Q machine is a telling example of bureaucratic bungling and waste. This machine is based on Compaq's once capable but outdated line of Alpha processors, acquired through its earlier purchase of Digital Equipment Corporation. This fact was known to present risks from the standpoint of system longevity and future software development, given Intel's major inroads into the high-end chip market.

In August 2000, DOE signed a $210 million contract with Compaq Computer (now part of Hewlett Packard) to deliver the hardware and operating system software for a 30+ teraOPS system to be delivered "not later than April 30, 2002." In the spring of 2001, Compaq announced that it was shifting its Tru64 UNIX server software environment to run on Intel's Itanium 2 chip series, and abandoning further iterations of its Alpha processor after 2004. Rather than heed this warning sign, Los Alamos pressed ahead to build a massive new computer center to house the new machine. Trumpeting the facility's unprecedented space and power requirements as though they were virtues, the LANL Daily News Bulletin stated:

> The 300,000-square-foot building features an unobstructed 43,500-square-foot computer room (about three-fourths the size of a football field) that is cooled by 130,000 gallons of circulating chilled water – a full 3,600 tons of cooling capacity, or enough to cool more that 500 homes.
>
> The electrical system brings 7.1 megawatts of power (expandable to 30 megawatts) into the structure along more than 200 miles of wire. There are more than 1,350 miles of fiber optic cable with approximately 20,000 individual fiber optic terminals.[18]

By June 2002, Los Alamos insiders were writing anonymous letters to the trade press calling the Q machine "a bust."[19] With 1024 nodes installed, representing one-third of the system, benchmark tests showed the 4096 processors running at 1 GHz rather than the promised 1.25 GHz, resulting in 8 TeraOps rather than 10 TeraOps of processing power. A Los Alamos spokesman claimed that options in the contract provided for upgrading the processors to 1.25 GHz in the nodes already acquired, bringing Q "Option 1" up to 10 teraOPS, and that contract options 2 and 3 would each deliver "separate 10 TeraOps systems…. If all goes according to plan, the 30.72 TeraOps system will be installed and tested by the end of calendar year 2002."[20]

The NNSA FY 2004 budget request, submitted in February 2003, implicitly admitted a further slip in the Q acquisition schedule, but continued the theme that full Q deployment was just around the corner, claiming that a “FY 2003 Performance Target” was to “complete acquisition of 30 TeraOps ‘Q’ super computer at LANL [Los Alamos].”[21]

Workers install the first 10-teraOps phase of the Q computer, the next-generation ASCI system. Q is planned as a 30-teraOPS computer platform.

FIGURE 4: HASTE MAKES WASTE. A Los Alamos photograph and caption from 2002 showing installation of the first 10-TeraOps phase of the ASCI Q system. Fully one third of the planned 30 teraOPS system was apparently never installed, and NNSA rarely mentions the system.

However, without further comment or explanation, the FY 2005 request notes, “the 20 teraOPS ASCI Q will continue to operate as a tri-lab resource.”[22] It seems that fully one-third of the Q system’s contract capability was never attained, and probably was never even installed.

This failure comes on top of Los Alamos’ problems with its $135 million first-generation ASCI supercomputer, the 3 TeraFlop “Blue Mountain” machine that it acquired from a different vendor, Silicon Graphics/Cray. Los Alamos admitted there were instability problems with the machine for the first eight to 12 months after it brought it on line in November 1998, but later claimed in June 2002 that “the Blue Mountain Platform has been the major production machine for nuclear weapon simulations at Los Alamos for the past three years and will remain so until the workload moves to the ASCI Q machine in 2002.”[23]

This assertion turned out to be incorrect. Not only was the Q machine unavailable to take over the workload from Blue Mountain in 2002, but NNSA reported in February 2003 that in the preceding year Los Alamos had successfully performed a “prototype calculation of a full weapon system with three-dimensional engineering features” for the W76 Trident submarine-launched ballistic missile warhead using neither its own Blue

Mountain nor Q, but Livermore's 12 teraOPS ASCI "White" supercomputer, via a remote hookup.

In other words, it appears that the $345 million Los Alamos spent on its first two ASCI machines has largely been wasted. This continues the historic pattern of relative success by Livermore in its supercomputing efforts in comparison with Los Alamos, which on previous occasions has been forced to abandon its own software development efforts and borrow from Livermore's generally superior work.

Now it appears that Livermore, through its continuing partnership with IBM, is about to hit another supercomputing home run. Back in November 2001, IBM announced a research partnership with Livermore to further develop IBM's Blue Gene program, a 5-year, $100-million effort the company launched in December 1999 to improve its capability of producing complex simulations for the life sciences, such as understanding the relationship between abnormal folding of proteins and disease.

IBM and Livermore are jointly designing a new supercomputer, called Blue Gene/L, based on IBM's new Blue Gene chips and innovative architecture, which is expected to top the list of the world's supercomputers in absolute performance, and also make revolutionary advances in terms of its machine footprint, power consumption, and cost-per-teraflop (trillions of floating point operations per second, a standard measure of computer processing speed). In comparison with Livermore's current ASCI White machine, which occupies 10,000 square feet, uses approximately 6 megawatts, and runs at a peak speed of 12 teraOPS, Blue G/L is expected to occupy about only 2,500 square feet, consume 1.5 MW, and run at sustained/peak speeds of 180/360 teraOPS.[24]

In other words, Blue G/L will be a quarter of the size and consume a quarter of the electric power of Livermore's current machine, but will be 15 times more powerful – a stunning improvement. Just one of its 64 cabinets, about the size of a standard refrigerator, represents 2.8 teraOPS of computing power, a supercomputer in its own right. With its vastly reduced footprint, power consumption and cost-per-teraflop, and its highly decentralized communications architecture using industry standard Ethernet connections and the Linux operating system to manage communications between computing nodes, the broad commercial potential of the BlueGene technology is obvious, and it likely will render most of DOE's previous ASCI investments obsolete.

With an investment of $100 million of its own money and a five-year plan of research, IBM achieved the kind of performance breakthrough that has eluded the multibillion dollar ASCI program, with its heavy emphasis on hasty serial procurements of ever larger and costly systems, to meet artificial and largely unverifiable weapons simulation "milestones" allegedly imposed by the "aging" of weapons and weaponeers. A far better strategy would have been to accept the limitations imposed by the no-test environment, and chart a technically conservative strategy for stockpile support that is relatively impervious to it.

Livermore is to be commended for amending its next mega-machine ASCI contract with IBM, for ASCI "Purple," to include deployment of Blue GL. But it is distressing that the laboratory probably will take this revolutionary technology, originally conceived to further understanding of the genomic roots of disease, and pervert it with yet another "unprecedented" simulation of nuclear weapons performance that provides "psychic income" to weaponeers, but absolutely no practical benefit to society.

FIGURE 5: Wait a little, gain a lot. A computer rendering of the revolutionary 360 teraOPS IBM-Livermore Blue Gene/L supercomputer, slated for installation in 2005. Compare this photograph with the preceding one showing the footprint of the first *half* of Los Alamos' 20 teraOPS ASCI Q machine, deployed in 2002.

WEAPONEERING EXTRAVAGANCE

A sense of just how overdone and self-indulgent the current nuclear weapons simulation effort has become can be gained from reading the detailed project justifications NNSA submitted to Congress. Below is an excerpt from the justification for Los Alamos' Strategic Computing Complex (SCC). The ambience of pampered entitlement is almost palpable:

> The SCC features a visualization environment consisting of two immersive theaters, one in the classified area and one in the un-classified area. These theaters will have overhead projection and wrap-around features supporting the latest virtual reality and visionarium environments…. A powerwall theater in the secure environment will provide high-resolution interleaved displays that fill a wall with the latest projection technology. A third simulation environment … is supplied by the [four] areas designated as collaboratories, … [each] will contain conference space, a media-stack including laser-disc recorders for animation production and viewing, an immersadesk for compact virtual-reality (VR) analysis, multiple high-resolution graphics heads, electronic white-board, video teleconferencing tools, and electronic collaborative tools for effective interaction at open and

> secure sites. The collaboratory provides the users, code developers, and managers with an informal, information- and technology rich environment….[25]

Not to be outdone, Livermore also wants its very own "visual interactive environment for weapons simulation" (VIEWS) capability, as part of its new Terascale Simulation Facility. This facility will have an "assessment theater" where "physical and computer scientists, working together, will visualize and make accessible to the human eye and mind the huge data sets generated by the computers," allowing them "to understand and assess the status of the immensely complex weapons systems being simulated … to assure the efficient operation of remote assessment theaters, high-speed networking hubs will connect the computers seamlessly to key weapons scientists and analysts at the highest performance available."

Not just weapons scientists, but a small army of "vendors and operational and problem-solving-environment staff must have immediate access to computer systems, since the simulation environment will require very active [read "expensive"] support." To house this bloated cadre of staff and contract workers to keep nuclear weapon simulators, Terascale Simulation Facility construction includes "a multistory office tower" adjacent to the computer center.[26]

NNSA's strategy of building ever larger massively parallel machines by aggregating large numbers of commercially available processors has generated criticism within the computing community because it has led to the acquisition of machines with ever larger power, space, maintenance and cooling requirements that are impractical for any but the most lavishly funded institutions. Moreover, even for institutions with deep pockets, the ASCI machines generally have proven to be an ineffective use of R&D funds. But the ASCI program also is open to broader challenge for diverting billions of R&D dollars to the pursuit of a complex "virtual testing" paradigm for stockpile stewardship that is as unnecessary as it is unattainable.

CHAPTER 5

THE NATIONAL IGNITION FACILITY (NIF)

Fusion Ignition Fades While Costs Soar

After ASCI, the second largest NNSA "campaign" in FY 2005 in terms of funding is the $492-million Inertial Confinement Fusion and High Yield Campaign, which will jump to a planned peak of $535 million in FY 2007 and account for total spending of $2.43 billion over the course of NNSA's projected Five Year National Security Plan.

Most of this planned funding is directed toward completing the National Ignition Facility (NIF), a massive 196-beam laser fusion facility under construction at Livermore, and achieving the technical readiness to begin fusion ignition experiments. NIF is by far the largest single project in the NNSA budget, and quite possibly the most expensive experimental facility ever built.

Its main goal is to focus the energy of its lasers inside a tiny cylindrical target, where much of this energy is converted to X-rays that compress and heat a frozen suspended droplet of heavy hydrogen isotopes (deuterium and tritium) sufficiently to ignite fusion reactions. Failing this objective, its proponents argue that NIF's powerful lasers can be employed to produce nuclear weapon-like temperatures and pressures in materials of interest to nuclear weapons designers, providing the kind of detailed data needed for the ASCI computer modeling effort.

According to DOE and NNSA, when the laser system installation is finally completed in September 2008, construction of NIF "officially" will have cost $3.5 billion. NRDC estimates that the actual cost of the project through FY 2008 will be as much as $5.2 billion, and further billions will be required to reach the first "demonstration" of the facility's namesake mission, fusion ignition.

In relation to NIF's marginal technical relevance for maintaining the "safety and reliability" of U.S. nuclear weapons, the escalating cost of the project is mind-boggling.

- At the time the project was approved for detailed site-specific design and construction in March 1997, DOE's official baseline estimate of "total project costs" was $1.07 billion, and completion was set for the third quarter of 2002.
- In FY 1998, that sum increased to $1.2 billion, and project completion slipped by a year, to "3Q 2003."
- Unrecognized in the cost estimate at the time was an additional $833 million in "other related costs" that did not appear in the official cost estimate until the FY 2001 budget request, bringing the Title 1 baseline for "total project-related costs" to $2.03 billion.

- In the summer of 2000, Livermore suddenly "discovered" that it had miscalculated the "construction management" aspects of the project, particularly the requirement for ultra-clean assembly of the laser beamlines and optical components, and the cost of the NIF project escalated dramatically.[27] Physical construction of NIF would now cost $2.25 billion, and a GAO investigation forced DOE to recognize an additional $1.2 billion in "other related costs" required to complete the facility, bringing the NIF's "total project-related cost" to $3.5 billion.

- At more than triple the original cost estimate, this became the new "baseline" for the NIF project. Completion was delayed five years, until "4Q 2008."

