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## **The Nuclear Safety Smokescreen**

### **Warhead Safety and Reliability and the Science Based Stockpile Stewardship Program**

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## ***Preface***

Intense diplomacy since 1990 over the extension of the Nuclear Non-Proliferation Treaty (NPT) has put the achievement of a Comprehensive Test Ban Treaty (CTB) at the forefront of the global nuclear agenda. It has been the hope of the non-nuclear states that a CTB would be a step towards a de-escalation of the nuclear arms race. It was thought that it would prevent design of new warheads and hence end the qualitative aspects of the arms race. Yet that is not how things have been shaping up since May 1995, when the nuclear powers achieved their main goal of an indefinite extension of the NPT. China began testing almost immediately after the indefinite extension; France followed suit. The United States, in positive contrast, continued its testing moratorium, and announced support for a “zero yield” CTB, under which no nuclear explosions would be allowed. However it has attached conditions to a CTB that, if adopted, could cause new and dangerous international instabilities. As it stands, the CTB has been mired in disagreement.

Among other things, U.S. advocacy of a “zero yield” CTB is tied to the start-up of a major new program called the Science Based Stockpile Stewardship (SBSS) program. This program would allow the U.S. to retain a large number of nuclear warhead designers for an indefinite period. Many official statements have also made it clear that the SBSS program is being conducted in the context of a U.S. decision to continue to hold onto a large nuclear arsenal for an indefinite period of time.<sup>1</sup>

The SBSS program is being promoted as essential to the maintenance of the U.S. stockpile because it would promote “safety and reliability” of the existing stockpile. The U.S. government states that it is not now designing new nuclear warheads. This report is an examination of the relationship of the SBSS program to safety, reliability, and warhead design capability. We have also attempted to analyze the relative importance of these factors in DOE’s pursuit of the program, and concluded that maintaining design teams and capabilities are central to it. Whether a program to create such design capabilities is warranted depends on one’s view of the commitments of the U.S. and nuclear weapons states under Article VI of the NPT, under which the nuclear weapons powers are obligated to pursue negotiations in “good faith” for complete nuclear disarmament. The NPT is law of all countries which have ratified it, including the United States.

We believe that so long as nuclear arsenals exist, safeguarding against accidental detonations of nuclear warheads is an issue of common concern that must be addressed, independent of one’s positions on nuclear disarmament. But the Department of Energy’s own data indicate that nuclear safety is not the main issue justifying the extensive new facilities. Other issues, such as reliability of arsenals for possible use in nuclear war and increasing the capability for new warhead design using laboratory facilities seem to be

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<sup>1</sup> Other recent decisions, such as the one to pursue tritium production for warhead maintenance, also make this clear. See Zeriffi 1996.

more at the heart of the SBSS program. Nuclear safety is a smokescreen behind which a permanent nuclear design establishment is to be maintained.

In this report we also explore the implications of U.S. nuclear strategy as it may relate to the SBSS program. Such a discussion is not an endorsement of any particular strategy. Our position is that all nuclear weapons states must make advances towards fulfilling their nuclear disarmament commitments under Article VI of the NPT. This is necessary both for progress towards the goal of ridding the world of existing weapons of mass destruction and preventing further proliferation problems from developing.

While this report examines the U.S. program for maintaining design capabilities, we note that other nuclear powers also appear to be following a similar course. For example, the Chinese government's insistence on maintaining the right to conduct "peaceful nuclear explosions" may be nothing but its own smokescreen for new nuclear weapon designs. France is building facilities similar to those of the U.S. Russia continues to operate weapons labs.

A full and extensive public debate on the dangers ahead of a CTB riddled with potential for failure is urgently needed. This report is intended as a contribution to that discussion.