Of course, this was not close to the real "bottom line" of the NIF debacle, but in the heat of election year 2000, neither the Clinton administration nor Congress were willing to risk a more penetrating investigation, one that might permanently tarnish this prime piece of California pork, and not-so-subtle payola to the University of California nuclear weapons establishment for its tight-lipped acquiescence to a nuclear test moratorium and Comprehensive Test Ban Treaty.

FIGURE 6: Exterior of the $5.4-billion National Ignition Facility. By the time the first ignition experiment is held in 2014, DOE will have spent some $8.5 billion on the facility, according to NRDC estimates.

Events have vindicated NRDC's earlier judgment – and assessments by independent scientists – that DOE's Inertial Confinement Fusion program was *not* scientifically or technically ready to construct an ignition facility in 1997. In the FY 2005 budget request, NNSA projects that an initial ignition demonstration, originally scheduled for FY 2005, two years after the first intended "completion" date of the laser facility, will now occur in FY 2014.

Faced with harsh congressional criticism of this latest delay, NNSA officials, in late March 2004, suddenly announced in hearings that they were moving up the first ignition demonstration to 2010, but offered no credible public explanation for what had led to the delay, or how they had suddenly managed to reverse it. This opaque behavior was par for the course for a project that from the beginning has consistently concealed its actual status from review panels – sometimes with their connivance – and from congressional committees, while serving up a heady brew of technological optimism, half-truths, and occasional outright lies to the news media and the public.

Senator Domenici, chairman of the Energy and Water Appropriations Subcommittee, was not happy with the sudden postponement of the ignition campaign and the escalating costs:

> DOMENICI: I am deeply concerned that the FY 2005 budget has slipped the target date for ignition back to 2014, as a result of numerous technical challenges, including the cryogenic targets…. I might say, as chairman of this committee, I don't like to get hoodwinked. And I don't like the way the laboratory, which will house NIF, has proceeded to spend the money, buy all the parts, everything that goes in it, ahead of time and have them all there. I wonder what would have happened if we would have said this program isn't going forward. They would say, 'Oh, we have all the things we need to build it.'
>
> …I want to say, you know how I feel right now, Dr. Beckner, is that I've been hoodwinked, and not a little hoodwink, a big one. Because I think what we're going to get out of this is a big civilian tool that can be used at that laboratory for a lot of research. And we're going to run around saying that's the best research laser facility the world has ever seen. And I tell you, if I see that coming, it [the NIF project] better not be asking me for any money because I would close it down. Because that's not fair. We never intended to spend $5 billion to $6 billion to build a laser facility for a laboratory that would provide civilian research and visitations from around the world. So I know you all look at this and say, 'Well, it's going to do something, right? And it's sure going to be extraordinary.' But that's not why I agreed to pay for it.
>
> BECKNER: I understand.
>
> DOMENICI: I agreed [when it was] very, very highly debated, that this was going to reach ignition and that would be the best part of science-based stewardship. Think of that, the best part.[28]

Domenici was reminding DOE that the driving rationale for the NIF was the ostensibly "critical" need to have an ignition facility capable of "propagating fusion burn and modest energy gain" in place by 2003 – when "most of the weapons in the stockpile will be in transition from their designed field life to beyond field life design" and "the number of designers with test experience will be reduced by about 50 percent" – to validate new three-dimensional weapon design codes for certifying the "safety and reliability" of the nuclear stockpile in the absence of nuclear testing.

With even the possibility – much less probability – of achieving ignition now variously postponed until "2010" or "FY 2014 or "within 4-5 years of full operation,"[29] it is clear that multibillion dollar "life extension" programs for the principle U.S. "enduring" stockpile weapons are proceeding *without* NIF. According to NNSA, "Remaining designers and analysts with test experience will be an indispensable part of this process, because they [i.e., not NIF ignition-capsule gain experiments] will validate the [computer] models and early simulation results" of a new "threshold state simulation capability, in which the first functional full-system-calculation codes requiring a 100+ TeraOps computer will be used to certify the [nuclear explosive performance of] the stockpile."[30]

NNSA continues to cling to its carefully circumscribed "revised baseline" cost estimate of $3.5 billion for the NIF laser system, but this is achieved by off-loading many of the costs of an "ignition-ready" facility, including the costs of developing and producing the "baseline" indirect (X-ray) drive target and the entire cryogenic target filling, transport, and positioning system, to other less-visible accounts. Based on the data in Appendix Table B, the true cost of the NIF project, through its laser system "completion" date at the end of FY 2008, is *at least* $5 billion. However, as the preliminary data for FY 2009 suggests, continued spending at the rate of roughly $500 million per year could be required for the next five to six years to reach the first ignition demonstration in FY 2014.

As shown in Appendix Table C, these numbers suggest that the cumulative *direct* cost of getting to the first NIF ignition demonstration in FY 2014 – assuming it happens at all – will be at least $8.4 billion, nearly triple the revised 2001 "baseline" cost estimate upon which DOE and Congress based their approval to continue the NIF project.

NNSA officials' response to this hemorrhaging of funds is to argue that as the project moves toward the receding "eventual goal" of "demonstrating" fusion ignition, it will still play a useful role in enabling "non-ignition high energy density physics experiments." But these experiments only serve to further augment the overall cost of the NIF program, adding another $125 million, for example, to the ICF program costs in the FY 2001 to FY2005 period, while still accounting for only a small percentage of the overall NIF program expenditure. The ability to run such experiments, most of which could have been conducted at alternative facilities like Omega and Z, or on a much cheaper, scaled-down version of NIF, cannot possibly begin to justify NIF's $8.5 billion projected cost.[31]

The NIF project succeeds or fails on the strength of its ability to achieve its primary ignition objective, originally promised for 2005 at one-quarter of the now likely ultimate cost. Moreover, had Congress understood from the beginning that an ignition demonstration would cost $5 billion to $8 billion, rather than $1.2 billion to $2.2 billion as originally advertised, it probably would not have supported spending that enormous sum of money on a gigantic glass laser that can merely provide on-off "demonstrations" of ignition and possibly modest gain, rather than serve as a technology prototype for a "driver" with at least the nominal potential for further development as a repetitively pulsed fusion energy power plant.

Although sold to Congress as a civilian-military "twofer," from the perspective of inertial fusion energy development (highly problematic in its own right), NIF is a technological blind alley, and was known to be so when the project started. Whether or not NIF achieves ignition, NNSA will have to abandon its technology development path if the objective remains usable fusion energy. Billions have been wasted, in effect, on a dead-end fusion "driver" technology. Much of the target physics and target development will have to be done over again as well, to match the characteristics of a more practical and capable driver technology than the inefficient high-energy glass laser.

CHAPTER 6

THE PIT MANUFACTURING AND CERTIFICATION CAMPAIGN

Los Alamos Lays a Golden Pit

The endless weapons complex "campaign" of resurrecting the capability to manufacture pits – the metal-encased plutonium or uranium shells in a nuclear bomb – has been ongoing since FY 1993. It has the immediate goal of "restoring" at Los Alamos "some limited capacity to manufacture pits of all types" that was lost in 1989 when the main Cold War pit plant, located at Rocky Flats northwest of Denver, imploded in a multibillion dollar cesspool of contamination, criminality, and managerial incompetence.[32] Historically, the Technical Area-55 site at Los Alamos always has been a site for plutonium pit production, fabricating as many as 60 pits for test devices and processing as much as 3,000 lbs of warhead plutonium per year at the height of the Cold War, enough material for about 340 fission triggers for thermonuclear bombs.

Los Alamos is well along in a $2.3 billion, decade-long modernization of its pit fabrication and plutonium chemistry complex, which is scheduled to begin producing 20 pits per year in 2007. While this is the officially designated output for the current Plutonium Facility (PF)-4 upgrade, it represents less than a full single-shift operation. In 1997 litigation over the environmental impact of the facility, DOE defended its option to produce 50 to 80 pits per year in the upgraded PF-4 facility without constructing additional floor space.

Whether this level is "sufficient" obviously depends not only on how large and diverse a nuclear weapons stockpile the United States seeks to maintain over the long term, but also on the range of prudent expectations for pit lifetimes, and how soon production of reserve replacement pits can be undertaken. For example, low-rate production of 20 to 80 pits per year beginning in FY 2009, when the average pit age will be about 25 years, could in theory ensure that no pit in an "enduring" stockpile of 500 to 1,600 weapons exceeds the expected minimum 45-year lifetime. But there is no data indicating that pits will not be capable of lasting as long as 60 years, or even longer.

DOES AMERICA REALLY NEED A "MODERN PIT FACILITY?"

The longer-range objective of NNSA's pit manufacturing campaign is designing and constructing a $2-4 billion Modern Pit Facility (MPF) beginning late in the next decade.

The draft programmatic environmental impact statement (PEIS) for this facility examines hypothetical production levels ranging from 125 pits per year (single shift operation) to 900 pits per year (double shift operation of a 450 pit per year capacity).

From Nuclear Warhead Pit Production: Background and Issues for Congress

Pit Manufacturing and Certification Campaign Budget, FY2001-FY2009

(Budget Authority, $ millions)

Fiscal Year	W88 Pit Mfg.	W88 Pit Certification	Pit Mfg. Capability	Modern Pit Facility	Support Activities at NTS	Total
2001 actual	95.4	51.8	8.0	2.0	30.0	187.2
2002 actual	103.2	86.8	5.6	8.9	44.5	249.0
2003 actual	109.9	105.1	1.2	4.2	41.5	261.9
2004 actual [a]	125.0	108.6	10.0	10.8	42.4	296.8
2005 request	132.0	101.5	21.0	29.8	52.2	336.5
2006 plan	132.6	88.9	23.3	43.3	35.5	323.6
2007 plan	139.9	45.3	34.4	94.6	0	314.2
2008 plan [b]	0	15.8	37.4	101.4	0	154.6
2009 plan [b]	0	0	53.0	105.2	0	158.2
Total	838.0	603.8	193.9	400.2	246.1	2282.0

Abbreviation: NTS, Nevada Test Site.

Source: FY2001 Support Activities at NTS figure was provided by NNSA March 3, 2004. Other FY2001 data: U.S. Department of Energy. Office of Management, Budget and Evaluation/CFO, *FY 2003 Congressional Budget Request*. vol. 1, National Nuclear Security Administration. DOE/ME-0001, February 2002, p. 170. FY2002 data: U.S. Department of Energy. Office of Management, Budget and Evaluation/CFO, *FY 2004 Congressional Budget Request*. vol. 1, National Nuclear Security Administration. DOE/ME-0016, February 2003, p. 225. FY2003-FY2009 data: U.S. Department of Energy. Office of Management, Budget and Evaluation/CFO. *FY 2005 Congressional Budget Request*, vol. 1, National Nuclear Security Administration. DOE/ME-0032, February 2004, p. 147.

Note: The Pit Manufacturing and Certification Campaign began in FY2001. Before then, pit funds were scattered in other programs, so earlier cost data are not available. The current Future-Years Nuclear Security Program projects funds out to FY2009; data beyond then are not available.

a. For FY2004, the pit campaign was reduced from $298.5 million to $296.8 million as a result of the omnibus rescission of 0.59 percent. The reduction was all applied to W88 pit manufacturing; the amount appropriated for that component was $126.7 million. Source for the latter figure: U.S. Congress. Committee of Conference. *Making Appropriations for Energy and Water Development for the Fiscal Year Ending September 30, 2004, and for Other Purposes*. 108th Congress, 1st Session, H.Rept. 108-357, USGPO, p. 158.

b. FY2008 and FY2009 funding for W88 Pit Manufacturing is currently included in Directed Stockpile Work. NNSA estimates that the cost for this activity will be $110 million a year for each of these two years. These amounts do not appear in Table 1, which presents funding for Campaigns.

Source: J. Medalia, *Nuclear Warhead Pit Production: Background and Issues for Congress*, CRS-RL31993, updated March 29, 2004. The total of $2.3 billion shown in the chart covers spending from FY2001 to FY2009, but the historical total is considerably higher, as the official effort to reestablish pit production at Los Alamos began in FY 1996. The actual total is probably closer to $3 billion.

The administration's prolonged delay in producing a nuclear stockpile plan reflecting the nuclear force reductions it agreed upon in the 2002 Moscow Treaty prompted Congress to restrict funding for the MPF project in FY 2004. When, and indeed *whether* the MPF is allowed to proceed, and at what scale, are major issues for Congress in the FY 2005 budget and beyond.