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### ***The Alphabet Soup List (ASL)***

AHF:	Advanced Hydrotest Facility
ASCI:	Accelerated Strategic Computing Initiative
CEP:	Circular Error Probable
CFF:	Contained Firing Facility
CHE:	Conventional High Explosives
CTB:	Comprehensive Test Ban
DARHT:	Dual Axis Radiographic Hydrodynamic Test facility
DoD:	Department of Defense
DOE:	Department of Energy
EEI:	Enhanced Electrical Isolation
ENDS:	Enhanced Nuclear Detonation Safety
FXR:	Flash X-Ray facility
IHE:	Insensitive High Explosives
LANL:	Los Alamos National Laboratory
LLNL:	Lawrence Livermore National Laboratory
NIF:	National Ignition Facility
NPT:	Non-Proliferation Treaty
NTS:	Nevada Test Site
PEIS:	Programmatic Environmental Impact Statement
PHERMEX:	Pulsed High Energy Radiation Machine Emitting X-Rays
SBSS:	Science Based Stockpile Stewardship
SNL:	Sandia National Laboratories
SSM:	Stockpile Stewardship and Management





## ***Summary of Findings and Recommendations***

As the United States participates in negotiations for a Comprehensive Test Ban treaty in Geneva, it is simultaneously putting into place a program to enhance the capabilities of its nuclear weapons design laboratories. The U.S. Department of Energy's Science Based Stockpile Stewardship (SBSS) program would build new experimental facilities to study the nuclear components of the United States nuclear arsenal, as well as a large scale computing initiative in order to more accurately model nuclear weapons. The implementation of the SBSS program is currently a part of the U.S. position to support a Comprehensive Test Ban treaty under which no nuclear explosions would be permitted (the "zero yield" CTB). Officially, the purpose of the SBSS program is to maintain the safety and reliability of the nuclear arsenal in the absence of nuclear testing. The Department of Energy (DOE) has argued that, as the nuclear arsenal ages, it will be an increasingly complex task to maintain the level of safety and reliability necessary without nuclear testing. The SBSS program is supposed to aid in this endeavor by providing information on the basic physical processes of nuclear weapons in order to create more accurate computer models, in essence to be able to conduct "virtual tests."

The purpose of this report is to examine DOE's statements regarding the safety and reliability of the nuclear arsenal and to assess the usefulness of the SBSS program in addressing the relevant issues. Our analysis of historical data regarding problems with nuclear warheads leads us to conclude that the SBSS program would provide little aid in maintaining the safety of the existing arsenal. Indeed, DOE's own data show that there have been no aging-related nuclear safety problems in warheads.

While the SBSS program's claims in regard to improving safety of the arsenal appear dubious at best, it has a clear relationship to increasing U.S. capability to design new warheads and to design major modifications to existing ones. The new SBSS facilities are of the types used previously as part of the weapons design program. One of the main goals of the program is to retain and attract new weapons designers. Furthermore, various official documents indicate that the ability to maintain weapons design capabilities is a priority of the DOE. Another purpose appears to be to maintain the reliability of the nuclear arsenal at extremely high levels. Such high levels of reliability may be necessary only if the United States pursues a strategy of first strike against opponents with large nuclear arsenals rather than retaliatory nuclear deterrence. However, the data that we have are too limited to enable us to arrive at a definitive conclusion in this regard.

The SBSS program is coupled with other problematic provisions in the U.S. position on the CTB.<sup>2</sup> Specifically, the U.S. government wants to:

- maintain the Nevada Test Site in a state of permanent readiness to resume full scale testing;

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<sup>2</sup> As noted in the preface, the other nuclear weapons states are pursuing similar policies.

- have a provision that would allow withdrawal from the CTB for reasons of “supreme national interest.”

The design capabilities inherent in existing and new SBSS facilities will provide the opportunity for the DOE to bring new weapons or modifications to existing weapons to a stage of near completion, in the same manner that a complex machine such as the Boeing 777 was largely designed using computers and wind tunnels. The SBSS program is likely to create pork-barrel driven pressures to withdraw from the CTB in times of crisis. The enormous financial advantages that the U.S. enjoys over Russia and China in the matter of military expenditures, despite recent reductions in the U.S. military budget, could contribute to reluctance on the part of other powers to engage in nuclear arms reductions.

This analysis leads us to the conclusion that a large SBSS program which includes expensive new experimental facilities with weapons design capabilities, could lead to dangerous international instabilities. It could have profound negative repercussions on the functioning of both the Nuclear Non-Proliferation Treaty (NPT) and the upcoming Comprehensive Test Ban treaty (CTB).

### **Principal Findings**

- The Department of Energy’s analysis of the need for an SBSS program mixes up safety and reliability issues in a misleading way. These issues are technically distinct and have vastly different political, military, and environmental implications.
- So long as there are intact warheads, nuclear safety is an issue of the greatest concern, since the human and environmental consequences of accidental detonations could be devastating. Reliability of warhead performance is a technical and political issue that is linked to military strategy. DOE has not justified the need for SBSS facilities as they relate to safety separately from reliability issues, and it has not related levels and types of reliability required to military strategy.
- DOE data show that the nuclear detonators in nuclear warheads (called “primaries”) have never had safety problems linked to aging. The data clearly indicate that SBSS facilities are not needed for nuclear safety. DOE statements that imply that aging-related nuclear safety issues can be solved using the SBSS program are not well-founded either in data or in analysis. Similar statements claiming the need for new facilities are even less justified.
- The SBSS program will give the U.S. powerful capabilities for designing new warheads (as mandated by present nuclear weapons policy). While these capabilities are unlikely to allow DOE to bring radical new warhead designs into production for deployment by the Pentagon, they would allow most design work to be completed, and the rest to be rapidly concluded should the U.S. withdraw from the CTB.

These principal findings are based on our detailed analysis of DOE data on safety and reliability problem types that is presented in the report. The main technical points in our analysis are as follows:

- The majority of kinds of safety and reliability problems have arisen from design or production of the warhead, rather than aging. As a result, the majority of problem types are found within the first few years of a warhead's production.
- Only 12 percent of safety problem types have involved aging, and only one-fourth of these were found in warheads still in the current stockpile. These have been addressed.
- All safety problems with primaries -- the most crucial component for nuclear weapons safety -- have been the result of the design of the warhead, rather than aging.
- The principal means of finding defects has been the Stockpile Evaluation Program, which does not involve the experimental facilities that are part of the DOE's SBSS program.
- Hydrodynamic testing, which involves many existing and proposed SBSS facilities, has a role in helping determine "one-point safety," which is a basic safeguard against accidental detonation. However, the DOE has already certified existing warheads as safe in this regard. Therefore, it would appear that even existing hydrodynamic facilities may not have any further role on one-point safety, especially as historical data do not indicate any aging-related nuclear safety problems. In view of its own declaration that the existing stockpile is safe and of its own data regarding the lack of aging-related nuclear safety defects, the DOE has not made a case that new hydrodynamic testing facilities will make material contributions to safety.
- High energy density facilities, such as the \$1 billion National Ignition Facility, would have no relevance to maintaining the nuclear safety of existing weapons in the arsenal.
- While aging has a greater affect on reliability than safety, reliability problem types are primarily with non-nuclear components and rarely have a severe effect on a warhead. While there may be deleterious effects on reliability if the stockpile is held for very long periods, these problems could be addressed without the SBSS program by re-manufacturing the defective parts. What is important is the final re-manufactured product, not the particular industrial process used for warhead maintenance. This process should be workable so long as there is no attempt to "improve" warhead design as part of re-manufacturing.
- The weapons effects component of the SBSS program is relevant to warhead effectiveness, not warhead safety.
- The manufacture of new nuclear components that are significantly different from the tested original could result in less reliable and/or less safe warheads.

### **Discussion of Principal Findings:**

Maintaining the safety of nuclear weapons should be one of the top priorities of the DOE's nuclear weapons complex as long as intact nuclear weapons remain in the arsenal. Accidental nuclear detonation or plutonium dispersal could have huge health and environmental consequences. However, the DOE has not demonstrated the need for the SBSS program to maintain nuclear safety. Nuclear weapons are currently safe, according to the DOE. Safety problems with primaries have never been linked to aging. Furthermore, 76 percent of the safety-related problem types in primaries were found in

warheads produced around the time of the 1958-1961 U.S.-Soviet nuclear testing moratorium, a time of rushed design work as the United States scrambled to get designs into production.