Quite apart from MPF, however, the administration's five-year national security plan calls for spending $336.5 million in FY 2005 (an increase of $40 million from FY 2004), and $1.3 billion on pit manufacturing and certification from FY 2005 to FY 2009, in addition to the $1.2 billion already expended from FY1998 through FY 2004. It is a mystery how so little capability could have resulted from such a huge expenditure.

In FY 2005, NNSA intends to manufacture "at least six certifiable W88 pits" to augment the six being produced in FY 2004. "These pits will be used in tests to support the goal of FY 2007 W88 pit certification."[33] Production of the 450-kiloton thermonuclear W88 warhead for the Trident II submarine-launched ballistic missile was cut short by the sudden collapse of plutonium pit operations at Rocky Flats in 1989 and the subsequent determination to close that facility.

According to NNSA's detailed budget submission, manufacture of these six "certifiable" pits, not including the original cost of producing and extracting the plutonium, will cost $132 million in FY 2005, or *$22 million per pit*, which amounts, at current prices, to roughly 482 times the value of the pit's weight in gold.[34]

Any claims that these manufacturing costs continue to reflect the costs of acquiring the necessary W88 pit production technology are spurious – DOE already has been overpaying for this technology for a decade. The sunk costs for "W88 Pit Manufacturing" from 1998 through 2004 alone amount to $740 million, and Los Alamos formally inherited the mission in 1996.[35]

By comparison, the Manhattan Project produced the first significant quantities of separated plutonium and manufactured it into pits within three years. So why, a half-century of experience and 70,000 pits later, does Los Alamos need 11 years and more than $2.5 billion dollars to confidently manufacture and certify one "war reserve pit" for the nuclear weapons stockpile? A full-scale congressional investigation is warranted.

In FY 2005 through FY 2007, "certification" of the W88 "golden pit" – as skeptical observers call this egregiously padded and possibly fraudulent effort – will ostensibly "require," according to NNSA, "the conduct of two complex subcritical experiments" underground in Nevada, and associated "dry runs" and "preparatory experiments." Including the costs of closely linked "pit campaign support activities" at the Nevada Test Site, this "accelerated" three-year effort (now moved forward from FY2009 to FY2007) to certify a *single* pit type for the stockpile will cost a mind-boggling $340 million – equivalent to the cost of five typical underground nuclear explosive tests. Moreover, all this activity is ostensibly being undertaken to "certify" what NNSA already knew back in the early 1990s – that the implosion behavior of plutonium pits produced by modern "near-net shape" casting techniques do not differ appreciably from "wrought" pits produced with the older machining methods. (British pits produced with the modern techniques were exploded at the Nevada Test Site before 1992 and showed no significant deviation from the performance previously observed in wrought pits.)

If genuine doubts persisted, NNSA could have resolved them with 40-year-old radiographic hydro-testing techniques that confirm whether a pit is hitting the required benchmarks (for material velocity, boost-cavity shape, and material density-versus-time) characteristic of successfully exploded pits produced by the Rocky Flats technology.

The "padding" of the pit certification effort with the costs of pursuing far more ambitious, extraneous goals is clearly evident in NNSA's budget request, which states that the W88 pit certification project is funding not only relevant "engineering tests" but also "physics experiments" and "a *comprehensive analytical effort to develop a computational baseline that will provide confidence in future simulation capability*" for assessing nuclear explosive performance (emphasis added).

During FY 2007, the pit campaign timetable calls for achieving a "robust 10 pits per year manufacturing capacity for W88 pits" at the Los Alamos PF-4 facility. By FY 2009, NNSA wants to reestablish pit-manufacturing technologies for the W87 intercontinental ballistic missile (ICBM) warhead and the B-61-7 Strategic Bomb. Together with the just reestablished pit manufacturing capability for the W88 warhead, these technologies "will enable the manufacture of other pit types within the stockpile."

The current draft environmental impact statement for the Modern Pit Facility (MPF) mentions three PF-4 "upgrade alternatives" ranging from 55 to 150 pits per year. Given sensible post-Cold War requirements for a much smaller nuclear stockpile, numbering in the low hundreds to deter nuclear strikes against the United States and its friends and allies pending the global elimination of such weapons, NNSA clearly could maintain a sufficient deterrent without the MPF. The average age of the current stockpile pits is 20 years, and NNSA assesses *minimum* lifetimes for properly maintained pits to be 45 to 60 years with no "life-limiting factors" yet identified. That would allow plenty of time to manufacture a small "hedge stockpile" of fresh pits to ensure that the United States is never without a fully functioning stock of primary components.

In light of NRDC's position that the United States could morally and credibly use nuclear weapons in only extremely limited military missions, a limited pit production capacity of 20 to 80 pits per year in existing facilities at Los Alamos would seem to cover the range of plausible future requirements, and represents an adequate hedge against stockpile aging.

More expansive attitudes toward to role of nuclear weapons in U.S. policy, such as those enunciated by the Bush administration's December 2001 Nuclear Posture Review, could lead to demand for a larger and more "robust" capability than that likely to be available at Los Alamos. Thus the current debate over the "need" for a Modern Pit Facility is really a proxy for a more fundamental, long-deferred debate: What role, if any, should nuclear weapons play in defense of the nation in the post Cold War world?

The Bush administration's nuclear plans and programs, overshadowed by the war against terror and the invasion of Iraq, have largely gone unexamined by the Congress. One can only hope that the Bush administration's push for the $4 billion MPF will focus congressional and national attention on the underlying issue.

CHAPTER 7

BEWARE WARNINGS OF AN IMPENDING TRITIUM GAP

A Stroke of the President's Pen Could Postpone it for Decades

The administration's program to satisfy future requirements for tritium, a gas that enhances nuclear explosions, is fraught with inefficiency, bad management, and a continuing failure to consolidate tritium R&D operations to a single site, and overall tritium operations to fewer sites. To be fair, the program was largely inherited from previous administrations.

NRDC estimates (see Appendix Table F) that DOE and NSSA have spent at least $2.6 billion since 1996 maintaining and attempting to restore U.S. tritium boost gas recycling, production and extraction capabilities.[36] This is a huge sum, given that U.S. requirements for tritium have been declining steadily with continuing reductions in the requirement for "active" stockpile weapons, *and that no fresh tritium was required or produced to support the stockpile over the last eight years.*

DOE spent this money ostensibly to restore its capability to support the START II stockpile tritium requirement of 4,900 "active" nuclear weapons with filled tritium reservoirs plus a plus a "five-year reserve" to replenish same in the event production were (implausibly) disrupted for a prolonged period. NRDC estimates that this artificially inflated requirement could be met from existing tritium supplies until 2007, at which time the reserve would dip below its "required" five-year support level. In 2012, the number of deployed weapons would begin to be affected, and the warhead inventory would need to be replenished with fresh tritium.

Suffice to say, this tritium requirement scenario is now outdated but has yet to be formally replaced with another, more realistic one, despite the administration's supposedly extensive Nuclear Posture Review in 2001.[37]

NRDC estimates that to support the reduced but still large nuclear force levels called for under the Moscow Treaty – for example 1,700 operationally deployed strategic weapons and 300 operationally deployable non-strategic weapons, with a five-year tritium reserve – would not require resumption of tritium production to prevent a decline in the reserve until around 2012, and actual weapons would not need fresh tritium until 2017. Clearly, the Bush administration and Congress have a lot of flexibility in determining both "required" operational nuclear force levels and when, or indeed *whether*, to resume tritium production.

Weapons with depleted tritium reservoirs still would detonate with a force ranging from few hundred to thousands of tons of TNT equivalent – still a devastating explosion, particularly if delivered by highly accurate GPS-guided systems. Given the strategic shift away from planning massive "counterforce exchanges" between superpower mega-arsenals resulting in the collateral deaths of tens of millions, there is no longer a "need" to maintain large numbers of high-yield (e.g., 100 to 1,000 kiloton) nuclear weapons ready to strike at a moment's notice. The declining tritium inventory could be concentrated in a small number of higher yield weapons retained solely for the purpose of ensuring a retaliatory deterrent against nuclear attack on the American homeland. Other deterrent requirements would be met by more discriminate kinds of military forces.

Given that the existing requirement for a five-year reserve makes no economic sense for a decaying asset such as tritium, and given that the president has the inherent authority under the Atomic Energy Act to direct production of tritium in any one of 100 civilians reactors in the (unlikely) event of a national security "emergency," shifting to a shorter two-year reserve makes more sense, and would further extend the date at which the tritium inventory decay curve crosses the fixed horizontal stockpile "requirement" line, indicating a need for new production.

A deployed nuclear force of 1,000 warheads, larger than the forces currently deployed by any nuclear weapon state save Russia, could be maintained with a two-year reserve until at least 2022 without producing additional tritium. It is by no means clear in today's post-Cold-War world that an operational nuclear force of even 100 deliverable weapons is any less of a deterrent than one comprised of 2,000 such weapons.

There would appear to be, in national security terms, little urgency attached to the NNSA's recent costly efforts to ensure future tritium target-rod irradiation and gas-extraction capabilities *unless* the Bush administration is bent on retaining a capability to "surge" U.S. nuclear forces to levels much larger than those outlined in the Moscow Treaty, which, as noted previously, already grossly exceed sensible nuclear deterrent requirements.

In 1998 the Clinton administration, in the form of Secretary of Energy Bill Richardson, finally managed to deflect a strong pork barrel push from the New Mexico and South Carolina delegations that would have resulted in the continued development (at Los Alamos) and construction (at the Savannah River Site) of a massive, electricity-gobbling $4 billion to $6 billion proton accelerator for producing tritium (APT). Nevertheless, DOE still managed to waste some $600 million on the R&D for this behemoth, which at one point in the late 1990s had some 700 lab and contractor employees working on it at Los Alamos, and it was not officially "closed-out" until FY 2002.[38]

The proton accelerator was intended to be the opening wedge of an even grander, more expensive scheme – still lurking in the mind's eye of Senator Pete Domenici and other Los Alamos partisans – to ensure the future prosperity of the laboratory. They would like to build massive accelerators to "transmute" long-lived nuclear waste streams into more manageable shorter-lived isotopes, while other facilities separated and recycled plutonium and uranium back into fuel elements for nuclear reactors.

NNSA has wasted additional public money trying to complete a new facility for extracting tritium gas from tritium producing burnable (neutron) absorber rods (TPBARs) used in the future contingency system for producing tritium in the Tennessee Valley Authority's Watts Bar and Sequoyah reactors. The official total cost of this Tritium

Extraction Facility (TEF) project, originally estimated at $391 million, is now $506 million, but the actual cost is higher still, as current project cost overruns are quietly "off-loaded" onto other NNSA operating and capital equipment accounts.

NNSA has pushed back completion of the TEF project, originally scheduled for the fourth quarter of FY 2004, to the fourth quarter of FY 2007 – a three-year delay. As shown in tables F and G in the Appendix, while officially funded through the Tritium Readiness campaign element, DOE also draws sums from other accounts, such as ADAPT and Readiness in Technical Base and Facilities to fund its Savannah River Site tritium activities, including costs associated with developing and equipping the new tritium extraction system. How much DOE is *really* spending on the TEF is anybody's guess.

Rather than consolidating or eliminating sites where tritium R&D activities are conducted – each site requires its own (decaying) minimum inventory of tritium and carries high fixed overhead costs for security and environment, safety and health – DOE has continued under both Clinton and Bush administrations to sustain tritium operations at both Los Alamos and Lawrence Livermore National Laboratories as well as at Savannah River. Indeed, the Bush administration's particular contribution is to reinvigorate the tritium R&D facility (B331) within Livermore's Superblock Complex.

This merely extends the existing pattern, inherited from the Clinton administration, of extravagant redundancy for plutonium R&D and penetrating radiography facilities. Successive administrations have allowed DOE to maintain these kinds of weapons program facilities in triplicate, at Livermore, Los Alamos and the Nevada Test Site, as though the nuclear arms race with the former Soviet Union had never ended.

CHAPTER 8

Conclusions and Recommendations

Since adopting a complex, simulation-based “virtual testing” and “virtual prototyping” strategy in 1995 as the paradigm for stewardship of the U.S. nuclear stockpile, DOE has spent tens of billions of dollars on new and upgraded experimental facilities, computers, networks, code development, and computer-controlled production equipment. But the agency remains unable to implement major parts of this grand – some critics would argue “grandiose” – strategy, as key experimental capabilities remain unfinished, mired in technical difficulties and huge cost overruns.