Nuclear weapons are currently reliable, according to the DOE. The majority of reliability problem types affect non-nuclear components and the majority of reliability problem types have a minimal effect on the warhead. In light of these facts, the DOE has failed to state how the SBSS program would maintain the reliability of an arsenal for a policy of retaliatory nuclear deterrence -- that is, a policy of nuclear retaliation in response to first use of nuclear weapons by an adversary. However, if the purpose of the arsenal is a first strike, a higher degree of reliability may be necessary, because achieving precision and rated yield could be technical factors affecting the "success" of a first strike aimed at destroying an adversary's nuclear missiles.

Maintaining the ability to design and produce new nuclear weapons, or even making militarily significant modifications to existing warheads, could have serious implications for the Comprehensive Test Ban Treaty and nuclear non-proliferation. The design capabilities of the SBSS program coupled with maintaining the Nevada Test Site in a state of readiness to resume testing could lead to serious new instabilities with unforeseeable consequences. For instance, it could lead to the disintegration of a Comprehensive Test Ban. It also violates the spirit of Article VI of the NPT under which the nuclear weapons states are pledged to pursue nuclear disarmament negotiations in "good faith."

The DOE has not considered alternative approaches to maintaining the safety of the nuclear arsenal after a CTB in its *Draft Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*. There are viable options which would not require new experimental facilities or the maintenance of a large cadre of weapons designers.

## **Recommendations**

1. DOE should demonstrate, in light of its own historical data on nuclear safety, why new experimental and computational capabilities are relevant to the safety of the existing U.S. nuclear arsenal.
2. The U.S. should adopt a policy of dismantling warheads whose primaries are deemed to be unsafe, instead of a policy that would make changes to the "physics package," which is the nuclear portion of warheads. This appears more prudent from the point of view of safety. It would also be in keeping with the spirit of the commitments of the nuclear weapons states under Article VI of the Non-Proliferation Treaty.
3. The U.S. government, including the DOE and DoD, should address specifically how the SBSS program is relevant to a strategy of retaliatory deterrence as distinct from a first use and first strike nuclear strategy. The option of first use of nuclear weapons has historically been part of U.S. nuclear strategy.<sup>3</sup>

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<sup>3</sup> Ellsberg 1986.

4. The U.S. government should clearly and unambiguously renounce nuclear weapons design and development, and invite international verification of this policy. It should also use the leverage created by the unilateral adoption of such a policy to pressure the other nuclear powers to follow suit.
5. Before embarking on the SBSS program, the DOE and DoD should examine carefully the ways in which it could create dangerous new international instabilities, including in U.S. relations with Russia, China, and the undeclared nuclear weapons states, Israel, India, and Pakistan.
6. Before embarking on the SBSS program, the DOE should examine carefully the non-proliferation consequences of the SBSS program. This examination should include the possible relation of the SBSS program to the potential for the U.S. or other countries breaking out of the CTB, and the potential for a breakdown in the CTB altogether.
7. In order to further the possibility of achieving a CTB in 1996 in a manner that could lead to greater security and greater confidence that the nuclear powers intend to create a path to nuclear disarmament and eventually abide by the spirit of Article VI of the NPT, the U.S. should:
  - Permanently close down the Nevada Test Site and focus on clean-up and conversion.
  - Use the leverage gained by shutting down the Nevada Test Site to pressure other nuclear powers to permanently shut down their nuclear test sites.
  - Cancel all underground sub-critical experiments.
  - Halt construction of new facilities under the SBSS program and on that basis urge the other nuclear weapons states to halt construction of similar facilities.
  - Participate with other countries to create a treaty against the first use of nuclear weapons in any conflict and against any threat of use of nuclear weapons against non-nuclear weapons states.

## ***Introduction***

The Department of Energy (DOE) proposes to spend billions of dollars in constructing and operating new experimental facilities at U.S. nuclear weapons laboratories. The program is called Science Based Stockpile Stewardship (SBSS). According to the DOE, the need for an SBSS program is a direct result of the moratorium on nuclear testing and new warhead development work and the impending agreement on a Comprehensive Test Ban Treaty (CTB). To the DOE the SBSS program is a “basic need” to meet national security policies which mandate a “safe and reliable stockpile without further nuclear testing and aggressive pursuit of enhanced experimental capabilities.”<sup>4</sup> Further, the Department of Defense (DoD) also requires the DOE to maintain the capability to design, fabricate, and certify new weapons. The U.S. government proposes to maintain its nuclear arsenal for an indefinite period of time.<sup>5</sup> The DOE proposes to use the SBSS program to accomplish this by:

- retaining nuclear weapons designers;
- building new experimental facilities, partly for the purpose of retaining weapons design teams and bringing in fresh scientific talent into nuclear weapons design;
- Using the SBSS program to replace nuclear weapons testing, to the extent feasible, to study weapons designs, effects of nuclear weapons detonations, and, as noted above, “safety” and “reliability” of nuclear weapons.
- Certifying that replacement components do not compromise safety or reliability of warheads.

These goals are linked. The DOE claims to have established the SBSS program in order to retain the weapons design and testing skills it believes are necessary to maintaining both the safety and reliability of the nuclear arsenal.<sup>6</sup> The Science Based Stockpile Stewardship program, according to the DOE, will be used to provide experimental test data on warhead behavior, aging effects and the basic physical process in warhead detonation.<sup>7</sup> Using this information, gained at the various SBSS facilities, the weapons laboratories hope to create more accurate computer models of warheads. In the past computer models have been used to help design new warheads. The DOE states it will use computer models to anticipate future problems and correct problems as they occur.<sup>8</sup> The SBSS program, according to the DOE, will replace the direct knowledge gained from full-scale nuclear tests with laboratory and computer exploration of the fundamental physical processes that occur in a nuclear weapon.<sup>9</sup> There are a host of documents in which the DOE has set forth their rationale for the SBSS program. The most recent is the *Draft Programmatic Environmental Impact Statement for Stockpile Stewardship and Management*.

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<sup>4</sup> DOE 1995c, p. 3-3

<sup>5</sup> DOE 1996, p. 2-7

<sup>6</sup> DOE 1995a, p. 4

<sup>7</sup> DOE 1995c, 2-10 and 2-11

<sup>8</sup> DOE 1995c, 2-10

<sup>9</sup> DOE 1996, p. 3-15

The DOE has large numbers of existing facilities in which it conducts experiments and computer simulations of warheads. It proposes to continue using most of these facilities and to build expensive new ones as part the SBSS program. The DOE has rejected alternatives to the SBSS program which would not have extensive new experimental facilities and the cadre of physicists necessarily attached to them.<sup>10</sup>

The Science Based Stockpile Stewardship program encompasses all three weapons laboratories (the three weapons laboratories are Los Alamos National Laboratory (LANL) in New Mexico, Lawrence Livermore National Laboratory (LLNL) in California, and Sandia National Laboratory (SNL) in New Mexico and California)<sup>11</sup> and the Nevada Test Site. There are various experimental and support facilities and programs located at these sites. The facilities can generally be split into four categories:

- Hydrodynamic facilities are used to study implosions, primarily, but not exclusively, of warhead primaries and secondaries.
- High energy density facilities are used to study boosted primaries and secondaries and can also be used for weapons effects testing.
- Weapons effects facilities simulate the conditions of nuclear explosions to test the durability and survivability in nuclear war environments of weapons components, both nuclear and non-nuclear.
- Advanced computational capabilities are being developed to allow the DOE to model warheads in three dimensions for “virtual testing.”<sup>12</sup> Additionally, the DOE is archiving all available data on nuclear weapons for reference.