Therefore, the agency is proceeding with major stockpile life-extension programs without satisfying the “requirement” of certifying them by new computer codes that have been “validated” experimentally. To be validated, those computer codes must demonstrate their ability to resolve and predict the effects of three-dimensional anomalies on the outcome of integrated nuclear explosive experiments.

The premise behind NNSA’s massive expenditure on the U.S. nuclear stockpile was that absent nuclear test explosions, it only could retain confidence in new or modified nuclear weapons’ performance by using data from costly nuclear experiments – including laser fusion – for three-dimensional “end to end” computer simulations of the entire nuclear explosion sequence, beginning with chemical explosive detonation in the primary and ending with thermonuclear burn and fissioning of the secondary. It then could check the resulting code predictions, for example, through highly penetrating, time-resolved radiographic “hydrotests” of the primary implosion system using Los Alamos’ Dual Axis Radiographic Hydrotest facility, or by fusion capsule gain experiments at Livermore’s National Ignition Facility.

(As previously discussed, the NIF capability is by no means at hand, and even if it were, there is scientific disagreement on whether the results of micro-fusion experiments, and computer code predictions of these results, can be confidently scaled to the temperature-pressure regime in nuclear weapons.)

When NNSA initially adopted the virtual testing strategy, critics, including NRDC, charged that the it was too ambitious, too costly, too provocative and, most important, *not necessary* for the task at hand, which they defined as sustaining confidence in the safety and reliability of a modest but sufficient nuclear weapons stockpile until global elimination of such weapons could be achieved.

The critics also noted, in detailed studies, that the large unclassified research component of the effort to model fundamental physical processes involved in generating nuclear explosions would tend to exacerbate proliferation of nuclear weapons knowledge.[39] Subsequent events have proven these criticisms to be well founded.

There was an alternative approach 10 years ago, which NNSA is slowly adopting due to the failure of its more ambitious stewardship efforts. That approach was and remains "engineering-based" stewardship, premised on assuring the ability to produce and replace non-nuclear components and subsystems that can be thoroughly tested, and on minimizing changes to primary- and secondary-stage nuclear components that cannot be tested to nearly the same extent.

Using this more conservative approach, NNSA can maintain confidence in the performance of nuclear explosive components, not through elaborate new end-to-end computer simulations of uncertain fidelity, but through careful engineering efforts that maintain existing (or better tolerances) in weapons manufacture, and rely on tried and true hydrotesting techniques for benchmarking the performance of previously successful fully-tested primary implosion devices. The agency can repeat these tests on random stockpile samples in subsequent years to ensure the deployed systems continue to hit the required benchmarks characteristic of successful test implosions leading to ignition of the boost gas.

On the other hand, ensuring adequate second-stage nuclear performance – the Cold War's strict performance criteria in which unexpected degradations in nuclear explosive yield ("unreliability") could affect "kill probabilities" against hardened "counterforce" targets such as missile silos and command centers – is clearly not as relevant as it once was, even to those who subscribed to the oddly detached moral psychology and doctrines of nuclear war-fighting deterrence. Even the Pentagon's own Defense Science Board has recently come round to the view that large numbers of high yield nuclear weapons are no longer required to support a credible and effective deterrence policy.[40]

This shift means that using computer simulations in an attempt to guarantee ("certify") highly predictable levels of primary boost performance – thereby ensuring full yield performance of the secondary – is no longer of primary importance, particularly in view of improvements in GPS-aided guidance. These improvements only accentuate delivery accuracy as the dominant contributor to weapon lethality against most classes of hard targets, with the possible exception of deeply buried targets, which can only be destroyed by large, fall-out producing, shallow-buried explosions.

For post-Cold War deterrence, it matters little (except perhaps to the potential victims) whether a nuclear weapon produces yields in the range of 100 to 1,000 kilotons, indicating complete burning of the secondary stage, or one to perhaps a few tens of kilotons, indicating partial or non-ignition of the secondary stage due to inadequate boosting. Relative to conventional weapons, the result still would be a powerful explosion that, accurately delivered, would destroy all but deeply buried point targets.

If the uncertainty in nuclear performance is biased toward lower yields, so much the better. Some "collateral" victims might live who otherwise might not have. The function of nuclear weapons is to deter wars, not "win" them by ensuring the highest possible capacity to destroy heavily protected nuclear command targets, thereby blanketing millions of civilians with deadly fallout.

In pursuit of obviously self-serving economic and bureaucratic motives, NNSA and its weapons laboratories have “mystified” and “complexified” the basic tasks of sensible stockpile stewardship well beyond the bounds of reason and fiscal sanity. Far from boosting confidence, the current program is actually structured to function as a constant wellspring of *uncertainty*, thereby fostering continuing “requirements” and “milestones” for ever more elaborate and expensive experimental and computational facilities, and, ultimately, a return to nuclear explosive testing, to resolve the accumulated conflicts and inconsistencies in the data generated by numerous scaled experiments and complex simulations.

RECOMMENDATIONS FOR CONGRESSIONAL ACTION

- 1) **Defer action on any new facility or weapons refurbishment request until the administration has submitted and Congress has examined, debated, and approved the essential contours of a plan to reduce the nuclear weapons stockpile to levels that make sense for the post-Cold War world.**

In NRDC’s view, an appropriate interim stockpile level is fewer than 1,000 total weapons (a minimum ten-fold reduction from the current stockpile) of which only a few hundred need remain in the “active” inventory, meaning they are equipped with electric power sources, neutron generators, and tritium reservoirs. None of these weapons need to be standing day-to-day alert (except for training purposes), and the number of expensive (and now pointless) undersea deterrent patrols for nuclear missile submarines should be drastically curtailed. The nuclear ICBM force also should be cut back significantly or even eliminated entirely, as it is no longer actively “deterring” anyone, and need not be kept on alert.

While others are likely to have more expansive views of future nuclear stockpile requirements, the most important thing for Congress is to cease ducking the nuclear weapons issue and *have the debate*, examining what can and should be changed. There are potentially billions of dollars in annual savings to be had from shifting to a far more compact and less alert nuclear force, supported by a smaller and more sustainable nuclear complex.

- 2) **Consistent with the requirements of a revised nuclear stockpile plan, determine how to rationalize and consolidate the NNSA complex to eliminate Cold War redundancies, reduce its environmental footprint, and reduce the security and safeguards overhead burden, which is growing rapidly.**

For example:

- (a) **End weapons plutonium, highly enriched uranium, and radiographic hydrotest operations at Livermore**, and stop the restart of the plutonium AVLIS (Atomic Vapor Laser Isotope Separation) pilot plant. Consolidate nuclear warhead stockpile support functions at Los Alamos and Sandia National Laboratories.[41]

- (b) **Retain Livermore’s role as a peer reviewer for weapon computations** and in making proliferation assessments.

- (c) **Designate Livermore as the lead laboratory for NNSA supercomputing**, stop the helter-skelter continuing acquisition from multiple vendors of massive supercomputers at the other weapons laboratories, phase out ASCI software development efforts at Los Alamos and consolidate them at Livermore, and mandate the development of unified hardware, software and networking standards for the weapons complex, with maximum emphasis on cost-effective sharing of computer resources. Cut the bloated out-year ASCI budgets by at least 50 percent, and focus the remaining ASCI resources on developing and sharing the evolving capability at Livermore. Japan developed its world leading Earth Simulator supercomputer with less than 1/10 of the funding DOE has poured into ASCI.

- (d) **Conduct an immediate review of the technical and scientific prospects for achieving fusion ignition at NIF**, and the costs and benefits to the stewardship program and civilian science from (1) persevering with the current project plan; (2) deferring the quest for fusion ignition and downsizing the facility into a facility for sub-ignition stewardship experiments; (3) focusing on ignition and civilian science missions, and abandoning plans to conduct nuclear weapons effects experiments, and experiments with plutonium and other weapon materials.

- (e) **Plan on sustaining a long-term steady-state tritium inventory sufficient to support only a few hundred active stockpile weapons** with substantial nuclear yields (i.e., greater than a few kilotons), and cancel current tritium production plans accordingly.

- 3) **Delete funding for the robust nuclear earth penetrator and Advanced Concepts "study" efforts.**

Despite administration denials, the FY 2005 request for nuclear earth penetrator project goes far beyond paper studies to include "hardware demonstration tests, … subsystem tests, and a full system test of the proposed [earth penetrator] design." Aside from valid concerns about the political consequences of such programs for the broader nonproliferation effort, an agency that has so egregiously mismanaged U.S. taxpayers' investment in stewardship of existing weapons has no business shopping for exotic new warheads to foist on an unsuspecting public.

- 4) **Delete funding for enhanced nuclear test readiness activities.**

There is no national security problem for which nuclear test explosions are the answer, and we should not be suggesting to the world, and especially proliferant states, that we think otherwise. President Bush claims his administration has no plans to resume nuclear tests. Increased funding for nuclear test readiness undermines this assurance. The funding request should match the rhetoric, or others will conclude that the rhetoric is not sincere.

- 5) **Streamline and simplify the current needlessly complex "virtual testing" paradigm for stockpile stewardship.**

After a decade, the current stewardship program has not built the kind of disciplined and conservative protocols that would permit indefinite, confident retention of a modest nuclear weapons stockpile at minimum cost to taxpayers, without nuclear testing and without needlessly antagonizing other nations. The intellectual premise of the current bloated stewardship effort – that the United States should continually expand its stock of nuclear weapons knowledge even as it threatens or preemptively strikes others whom we suspect of doing the same thing – runs counter to U.S. nonproliferation objectives.

- 6) **Put in place a capability for low-rate (20 to 50 per year) remanufacture of weapons based on recycled or recast pits of existing design.**

Defer consideration, possibly indefinitely, of a larger capacity Modern Pit Facility until both pit lifetimes and future nuclear weapons requirements are clearer, and rely on the newly modernized interim pit fabrication capability at Los Alamos as a sufficient hedge against uncertainty.

- 7) **Reinvigorate unilateral, bilateral, multilateral, and international efforts to reduce and eliminate national stocks of nuclear weapons and weapons-usable nuclear materials.**

Based on the stated policies of the current administration, implementation of this objective likely must await a "regime change" in the United States.

- 8) **Direct DOE to establish an independent outside advisory committee under the Federal Advisory Committee Act to conduct peer reviews of stewardship science and technology projects.**

Major difficulties and delays in several of NNSA's ambitious lead projects for stockpile stewardship point to the need for ongoing independent technical and programmatic oversight and advice.

APPENDIX

WHAT THINGS REALLY COST IN THE NNSA "WEAPONS ACTIVITIES" BUDGET

In the decades before post-Cold war public relations propelled a morphing of the U.S. nuclear weapons program into the more benign-sounding "Science-Based Stockpile Stewardship," DOE presented its nuclear weapons budget request to Congress in a fairly straightforward fashion. The major budget categories were Nuclear Weapons Research and Development, Nuclear Weapons Testing, Nuclear Weapons Production and Surveillance, and Nuclear Weapons Materials Production.

Today's budget structure for Nuclear Weapons Activities, while covering much the same ground, is now comprised of the major elements summarized in Table A, the contents of which are no longer understood by most members of Congress, other agency decision-makers, the news media, or the public. Note the prevalence of broad, vague, generic and basically meaningless categories of funding: Science Campaign, Engineering Campaign, Readiness Campaign, Readiness in Technical Base and Facilities. From these one would hardly know that NNSA is working on nuclear weapons.

Directed Stockpile Work (DSW*)* – funded at $1.4 billion in the current budget year and the FY 2005 request – is directed toward "maintaining confidence in the safety, security, and reliability of the nuclear weapons in the nation's stockpile through maintenance and evaluation" and "refurbishment" of existing weapons. The refurbishments consist of so-called "life extension programs" for each nuclear weapon type to be retained in the stockpile, but these actually involve substantial and costly upgrades to the weapons that go far beyond "maintenance," or even what most people commonly understand by the term "refurbishment." In fact, $433 million of this funding is currently devoted to a budget element called Stockpile Research and Development, while only $38 million is directed toward Dismantlement/Disposal of nuclear weapons.