The construction cost for new experimental facilities has been estimated at approximately \$2 billion. This does not include the cost of operating or decommissioning the facilities. The cost of the Accelerated Strategic Computing Initiative (ASCI), the program to provide enhanced computational capabilities, has also been estimated at approximately \$2 billion.<sup>13</sup>

The SBSS program is more than just a collection of facilities and programs. The heart of the program lies with the scientists and engineers who will use those facilities. The DOE itself considers retaining weapons designers and attracting new scientists into these programs an integral part of the SBSS program. This is part of “preserving the core intellectual and technical competencies of the weapons laboratories.”<sup>14</sup>

In this paper, we examine

- the relationship of the SBSS program to safety issues;
- the relationship of the SBSS program to reliability issues;

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<sup>10</sup> DOE 1996, pp. 3-5 - 3-7

<sup>11</sup> We will refer to these as Los Alamos, Livermore and Sandia respectively.

<sup>12</sup> “Draft Accelerated Strategic Computing Initiative (ASCI) Program Plan.” Downloaded off the Internet homepage of the Department of Energy’s Defense Programs Office. The page was last changed on 12 June 1995. The homepage was taken off the Internet in March of 1996.

<sup>13</sup> Weida 1996, Collina and Kidder 1994.

<sup>14</sup> DOE 1995a, p. 1

- the need for new facilities to carry out functions deemed as essential by the DOE for safety and reliability;
- the consequences of pursuing laboratory testing that can clearly enable new weapons design and that might provide incentives for pork-barrel-driven pressures for the U.S. government to withdraw from a Comprehensive Test Ban Treaty down the road.
- the potential consequences of pursuing the SBSS program for nuclear non-proliferation and disarmament.

## ***Background***

### **A. Nuclear Weapons**

Nuclear warheads contain thousands of components that include the nuclear explosives, the triggering mechanisms, and control, safety, security, and guidance systems. Reliable operation of such a complex device when detonation is intended and preventing detonation when it is not form the core of reliability and safety issues related to warheads.

In order to evaluate the need for the SBSS program it is necessary to understand the basics of how a modern nuclear warhead operates and the different types of components and materials used. Modern nuclear warheads typically consist of two main stages: a fission primary and a secondary that has both fusion (thermonuclear) and fission components. Although these two stages form the core of a nuclear warhead, they only account for a small percentage of the components (in one example, the primary and secondary accounted for five percent of the components).<sup>15</sup> There are a larger number of non-nuclear components in a warhead.

**Primary:** The primary stage of a warhead has a “pit” of nuclear material that explodes, deriving its energy from nuclear fission. In the fission process, the nucleus of a heavy atom is split into two smaller components by a neutron, releasing excess energy and more neutrons. The neutrons from the first fission event can then fission other nuclei of heavy atoms. If there is enough fissile material arranged in the right geometry (a critical mass) a chain reaction will occur, whereby each fission causes at least one more fission. In a nuclear weapon, the chain reaction grows rapidly so as to yield an explosion. That is, each fission produces more than one fission causing the release of a large amount of energy - enough to generate an explosion before the device assembly is blown apart and the chain reaction stops.

Plutonium-239 and/or highly enriched uranium (uranium with a large concentration of uranium-235) are the two materials used to accomplish the nuclear detonation of the pit. These atoms are chosen because they are fissile and hence can sustain a chain reaction. Some isotopes such as uranium-238 are fissionable by higher energy neutrons, but cannot sustain a chain reaction. A “supercritical mass” is required to achieve an explosion; it is created by compressing uranium-235 (in the form of highly enriched uranium) and/or

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<sup>15</sup> DOE 1995b, p. 2-12



plutonium-239. The whole nuclear explosion happens very quickly (on the order of one microsecond). In a nuclear warhead primary, high explosives implode a spherical “pit” of plutonium or highly enriched uranium into a supercritical mass.

**Boosting:** In order to make more efficient use of the fissile material in the primary, a technique called boosting was developed. A mixture of tritium and deuterium is injected into the primary before the implosion. The high pressures and temperatures of the implosion induce fusion reactions between the nuclei of tritium and deuterium, releasing a number of excess neutrons which fission more of the original fissile material before the pit is blown apart by the force of the explosion. The fusion energy of the boosting process is small compared to the fission energy of the primary and does not contribute significantly to the yield of the warhead. But by requiring less fissile material for the same yield, boosting has allowed the DOE to develop lighter warheads which gives DoD missiles greater range and allows for more warheads in multiple warhead missiles.

**Secondary:** The secondary uses a fusion process to release energy, but relies on the energy of the primary explosion to initiate the fusion process. Neutrons from the primary explosion create tritium from the lithium in lithium-deuteride. X-rays from the primary compress the material, causing fusion reactions between the tritium and deuterium nuclei. The process is aided by reflective barriers and compression from the primary explosion. Secondaries can also use U-235 or Pu-239 and U-238 for added energy. The neutrons from the fission reaction are energetic enough to fission the U-238, which adds to the overall yield of the warhead.

**Other Components:** As noted above, nuclear warheads can be very complex and may contain thousands of components. Only a small number are located in the “nuclear package”<sup>16</sup> (also called the “physics package”). The nuclear package consists of both the primary (including high explosives, detonators, etc.) and the secondary. The rest are non-nuclear components including arming and firing systems, parachutes, radars, batteries, etc.

## **B. SBSS and Nuclear Weapons Production and Management**

The SBSS program is part of the DOE’s larger Stockpile Stewardship and Management Program which will monitor nuclear weapons, provide manufacturing capabilities, and ensure an adequate tritium supply for nuclear warheads.<sup>17</sup> One officially designated function of the Stockpile Stewardship and Management program is to detect problems with nuclear warheads that may need corrective action. The Management program also includes (i) dismantlement of retired warheads, (ii) replacement of warheads and warhead components, and (iii) production of new design or modified warheads and their nuclear and non-nuclear components.

Until now, the DOE has relied mainly on the Stockpile Evaluation Program to discover safety and reliability problems. This program is distinct from its laboratory capabilities and has been in place since 1958. It was designed to monitor warheads during

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<sup>16</sup> DOE 1995b, p. 2-12

<sup>17</sup> DOE 1995a, p. 4. For more information on the DOE’s plans to produce tritium see Zerriffi 1996.

production and after deployment and to fix any problems that were found. The program withdraws new components and complete warheads from both the production line and from deployment. The number of samples varied over the years and also varied according to whether the warhead was in production or deployed. Currently, the program consists of withdrawing approximately eleven warheads of each type from the stockpile every year. According to the DOE:

[T]hese samples are subjected to some disassembly and inspection prior to testing, and the non-nuclear components are then assembled into a laboratory test bed for system level testing or into a Joint Test Assembly for flight testing. Although there are variations, in general the nuclear explosive package from one sample per year per weapon type is destructively examined for dimension and material composition changes.<sup>18</sup>

The ten warheads that are system tested are reassembled and returned to the stockpile.

Over the decades, the DOE has created a database of problems found with the nuclear arsenal. A majority of these problems (75%) were discovered during the Stockpile Evaluation Program, while the rest were discovered during research and development, underground testing, and a variety of other methods. According to the DOE, the SBSS program will not only help to find problems previously discovered during underground testing, it will also help solve future problems.<sup>19</sup>

The questions of how problems in existing warhead components are detected and what is done once a problem is found have a significant impact on the need and scope of the SBSS program. DOE considers three options if a problem is found with a particular component:

1. No Action: If the problem has a minor effect the DOE would consider not fixing the problem.
2. Re-Manufacture: The DOE would re-manufacture components to their original specifications.
3. Re-Certification: The DOE would either re-manufacture components or design new replacement components. In either case, the components would have to be certified to ensure they perform adequately and do not introduce new problems. This is the approach favored by DOE for problems where action is deemed necessary.<sup>20</sup>

The Stockpile Management Program would manufacture new components and use SBSS facilities as part of the certification process. DOE does not consider a fourth option: removing the problematic warhead from the stockpile.

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<sup>18</sup> Johnson et al 1995, p. 6. During the system level test all the arming and firing systems are tested using electrical inputs or a centrifuge to imitate the trajectory sensing devices. In joint flight tests, the warhead's nuclear explosive package is removed and replaced with a data recorder. The warhead is then flown in order to obtain realistic information on the weapons response.