The *campaigns* component – accounting for some $2.4 billion or 38 percent of the total current funding for Nuclear Weapons Activities – is the single largest component by far in the NNSA budget. It consists of a grab bag of activities that in an earlier era were openly described as "nuclear weapons research and development." Now, under the essentially meaningless "campaigns" rubric, one finds five opaque program element titles: Science Campaigns, Engineering Campaigns, Inertial Confinement Fusion and

High Yield, Advanced Simulation and Computing, Pit Manufacturing and Certification, and Readiness Campaigns.

TABLE A: Bush Spending Plan for Nuclear Weapons Research, Development, & Production: FY 2005 – FY 2009 (Dollars in Thousands)

Weapons Activities	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FYNSP Total
Directed Stockpile Work	1,406,435	1,521,175	1,648,144	1,778,400	1,812,398	8,166,552
Science Campaign	300,962	301,382	307,784	328,330	341,028	1,579,486
Engineering Campaign	242,984	268,207	226,357	284,020	236,838	1,258,406
Inertial Confinement Fusion & High Yield Campaign	492,034	521,319	535,070	437,069	440,557	2,426,049
Advanced Simulation and Computing Campaign	741,260	781,509	825,705	834,160	848,359	4,030,993
Pit Manufacturing and Certification Campaign	336,473	323,508	314,180	154,579	158,168	1,286,908
Readiness Campaign	280,127	330,801	307,383	357,027	376,460	1,651,798
Readiness in Tech Base & Facilities	1,474,454	1,600,185	1,753,217	1,839,266	1,915,754	8,582,876
Secure Transportation	201,300	185,000	185,971	190,014	195,000	957,285
Nuclear Weapons Incident Response	99,209	100,136	100,657	98,331	100,609	498,942
Facilities Recapitalization	316,224	372,707	425,848	472,114	475,531	2,062,424
Safeguards and Security	706,991	607,071	618,684	613,690	626,298	3,172,734
Total, Weapons Activities	6,598,453	6,913,000	7,249,000	7,387,000	7,527,000	35,674,453

Source: “FYNSP Schedule,” DOE/NNSA FY 2005 CBR, p. 50.

Science Campaigns ($301 million, +27 million) is really a series of applied science and technology research projects to improve U.S. capabilities for nuclear weapons design. In the FY 2005 budget request, Primary Assessment Technologies (called Primary Certification in FY 2004) contains $81.5 million to develop tools and methodologies to predict (“certify”) whether a specific design for the “primary” (trigger) stage of a nuclear weapon will achieve the explosive power required to drive the full weapon to its nominal design yield.

A BUSY SCHEDULE AT THE NEVADA TEST SITE

The FY 2004 request for Primary Assessment Technologies includes $30 million (+$5.3 million) for improving Nevada Test Site readiness to resume underground nuclear test explosions (in prior years this activity was funded under Readiness in Technical Base and Facilities.) It also includes some of the funding for “subcritical experiments” with high explosives and fissile material conducted at the Nevada Test Site in the underground U1a Complex, and for plutonium shock loading experiments in Livermore’s big gas gun, the Joint Actinide Shock Physics Experimental Research Facility (JASPER), also located at the test site.

The next subprogram of Science Campaigns, Dynamic Materials Properties, ($91.5 million, + $10 million) appears to cover much the same ground as Primary Assessment Technologies, and it is not immediately clear why there are two separate programs, except perhaps to maximize the flow of funds to each nuclear design laboratory. This subprogram also supports Nevada Test Site experiments at the U1a Complex, JASPER, and the recently moved (from Los Alamos) Atlas Pulsed Power Facility, and at the Los Alamos Neutron Science Center and Sandia's pulsed power Z-facility in Albuquerque.

ADVANCED RADIOGRAPHY AND PLUTONIUM AVLIS

"Advanced Radiography" ($62.4 million, + $6.7 million) seeks better "quantitative radiographic data to improve the link between radiographic images [of imploding inert primaries] and the assessment of [nuclear explosive] primary performance." This sub-program also supports a secretive Advanced Materials Project at Livermore that is reviving the Plutonium AVLIS (Atomic Vapor Laser Isotope Separation) pilot plant mothballed in the early 1990s, when the first Bush administration cancelled construction of the full-scale plant slated for the Idaho National Engineering Laboratory.

According to Bruce Goodwin, Livermore's associate director for defense and nuclear technologies, the Advanced Materials Project will be "purifying [plutonium] isotopes for [dynamic] experiments." The secretive laser isotope separation project reportedly will deal with only "a few hundred grams at a time." Over a 10-year period, Godwin said, only "50 to 100 kilograms would be used."[42] The plutonium isotope in question is almost certainly the rare and significantly less fissile Pu-242, which can be used for above-ground radiographic "hydrotests" (test implosions) of full-scale nuclear weapon primaries without producing an explosive nuclear chain reaction.

As noted in the body of the report, the chief preoccupation of the Advanced Radiography sub-program is fixing the badly botched second-axis of Los Alamos' Dual Axis Radiographic Hydrotest (DARHT) facility, ostensibly and arguably the most technically important facility in the science-based stockpile stewardship program.

The DARHT project began life in the FY 1988 budget request as a modest $30 million upgrade involving deployment of two single pulse 16-Mev electron-beam accelerators producing X-rays. The project has since been "rescoped" several times, including division in 1997 into two distinct phases, and costs have ballooned to at least $327 million, according to a May 2003 report by the DOE inspector general.[43] The audit disclosed that the "the DARHT facility would not be fully operational until June 2004 – 15 months later than its [most recent] projected completion date of March 2003," but that recent IG assessment is already obsolete. Given the magnitude of the schedule delay subsequently included in the current NSSA budget request, it seems likely that Los Alamos officials may have mislead the IG investigators.

Phase I, consisting of a Radiographic Support Laboratory and a twin axis Hydrotest Firing Site with one flash X-ray machine installed, was ostensibly finished in FY 2000 at a cost of $105.7 million. Installation in Phase II of the second flash X-ray machine, the Long Pulse Induction Accelerator, has been a debacle. This machine is supposed to be capable of providing “four high-quality beam pulses over four microseconds, with each pulse comparable in quality to the single pulse machine in the first axis.”[44] Phase II was originally to have been completed by the end of FY 2002 at a cost of $154 million, but the current budget request for “Advanced Radiography” now states:

> In *FY 2005-2006*, the focus of this activity is on *the commissioning* of the Dual-Axis Radiographic Hydrotest (DARHT) facility, including solutions to high voltage breakdown problems on the 2nd axis discovered during early commissioning experiments. Optimization includes improving beam spot size and detector develop-ments to improve radiographic image resolution, *installation and activation of the second axis beamline hardware, and the multi-pulse target assembly*. Supporting work includes the development of a composite vessel technology to mitigate the environmental consequences of hydrotests (emphasis added).[45]

The revised timeline for this ostensibly highest priority project in the stockpile stewardship program now calls for the “first 2-axis hydro shot in support of stockpile assessment” to be conducted in FY 2007, *19 years* after the DARHT project’s inception, *15 years* after U.S. entry into a nuclear test moratorium, and *four years later* than called for under the revised two-phase project timetable, but even this elongated schedule presumes success in finding and implementing a technical fix for the flawed second axis.

Those who support relying on modern hydrotest data rather than nuclear test explosions to sustain confidence in the performance of an enduring nuclear stockpile could be forgiven for getting the impression that Los Alamos and NNSA managers are doing everything they can to undermine the technical basis for continued U.S. observance of a nuclear test moratorium and eventual ratification of a Comprehensive Test Ban Treaty. Alternatively, one could surmise from the dismal performance record that DARHT never really had the top priority claimed for it when NNSA managers exempted it from NEPA programmatic analysis in 1995, on the grounds that it had an urgent independent utility apart from all other elements of the Stockpile Stewardship and Management program. [46] Either way – and there is probably an element of truth in both hypotheses – this botched project merits a full-blown congressional inquiry.

SECONDARY ASSESSMENT TECHNOLOGIES

The fourth and final component of FY 2005 Science Campaign budget request is called Secondary Assessment Technologies ($65.6 million, + $11.5 million), formerly Secondary Certification and Nuclear Systems [Performance] Margins Campaign in the FY 2004 budget. This subprogram funds experiments on high energy density physics (HEDP) facilities, including the partially completed National Ignition Facility (NIF) at Livermore, the Omega Laser at the University of Rochester, and the Z Machine at Sandia Albuquerque, to validate computer codes used to predict nuclear weapons performance, and improve models of physical properties and processes at the extreme physics regimes relevant to nuclear weapons design.

Like Advanced Radiography, NNSA managers also may be tapping this operating-funds account to off-load excess capital costs from troubled NNSA projects that continue to overrun even their *revised* "total project cost" baselines, in this case, Livermore's exorbitant $4.2 billion NIF project. After all, what is a "National Ignition Facility" without an ignition target? The budget request states that an FY 2005 "area of emphasis" for Secondary Assessment Technologies will be "development of advanced target fabrication and diagnostic techniques required to support experiments" on NIF and other HEDP facilities. This probably refers primarily to non-ignition experiments to provide modeling data for the ASCI simulation program, but there is likely some overlap in both target fabrication and diagnostics with the effort to achieve ignition.

ENGINEERING CAMPAIGNS

The Engineering Campaigns program element ($243 million, -$22 million) is largely within the purview of Sandia National Laboratories. It develops enhanced "use-denial" and weapon initiation options for all stockpile weapons, establishes certification methodologies for non-nuclear components that do not rely on confirmation by further nuclear tests, develops radiation hardening techniques and hardened components for increased "survivability" of nuclear weapons systems in the intense radiation of a nuclear warfare environment, and develops (and seeks to experimentally validate) "design-to-effects" tools that translate the Pentagon's military effects "requirements" into warhead design specifications.

The two largest subprograms within Engineering Campaigns element are Enhanced Surveillance ($99.9 million, + $8.6 million) and Microsystems and Engineering Sciences Application (MESA) Complex (construction and "other project costs" total $53.3 million in FY 05). Enhanced Surveillance primarily funds assessments of stockpile weapon components and materials, including new diagnostic techniques, and seeks to develop "aging models to predict lifetimes of components and materials." But this subprogram also is used to fund "advanced diagnostics and telemetry to support flight test requirements" involving new or modified weapons." (The MESA project is described in detail in the body of this report.)

ICF AND NIF

The second largest NNSA "campaign" in FY 2005, in terms of funding, is the Inertial Confinement Fusion and High Yield Campaign, ($492 million, -$22.2), which will rise to a planned peak of $535 million in FY 2007 and accounts for total spending of $2.43 billion over the course of NNSA's projected Five Year National Security Plan. Most of this planned funding is directed toward completing the National Ignition Facility (NIF), a massive 196-beam laser facility under construction at Livermore, and achieving the technical readiness to begin NIF fusion ignition experiments.

TABLE B: Cost Estimate of "Ignition-Ready" National Ignition Facility (NIF) Through FY 2009 (Dollars in Millions)

NIF Funding by Year and Category	FY2004 & Prior Years	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FYNSP Total (FY05- FY09)	"Ignition-Ready NIF" (Total Program Cost through FY2009)
NIF Construction & Other Project Costs [a]	1,830.2	132.0	138.6	128.6	18.7	0	417.9	2,248.10
NIF Laser System Integration/Demo	723.0	114.0	117.0	121.0	125.0	0[b]	477.0	1,200.00
NIF Ignition Target	517.0[c]	76.5	90.2	94.0	102.6	105.1	468.4	985.40
NIF Diagnostics & Cryogenic System	194.0[d]	44.0	48.9	48.4	46.8	47.7	235.8[e]	429.80
ICF Support Ops & Target Production [f]	168.0[g]	31.5	32.9	40.1	38.7	170.35[h]	313.55	481.55
Total Direct Costs	3,431	398.0	419.0	423.5	323.1	323.15	1,912.65	5,344.85
Deficit Financing at 4.5% APR	Not incl.	18	19	19	14.5	14.5	86.00	86.00
Total Cost							**1,998.65**	**5,430.85**

[a] In addition to physical construction, this line includes the costs of NIF conceptual design, detailed facility design, NEPA compliance, "R&D necessary to complete construction, and "optics vendor facilitization and quality assurance." For the three out-years FY2006-08, there is a $26 million discrepancy between the total given by the annual funding profile shown in the FYNSP for "96-D-11 National Ignition Facility" and the "Schedule of Project Funding" for "NIF Total Project Costs – Outyears," so we have distributed this discrepancy evenly over the three outyears, adding $8.6 million to each year.

[b] FY 2009 represents the planned start of NIF routine operations. Annual operations funding shifts to "ICF Facility Operations and Target Production" line.

[c] Because of almost constant DOE weapons program budget restructurings and re-labeling of line items, and DOE's attempts to conceal from Congress the true cost of the NIF Project, it would take a major official auditing effort to gauge the full extent of DOE's actual "prior year" investment in the NIF project, particularly the indirect research and overhead costs. This figure includes the total amounts from the "Ignition" account for FY 2001-2004, plus 66% of LLNL's "Base ICF Program" cost for FY 1998-FY 2000.

[d] Includes funding from "Experimental Support Technologies" line for FY 2001-2003 and "Target Development, Fabrication and Handling" for FY 1998-FY2000.

[e] An independent analysis by former OMB budget examiner Dr. Robert Civiak in May 2001 estimated future costs of $175 million for diagnostics and $100 million for the target positioning system, which are consistent with the estimate given here.

[f] Since this account now supports "ICF target production" for all ICF facilities, including NIF, and "operations" at four other lesser ICF Program facilities – two of which directly support the "backup" NIF "direct drive" target program – this table allocates half of this funding line as an R&D related overhead cost of the NIF project. This is admittedly subjective. Some might argue that entire cost of the supporting Omega and Nike laser programs, and Los Alamos target fabrication effort should be allocated to NIF, while others might argue that these programs have some independent utility (particularly Nike, which is a very different type of laser from NIF and Omega) and allocate perhaps only 33% to the NIF Project. Given that NIF is the only facility nominally capable of imploding ignition targets, and target fabrication is critical to the success of the entire program, we have chosen 50%.

[g] Includes costs from FY1998-FY2004, allocated as follows: FY 1998-2000 = 0.5 x (the sum of ICF funding for UR/LLE Omega, NRL Nike Laser, and General Atomics Target Program); FY 2002-2004 = 0.5 x (sum of "Operations of Facilities/Target Production" line)

[h] Includes NNSA's projected $130.345 million/yr for "NIF Operations" plus $40 million/yr for supporting facility operations and target production. This estimate is likely to prove conservative.

According to DOE and NNSA, when laser installation is finally completed in September 2008, construction of NIF will have "officially" cost $3.5 billion. The actual cost of the project through FY 2008 will actually be at least $5.2 billion, and further billions will be required to reach the first "demonstration" of the facility's namesake mission, fusion ignition, now set for 2014.

In relation to NIF's marginal technical relevance for maintaining the "safety and reliability" of U.S. nuclear weapons, the cost of the project is mind-boggling. The true cost of the NIF project, through its laser system "completion" date at the end of FY 2008, is *at least* $5 billion, However, as the preliminary data for FY 2009 suggests, continued spending at the rate of roughly $500 million per year will be required for the next five to six years to reach the first "ignition demonstration" in FY 2014. Our "operations funding estimate" includes NNSA's official low-ball annual cost estimate for NIF facility support personnel, maintenance and repair costs, and utilities, plus another $40 million per year in operating funds for directly related critical facilities, such as target production.

As shown in Table C, these numbers suggest that the cumulative *direct* cost of getting to the first ignition demonstration on the NIF in FY 2014 – assuming it happens at all – will be at least $8.4 billion, nearly triple the revised 2001 “baseline” cost estimate upon which DOE and Congress based their approval to continue with the NIF project.

TABLE C: Estimated Total Cost of “Ignition-Ready” NIF by 2014 (Dollars in Millions)

	FY 2008 & Prior Years	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	Cumulative Costs through FY2014
NNSA Official “Baseline” Cost	3,448.1							
NIF Ignition Target Development	880.3	105.1	107.7	110.5	133.3	116.2	119.2	691.9[a]
NIF Diagnostics & Cryogenic System	382.1	47.7	50	50.2	52.7	54	56.5	311.1[b]
ICF/NIF Facility Ops & Target Production	311.2	170.35	200	235	270	310	350	1,535.35[c]
Lab Overhead @ 45% of Direct Operations Cost	(included in NIF research program)	77	90	106	122	140	158	693.0
Subtotal	5,021.7	400.05	447.7	501.7	578.0	620.2	683.7	8,253.05
Interest Expense @ avg 4.5 % APR	71.5	18.0	20.0	22.6	26.0	27.9	30.8	216.8
Total	5,093.2	418.05	467.7	524.3	604.0	647.9	714.5	8,469.85

[a] Assumes continued funding at FY 2009 level, plus 2.5% annual inflation adjustment for FY 2009-2014. This assumption may be excessive if one or more producible target designs are developed earlier rather than later in the program.
[b] Assumes continued funding at FY 2009 level, plus 2.5% annual inflation adjustment for FY 2009-2014. This assumption likely underestimates the costs of equipping NIF for conducting and diagnosing cryogenic target experiments, but we have no way of independently estimating how much this effort will ultimately cost.
[c] For FY2010-FY2014, this estimate assumes that NIF operations funding will increase steadily from DOE’s 2009 forecast level ($130 million plus $40 million for “target production”) to the “rule of thumb” suggested by the National Academy of Sciences for operating “high technology” research facilities—10-13% of the total project cost. Using the minimum 10% and DOE’s own (grossly understated) figure of $3.5 billion for total project cost still yields an annual NIF operating budget of $350 million. Hence we have assumed a four-year “ramp-up” to this level in our estimate.

However, NRDC believes that there are additional substantial “indirect” overhead costs associated with supporting and administering a cadre of highly specialized laser-fusion scientists and high-energy glass-laser system engineers, and their associated computing, equipment, and database resources, to conduct experiments on the NIF and Omega. Full and fair attribution of these indirect “laboratory overhead” costs to the NIF project’s requirements, at standard lab overhead rates (45 to 55 percent), likely would add another $700 million to $840 million to the NIF program cost estimate, bringing the actual cost of achieving ignition on the NIF to around $8.3 billion.

Given that NIF is a “discretionary expenditure,” and that its prolonged and more costly construction is occurring at a time of sharply rising budget deficits, there is now a *real* rather than merely “imputed” interest cost to the project. With true NIF-related project outlays of some $400 million to $600 million annually requiring deficit financing over the 10-year period until 2014, the government must in effect borrow that amount each year to keep the project going. Assuming an average T-bill rate of 4.5 percent for the period 2004 to 2014, that's another $216 million in interest that must to be added to the true cost of the NIF project, bringing the total cost of an "ignition ready" NIF to $8.5 billion by 2014.

SIMULATION COSTS

In NNSA's FY 2005 request, the Bush administration reveals that it intends to spend $740 million next year (+19.9 million), on the Advanced Simulation and Computing Initiative (ASCI) Campaign, and an astonishing $4.031 billion through FY 2009 – an average of $806 million per year on nuclear weapons computing alone.

As shown in Table D (see below), over the five-year period 2002 to 2006, NNSA will have added some 656,000 square feet of floor space dedicated to nuclear weapons supercomputing at a cost of $263 million, just for the empty buildings and utility support systems. The bill for equipping these centers with supercomputer hardware and advanced display technology through the end of the current Five Year National Security Plan comes to $1.71 billion, and operating them will cost another $1.35 billion. So by the end of 2009 all this supercomputing overkill will have cost U.S. taxpayers at least $3.3 billion, just for the buildings and computer hardware! Developing the three-dimensional weapons simulation codes (applications software) to utilize all this supercomputing power will cost billions more.

READINESS CAMPAIGN

NNSA's Readiness Campaign is intended to "revitalize the nuclear weapons manufacturing infrastructure" by improving both its "responsiveness" and its "technology base." Claiming marching orders from the Bush administration's December 2001 Nuclear Posture Review, NNSA claims "a truly responsive infrastructure is the cornerstone of the new nuclear defense triad" outlined in that document. "To be considered a credible deterrent, this infrastructure must include a manufacturing capability with state-of-the-art equipment combined with cutting-edge applications of technology, and an ability to quickly provide modified or enhanced capabilities and products to meet emerging threats."[47]

In FY 2005 to FY2009, five subprograms – covering capabilities for thermonuclear component ("secondary") manufacturing, high explosives production and weapons assembly/disassembly, electronic and mechanical components, new computerized production technologies, and readiness to produce tritium for stockpile weapons – comprise the planned Bush Readiness Campaign with a projected price tag of $1.65 billion. Some of this work is necessary for maintaining a nuclear deterrent stockpile, but much of it is not.

Consider, for example, the Advanced Design and Production Technologies (ADAPT) nuclear weapons program, which has received more than $548 million since FY 1998 and is slated to receive another $459 million in spending over the next five years, for a total of more than $1 billion. As shown in Table E, this program has been developing and deploying new weapons production technology for quite some time, and the program shows no signs of abating. The objective appears to be a modern, geographically dispersed, but nevertheless highly integrated "virtual" weapons design and production enterprise, making maximum use of computer-aided-design and manufacturing (CAD/CAM) techniques and high-speed secure networking to enable rapid prototyping and low-volume production of nuclear weapon parts.

TABLE D: The NNSA Buildup in Nuclear Weapons Simulation Capacity

New ASCI Facilities	Square Footage	Year Added	Number of Nuclear Weapons Simulation Staff	Construction Cost (excl. computers) $ in millions	Facility Annual Operating Costs ($ mil.)	Computer & Displays (VIEWS) Acquisition FY2002-2009	Weapons Computing Capacity (in trillions of floating point operations per second (TeraOPS)
Los Alamos Strategic Computing Complex (SCC)	267,000	FY 2002	300 "nuclear weapon designers, computer scientists, code developers, and university and industrial scientists and engineers"	100	63.5 ($508 million through FY09)	Data not available by site	"Scaleable" Facility has 20 TeraOPS operating, can support 50 with current mechanical infrastructure, has space 150 TeraOPS in a 43,500 sq. ft. computer room
Sandia/NM Joint Compu-tational Engineering Laboratory (JCEL)	64,900	FY 2003	175 "scientists and engineers" exploring "design alternatives using iterative simulations of virtual prototypes."	30.8	53.1 ($372 million through FY2009)	Data not available by site	50 TeraOPS in FY 2005
Livermore Terascale Simulation Facility (TSF)	253,000	FY 2004-2006	288 "weapons scientists, engineers and support staff" in a four story office complex	94.3	66.2 ($265 million through FY 2009)	Data not available by site	60 TeraOPS to be installed in FY 2004, 100 in FY 2005, 200+ capacity in two 128 x 192 ft. two-story computer rooms
Sandia/CA Distributed Information Systems Laboratory	71,516	FY 2004	130 "employees and visiting researchers... to apply vital high-end distributed resources across thousands of miles to meet the urgent and expansive design, analysis, and engineering needs of stockpile stewardship."	38	33.2/yr ($199.2 million through FY 2009)	Data not available by site	N/A - facility will emphasize distributed and distance computing techniques for sharing data, computing resources between sites.
Total	656,416 sq. ft.	over 5 years	893 professional staff	263.1	$216/yr $1.35 billion through FY 2009	$1.2 billion for com-puters $510 million for displays	360 TeraOPS (projected) in FY 2007

Sources: DOE/CBR's FY 2000-2005.

TABLE E: Funding for Advanced Design and Production Technologies (FY 1998 – FY 2004)

Fiscal Year ($ in 1,000's)	1998	1999	2000	2001	2002	2003	2004	Total
Prior Funding	90,098	79,520	85,000	75,958	68,432	71,581	77,461	548,050
Fiscal Year	2005	2006	2007	2008	2009			
Future Funding	84,788	89,506	89,441	95,633	99,522			458,890
Total Spending (Projected)								$1,006,940

In recent years, NNSA has used ADAPT funding from the Process Development Program to "develop and prototype equipment and processes to recover tritium effluents from tritium facilities and assure product quality," effectively supplementing funding for the troubled Tritium Extraction Facility (see below), which has vastly overrun its budget.[48] This trend continues, although less visibly, in the FY 2005 budget request, which makes ADAPT a sub-element of Readiness Campaigns and briefly states that a "major focus area" of the program will be "developing capabilities and improvements to tritium processing."

TRITIUM COSTS

NRDC estimates that DOE and NSSA has spent at least $2.6 billion since 1996 maintaining and attempting to restore U.S. tritium recycling, production, and extraction capabilities. The recent spending has been premised on restoring a capability to support the START II stockpile tritium requirement (i.e. 4,900 "active" nuclear weapons with filled tritium reservoirs plus a plus a "five-year reserve" to replenish same in the event production were (implausibly) disrupted for a prolonged period. Suffice to say, this tritium requirement scenario is now outdated but has yet to be formally replaced with another, more realistic one (see text of report for detailed discussion of future tritium requirements.)

TABLE F: Tritium Capabilities Spending Estimate: FY1996 – FY 2004 (Dollars in Thousands)

Program: FY	1996	1997	1998	1999	2000	2001	2002	2003	2004	Total
Target Irradiation & Extraction Capabilities	75,000	100,000	260,855	167,000	170,000	165,321	132,489	129,802	134,115	1,334,582
Consolidate & Modernize Tritium Recycle Facilities		1,500	8,492	20,408	28,400	29,141	29,561	21,908	0	139,410
SRS Tritium (RTBF) Operations Fundinga	75,000 (est.)	75,000 (est.)	75,000 (est.)	75,000 (est.)	52,046 (actual)	75,191 (actual)	73,753 (actual)	83,035 (actual)	78,016 (actual)	662,041
SRS Capability for Advanced Loading Missions (CALM)							1,118	1,381	261	2,760
RTBF Material Recycle & Recoveryb	8,000	9,000	10,500	10,500	10,500	10,500	10,500	10,500	10,500	90,500
SRS Tritium Sitec Safeguards & Security	8,000	8,500	9,000	9,500	9,825	10,329	13,055	11,450	11,885	96,719
Tritium R & D Facilities, RTBF Funding (est.)d	25,000	26,000	27,000	28,000	29,000	30,000	31,000	32,000	33,000	261,000
Total FY1996-2004										2,587,012

[a] For FY 1996-2000, this number was not broken out under the old budget structure, but an estimate of 50% of the $152 million provided in FY 98 for “limited life component exchange” (i.e. neutron generators and tritium reservoirs) is consistent with actual amounts for FY 2001-2005 SRS Tritium Site “operations costs” that were identified in the budget.

[b] Estimated values, based on actual value of $7 million in FY 1995 that represented 12.25 % of the total MR&R line that year. Recent actual values may be significantly higher, but are unlikely to be significantly lower.

[c] FY 96 – FY 1999 safeguards and security costs for SRS were not separately identified in the former DOE Defense Programs budget.

[d] RTBF funding base “guesstimate ” in FY 96 as follows: Los Alamos “Weapons Engineering Tritium Facility (WETF)” - $12 million/yr; Los Alamos “Tritium Science and Fabrication Facility (TSFF) - $11 million; total = $23 million out of LANL/RTBF operations funding of about $300 million per year . Livermore’s “Tritium Facility” (B331) in the “Superblock Complex” estimated at $2 million/yr out of an RTBF total of $40 million. Annual sum of $25 million for all three facilities is then escalated by $1 million (4%) per year. It should be emphasized that this is only a guess, and the real number may be significantly larger or smaller than that estimated.

TABLE G: Projected Tritium Capabilities Spending FY2005-2009

FYNSP (Planned)	2005	2006	2007	2008	2009	Total
Target Irradiation & Extraction	79,850	97,808	68,059	85,586	91,637	422,940
Cleaning & Loading Mods (CALM)	8,025	15,822	14,650	12,479	4,004	54,980
SRS Tritium Site RTBF Operations Fundinga	95,173 (request)	83,144 (est.)	85,275 (est.)	87,462 (est.)	89,704 (est.)	440,758
RTBF Material Recycle & Recoveryb	10,500	10,770	11,045	11,329	11,619	55,263
SRS Tritium Site Safeguards & Security	12,000	12,307	12,623	12,948	13,280	63,158
Tritium R & D Facilities, RTBF Funding (est.)c	34,000	35,000	36,000	37,000	38,000	180,000
Tritium Facility B331 Modernization, LLNL						14,000 (est.)
Total Tritium Cost: FY 2005-FY2009						1,231,099

[a] FY 2006-09 amounts are estimated, based on average of prior five years of funding, escalated by 2.5% per year.

[b] Estimated amounts, based multiplying total FY2005 MR&R costs by known (1995) SRS percentage of 12.25, and escalating result by 2.5% per year for FY 2006-2009. Since 1995 represented the post Cold War low point in Weapons Activity funding, this methodology probably understates the actual cost.

[c] From previous table, RTBF funding base "guestimate " in FY 96 was as follows: Los Alamos "Weapons Engineering Tritium Facility (WETF)" - $12 million/yr; Los Alamos "Tritium Science and Fabrication Facility (TSFF) - $11 million; total = $23 million out of LANL/RTBF operations funding of about $300 million per year . Livermore's "Tritium Facility" (B331) in the "Superblock Complex" estimated at $2 million/yr out of an RTBF total of $40 million. Annual sum of $25 million for all three facilities is then escalated by $1 million (4% declining to 2.7%) per year to reach FY2009 estimate of $38 million. It should be emphasized that this is only a guess, and the real number may be significantly larger or smaller than that estimated.

READINESS IN TECHNICAL BASE AND FACILITIES

The DOE's FY 2005 request for Readiness in Technical Base and Facilities is for $1.47 billion, an increase of $66 million over this year. This catch-all program category, alluded to above in the previous discussion of spending on tritium-related projects, is a functionally meaningless account with vague sounding sub-programs titles such as "Operations of Facilities Program Readiness" and "Construction" that conceal far more than they reveal.

From the program analysis standpoint, such categories are useless, as they reveal nothing about how NNSA is allocating and investing its "operating" and "capital" funds across the functional program areas required for nuclear weapons. A more transparent and useful budget breakdown would resemble something along the lines of the following:

- "nuclear weapons design, testing, and simulation,"
- "plutonium processing and component fabrication,"
- "uranium operations and other secondary nuclear explosive materials,"
- "tritium production, purification and reservoir replenishment,"

- “limited-life components,”
- “high explosive components,”
- “other non-nuclear components,”
- “weapons system integration and flight-testing,”
- “weapons assembly and modification”
- “stockpile surveillance and evaluation,”
- “warhead dismantlement,” and
- “nuclear component storage.”

Within each of these functional categories, expenditures should and could be identified by type of activity (e.g., R&D, field-testing, production, surveillance and evaluation) by type of expenditure (e.g., operations funding, capital equipment, construction, safeguards and security) and by site and facility (e.g. Los Alamos TA-55, LLNL B331). Such required budgeting would simultaneously reveal not only how DOE is allocating its funding between *operations* and *capital investment*, and between *R&D* and *stockpile maintenance* activities, but it would make clear to Congress the real costs of the redundant capabilities and locations that are being sustained within the current complex.

For the moment, however, or until it demands better, Congress is stuck with such dysfunctional monikers as Readiness in Technical Base and Facilities, which immediately raises the question, “Readiness for what?” To resume the technological arms race with Russia (or China?) To “surge” future production of nuclear weapons to discourage any would be challengers to U.S. nuclear supremacy?

Within Readiness in Technical Base and Facilities the two largest sub-programs in FY 2005 and recent years are Operation of Facilities, at $1.02 billion, and Construction at $206.3 million. Los Alamos facilities get roughly a third of the “operations” funding at $319 million, followed by Sandia at $151 million, the Kansas City Plant (which makes non-nuclear warhead components) at $102 million, the Pantex Plant at $98 million, and the Oak Ridge Y-12 National Security Complex at $98 million. This spending has no particular programmatic focus, but rather operates and maintains a wide range of “program infrastructure and facilities … in a state of readiness, ensuring each capability (workforce and facility) is operationally ready to execute programmatic tasks identified in Campaigns and Directed Stockpile Work (DSW).”

To make matters worse, NNSA shuffles programs and projects in and out of the Readiness in Technical Base and Facilities category and makes “comparability adjustments” to prior year funding, making it even harder to discern trends in spending or to follow projects from beginning to end. Such budget games mask the fact that 14 years after the dissolution of America’s only plausible nuclear adversary, NNSA’s overhead expenses continue to rise even as America’s nuclear forces and requirements have been significantly reduced.

GLOSSARY OF ACRONYMS AND TECHNICAL TERMS

AHF	Advanced Hydrotest Facility, a multi-axis dynamic radiography facility, for imaging imploding nuclear weapons, proposed billion-dollar follow-on to DAHRT (see below)
ASCI	Advanced Simulation and Computing Initiative (formerly Advanced Strategic Computing Initiative)
AVLIS	Atomic Vapor Laser Isotope Separation, a process that uses laser light to selectively charge and collect a particular isotope in a stream of vaporized radioactive material, such as plutonium or uranium
CTBT	Comprehensive Test Ban Treaty
DARHT	Dual Axis Radiographic Hydrotest Facility, a Los Alamos facility that takes a rapid sequence of X-ray images of a mock nuclear weapon test implosion
FYNSP	Five Year National Security Plan, submitted by NNSA with its annual budget request, projecting future nuclear weapons funding requirements
HEDP	High Energy Density Physics, applicable to the study of nuclear weapons and stars
ICBM	Intercontinental Ballistic Missile, used to deliver nuclear weapons at long range, based on land
ICF	Inertial Confinement Fusion, a proposed path to achieving the fusion of light elements in the laboratory using lasers, electrical pulse power machines, or ion beams to raise the density and temperature of a target to a level that ignites fusion reactions in the material.
IFE	Inertial Fusion Energy, the application of ICF for civil power generation
LANL	Los Alamos National Laboratory, one of two nuclear weapon design laboratories operated for DOE's National Nuclear Security Administration by the University of California, located in northeastern New Mexico
LLNL	Lawrence Livermore National Laboratory, the second NNSA nuclear weapon design laboratory operated by the University of California, located 50 miles east of San Francisco
MESA	Microsystems Engineering Sciences and Applications complex, under construction at Sandia National Laboratory to produce micro-machine components for nuclear weapons
MOX	Mixed oxide fuel is a nuclear reactor fuel made by mixing plutonium oxide and uranium oxide and compressing it into ceramic pellets.

	While some European reactors use MOX fuel, it also has been proposed as a technique to dispose of weapons-grade plutonium from the U.S. and Russian Cold War arsenals.
MPF	Modern Pit Facility, a Bush administration proposal to build a new $2 billion to $4 billion factory for processing and fabricating plutonium components for nuclear weapons
NIF	National Ignition Facility, a massive $5-billion high-energy laser under construction in Livermore, California, that is supposed to ignite fusion reactions in a tiny frozen droplet of heavy hydrogen
NNSA	National Nuclear Security Administration, a quasi-independent agency with the Department of Energy that operates the U.S. nuclear weapons complex and is also charged with reducing nuclear proliferation risks worldwide
NTS	Nevada Test Site, formerly the site of hundreds of underground nuclear explosions, now used for underground “subcritical experiments” with high explosives and plutonium
Omega	A powerful glass laser facility at the University of Rochester Laboratory for Laser Energetics (UR/LLE) that is used as an R&D facility for the NIF Project. Omega is exploring the “direct drive” approach to fusion ignition, in which the laser light strikes the target and compresses it directly, rather than first being converted within a small cylinder (hohlraum) to X-rays (“indirect drive”)
Pu-239	The isotope of plutonium most suitable for use in nuclear weapons
Pu-242	A scarce isotope of plutonium that fissions much less easily than Pu-239, and therefore can be used for high-fidelity, full-scale radiographic hydrotests of the first stage of a nuclear weapon without causing a nuclear explosion
RNEP	Robust nuclear earth penetrator, a new high-yield nuclear weapon under development by the Bush administration to destroy deeply buried targets
SBSS	Science-based stockpile stewardship
SRS	Savannah River Site, a large Department of Energy reservation in South Carolina where the NNSA currently purifies recycled tritium and loads it into reservoirs that are then returned to weapons in the stockpile
TEF	Tritium Extraction Facility, under construction at the Savannah River Site in South Carolina to process tritium bearing rods irradiated in the Tennessee Valley Authority’s Watts Bar reactor
TeraOPS	Trillions of operations per second, a measure of computer processing speed
Tritium	a radioactive heavy isotope of hydrogen, which together with deuterium is used as a source of fusion neutrons to boost the first stage (primary) fission yield of a nuclear weapon. Also used to fuel the ICF capsules that are the targets of the NIF.

TSF	TeraScale Simulation Facility, a new weapons supercomputing center under construction at Lawrence Livermore National Laboratory in California
VIEWS	Visual Interactive Environment for Weapons Simulation, advanced display technology for viewing and understanding what is occurring in complex nuclear weapon simulations
Z Machine	A large electrical pulse power machine at the Sandia National Laboratory in Albuquerque that is a powerful generator of X-rays, and a less expensive alternative to NIF for some stockpile stewardship experiment

ENDNOTES

[1] Hecker quoted in C. E. Paine, "A Case against Virtual Testing," Scientific American, September 1999, p. 66.

[2] *DOE/NNSA FY 2005 CBR*, "Weapons Activities/Readiness Campaign," p. 158. As shown in Appendix Table E, an NNSA program called Advanced Design and Production Technologies (ADAPT) has received more than $548 million since FY 1998, and is slated to receive another $459 million over the next five years, for a total of more than $1 billion for new design and production technology for nuclear weapons over the 11-year period. And this is but one of several accounts that funds capital equipment upgrades to the weapons production complex.

[3] For FY 2004, Congress appropriated $6.237 billion for "weapons activities," but this sum excludes the costs of administering the program, which are appropriated separately. Based on its 72 percent share of NNSA's total budget in FY 2004, weapons activities account for $251 million of the $340 million appropriation for NNSA's Office of the Administrator, bringing the actual FY 2004 total for nuclear weapons spending to $6.488 billion.

[4] DOE/NNSA FY 2005 CBR, Weapons Activities/Directed Stockpile Work, p. 63. In addition, NNSA proposes $4.1 billion (outside the weapons Activities account) for U.S. Navy nuclear reactor development.

[5] DOE/NNSA *FY 2003 CBR*, Weapons Activities/Directed Stockpile Work, p. 76.

[6] Despite more than a 10-year hiatus in the operation of this intrinsically hazardous "Engineering Demonstration System" (EDS) pilot plant, originally constructed in the late 1980s for DOE's cancelled Special Isotope Separation Project for weapons plutonium, NNSA secretly determined in June 2002 that it could "conduct a series of limited laser isotope separation experiments on plutonium (and no radioactive surrogates of plutonium)" using "newly built solid state laser systems," without preparing any updated NEPA analysis. This phase of the EDS project's restart is arbitrarily designated the "Advanced Material Program," and is included in the "No Action Alternative" in the recently issued *Draft Site-Wide Environmental Impact Statement for Continued Operation of the Livermore National Laboratory (LLNL SW/PEIS).* NNSA plans continuing operation of the facility with plutonium beginning in FY 2007, and this phase of the project, called the "Integrated Technology Project," is part of the "proposed action" analyzed in the current draft EIS. NNSA's failure to prepare a timely EIS analyzing the proposed refurbishment and restart of the EDS, including test runs with plutonium, could trigger a legal challenge to the project.

[7] *DOE FY 2005 CBR*, "Weapons Activities/Science Campaign," p. 88.

[8] *Audit Report: Dual Axis Radiographic Hydrodynamic Test Facility*, DOE/IG-0599, p. 4. The report cites an official "total project cost" of $270 million, plus $57.5 million in additional costs "associated with work elements transferred outside of the project." NRDC believes that the final cost of the fully commissioned DARHT facility will be even higher, probably $500 million.

[9] DOE FY 2005 CBR, "Weapons Activities/ Science Campaigns, table, p. 84.

[10] DOE FY 2005 CBR, Weapons Activities/Engineering Campaigns, p. 105-107.

[11] The funding history of the MESA project supports this view: The FY 2003 Omnibus Appropriations Act provided $113 million, an increase of $38 million above the request. The FY 2004 Energy and Water Development Appropriations Act, P.L. 108-137, enacted December 1, 2003, provided $87 million for MESA, an increase of $25.2 million above the request. These increases were "unauthorized appropriations," meaning the additional funds exceeded the congressionally authorized funding levels for the MESA project specified in the relevant National Defense Authorization bills, and almost certainly done at the behest of the senior senator from New Mexico, Pete Domenici, chairman of the Energy and Water Appropriations subcommittee.

[12] The first generation of ASCI machines deployed from 1996 to 2000 had processing speeds ranging from roughly 1 to 10 teraOPS (trillions of floating point operations per second); the current second generation has speeds in the 10 to 100 teraOPS range, and the third generation, starting in 2005, will have speeds of hundreds of teraOPS to 1 or more petaOPS.

[13] DOE FY 2003 CBR, p. 150.

[14] The production of fusion neutrons in the core of the primary "boosts" the fission explosion that comprises the first stage of a two stage thermonuclear weapon.

[15] Sources: For FY 1996 to FY 2001, ASCI budget requests as compiled by Greg Mello and Blake Trask of the Los Alamos Study Group (www.lasg.org), undated tables prepared circa April, 2002; for FY 2002 to FY 2005, NNSA CBR's.

[16] http://www.top500.org/dlist/2003/11

[17] *Problems in the Management and Use of Supercomputers,* GAO/T-RCED-99-257

[18] LANL Daily News Bulletin (online), Friday, May 17, 2002. Seven megawatts of electric power is enough to supply the needs of some 5,800 homes.

[19] Only 6 TeraOps had been installed by the April 30 contract date, accounting for 768 of the 3,072 AlphaServer nodes (with a total of 12,288 1.25 GHz CPU's) specified in the contract.

[20] Jim Danneskiold, Los Alamos National Laboratory spokesman, in a Letter to the Editor, Supercomputing Online.com, 6/19/2002.

[21] DOE/NNSA FY2004 CBR Weapons Activities/Campaigns/Advanced Simulation and Computing, p.199 (web version)

[22] DOE/NNSA FY 2005 CBR, Weapons Activities/Advanced Simulation and Computing Campaign, p.134.

[23] Danneskiold, op. cit.

[24] "BlueGene/L Facts," at www.research.ibm.com/bluegene.

[25] DOE Defense Programs FY 2000 CBR, Weapons Activities, p.112.

[26] DOE-NNSA FY 2005 CBR, Weapons Activities, p. 144.

[27] GAO investigators found that by early 1999, "two dozen senior NIF managers knew the project faced growing problems that threatened both its costs and schedules, but these concerns were not shared with [external contract] reviewers." GAO also found that DOE had "instructed the

contractor not to examine NIF supporting research and development, which was a vital part of the NIF program," and that "a DOE manager and the Laboratory's NIF Project Manager edited the [supposedly independent] contractor's draft report before it was submitted to Congress." The contractors report, requested by Congress, had concluded that NIF was "by far the best managed of any U.S. government project" that the contractor had reviewed. The following year, the total cost of the project tripled, completion of the laser system was delayed five years, and the promised demonstration of ignition – the essential *raison d'etre* of the project – became an "eventual goal." In response to this debacle, carefully documented by the GAO, Congress and the Clinton administration did nothing except give the project more money.

[28] Associated Press hearing transcript, Energy and Water Appropriations Subcommittee hearing on the NNSA budget request, March 23, 2004. The "Dr. [Everett] Beckner" referred to in the transcript is the deputy NNSA administrator for defense programs.

[29] DOE/NNSA FY 2005 CBR, p. 143.

[30] Ibid.

[31] For descriptions of Omega and Z, see the Glossary in the front of this report.

[32] In 1989, nuclear weapons production at Rocky Flats was abruptly halted because of serious environmental, safety and health problems at the plant. Operations at the plant and the site contractor, Rockwell International, were the subject of an intensive two-year federal grand jury investigation that began in 1989 after FBI agents raided the plant. Rockwell, which had operated Rocky Flats for more than a decade ending in 1989, later pled guilty to 10 environmental crimes and paid an $18.5 million fine. In 1993, a Colorado federal judge released the grand jury's report, which said the federal government and Rockwell repeatedly violated environmental laws under the guise of national security. Grand jurors alleged, among other things, that the Energy Department and Rockwell employees engaged in an ongoing criminal enterprise by repeatedly violating environmental laws. For a detailed look at this sordid history, see Len Ackland, "Making a Real Killing: Rocky Flats and the Nuclear West," University of New Mexico Press, 1999.

[33] DOE FY 2005 CBR for Weapons Activities/Pit Manufacturing and Certification Campaign, p.151.

[34] A typical weapon grade Pu pit = 3,500 grams/31.103486 gms/oz t = 112.52757 oz t (Gold) @$405.00/oz t = $45,573.66; $22/0.04557366 = 482.

[35] DOE CBR's for Weapons Activities, FY 2000-2005. Ironically, a cursory April 2002 "Audit" of the Los Alamos Pit Production effort by the DOE Inspector General (DOE/IG-0551) noted that the program was slipping behind schedule and missing important technical milestones, but said not one word about the burgeoning costs of the project, and whether they were remotely justified by the work performed and the technical capabilities achieved.

[36] Tritium, a radioactive isotope of hydrogen, is used to boost the fission reaction in the primary stage of nuclear weapons, enabling the use of lesser amounts of plutonium and high explosive and making the weapons more resistant to accidental nuclear detonation. But tritium decays at the rate of 5.47 percent per year, so the stockpile must ultimately be replenished when stockpile reductions can no longer keep pace with the decline in the tritium inventory. Powerful, reliable nuclear weapons can be designed without tritium.

[37] In reality, other than grafting strained rationales for missile defense and a technologically dynamic defense infrastructure onto the longstanding *idée fixe* of a triad of redundant offensive strategic forces for nuclear deterrence, the 2001 Nuclear Posture Review merely tinkered with the nuclear force-planning assumptions of Clinton's overly cautious 1993-94 review.

[38] Ian Hoffman, "LANL Loses Production of Tritium, Research to Continue," *Albuquerque Journal*, December 23, 1998.

[39] See, for example, C.E. Paine, "A Case Against Virtual Nuclear Testing," *Scientific American*, Vol. 281, No. 3, Sept. 1999, p. 64; C.E. Paine and M.G. McKinzie, "Does the U.S. Science-Based Stockpile Stewardship Program Pose a Proliferation Threat?" *Science and Global Security*, 1998 Volume 7, pp. 151-193; M.G. McKinzie, T. B. Cochran, C.E. Paine, *Explosive Alliances*: Nuclear Weapons Simulation Research at American Universities, NRDC Nuclear Program, Washington, D.C., Jan. 1998.

[40] "The nuclear weapons program as currently conceived – a program focused primarily on refurbishing the legacy stockpile – will not meet the country's future needs." *Report of the Defense Science Board Task Force on Future Strategic Strike Forces*, Office of the Under Secretary of Defense For Acquisition, Technology, and Logistics, Washington, D.C. 20301-3140, February 2004, p. 1-10.

[41] This was a key efficiency recommendation, never implemented, of the 1994-95 "Galvin Commission" on Alternative Futures for the Department of Energy National Laboratories.

[42] "Lab plans to revive plutonium project," by Dan Stober, *San Jose Mercury News*, July 17, 2002 (posted).

[43] *Audit Report: Dual Axis Radiographic Hydrodynamic Test Facility*, DOE/IG-0599, p. 4. The report cites an official "total project cost" of $270 million, plus $57.5 million in additional costs "associated with work elements transferred outside of the project. NRDC believes that the final cost of the fully commissioned DARHT facility will be even larger, probably on the order of $500 million.

[44] DOE FY 2000 CBR, Feb. 1999, Vol. 1, p. 158.

[45] DOE FY 2005 CBR, Feb. 2004, "Weapons Activities/Science Campaign," p. 88.

[46] In a 1997 NEPA lawsuit contesting the adequacy of DOE's programmatic analysis of the Stockipile Stewardship and Management Program, plaintiffs argued that all of NNSA's current and planned radiographic facilities should be included in the analysis of the future complex required for maintaining the safety and reliability of a significantly reduced stockpile in a no-test environment.

[47] DOE/NNSA FY 2005 CBR, "Weapons Activities/Readiness Campaign," p. 158.

[48] DOE/NNSA FY 2004 CBR, Weapons Activities/Engineering Campaigns/Advanced Design and Production Technologies, p. 160. Note that in FY 2005,

the ADAPT program was shifted from the Engineering Campaigns to the Readiness Campaign portion of the budget, where the tritium project is located.