<sup>19</sup> DOE 1996, pp. 2-3 - 2-7

<sup>20</sup> DOE 1995b, p. 2-12

## ***Analysis of Historical Safety and Reliability Data***

### **A. Overview**

The fundamental public rationale for the SBSS program hinges on the twin issues of safety and reliability of the nuclear arsenal. Without this, it would be difficult for the DOE to justify operating existing facilities, much less building new ones, because its official stance is that there are no new weapons being designed at the present time. (We will examine this claim later in this report.)

An evaluation of the merits of the SBSS program must, therefore, begin by examining the issues of safety and reliability. However, this task is made difficult because the DOE documents on the SBSS program rarely distinguish between safety and reliability, despite providing specific definitions of each. It is therefore difficult to judge whether a particular problem being discussed, such as metal corrosion, affects safety, reliability, or both. One report on nuclear weapons, conducted by a panel composed of personnel from all three weapons design labs, presents most of the data with the numbers for safety and reliability added together and in no way distinguishes between the two.<sup>21</sup> But safety and reliability are two quite different concepts and it is crucial to separate them to examine DOE claims for the SBSS program.

The DOE defines safety as “[M]inimizing the possibility that a nuclear weapon will be exposed to accidents and preventing the possibility of nuclear yield or plutonium dispersal should there be an accident involving a nuclear weapon.”<sup>22</sup> There are two parts to this definition of safety. One is the risk to the weapon and the other is the risk to people. They are connected by the potential for a nuclear weapon to detonate if it is exposed to an accident.

DOE has established specific safety criteria for nuclear weapons including:

- Warheads should have less than a one in a billion chance of prematurely detonating prior to launch if they are exposed to normal conditions and less than a one in a million probability when exposed to abnormal conditions.
- If detonation occurs at one point on the high explosive in the primary, then the probability of the yield being greater than 4 lb. of TNT should be less than one in a million. This “one-point safety” criterion should be inherent in the design of the warhead.
- A variety of qualitative safety standards including measures to prevent unauthorized launch or detonation of nuclear weapons have been specified.<sup>23</sup>

Safety is primarily a technical issue since accidental or unauthorized detonation of a nuclear warhead is highly undesirable, independent of one’s position on the future course of non-proliferation and nuclear disarmament. If a warhead is found unsafe, there are

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<sup>21</sup> Johnson et al. 1995

<sup>22</sup> DOE 1995a, p. 19

<sup>23</sup> Drell and Peurifoy 1994, pp. 296-297

two possible ways to increase safety: remove the warhead from service or making it safer.

Reliability is defined by the DOE as

the ability of an item to perform a required function. Implicit in the above definition of “required function” for one-shot devices, such as nuclear weapons, are the required conditions and duration of storage, transportation, and function. Also implicit in the above definition of “ability” is the concept of successful performance. Successful performance is defined as detonation at the desired yield (or higher) at the target (i.e., desired burst height or desired delay time within the desired CEP [Circular Error Probable]) through either the primary or any designed backup mode of operation. Thus, reliability is the probability of successful performance and has mathematical limits of 0 and 1. Unreliability, also called the failure probability, is the mathematical complement of reliability (i.e.  $\text{Unreliability} = 1 - \text{Reliability}$ ). Statements about reliability may be expressed in terms of either the success probability (reliability) or the failure probability (unreliability).<sup>24</sup>

As we will discuss, reliability, unlike safety, is both a technical and political issue.<sup>25</sup> The political aspects relate mainly to the nuclear strategy that the U.S. chooses to adopt. As a result reliability must be viewed not only in technical terms, but also in its relation to domestic and global politics, military postures and theories, and treaty commitments, notably the NPT.

IEER has analyzed DOE historical data on safety and reliability problems of nuclear warheads.<sup>26</sup> The warhead problems that DOE lists as serious enough to merit corrective action are called “Actionable Defect Types.” However, these problems do not necessarily result in changes to the warhead, but sometimes only to a change to the procedure causing the problem. Sometimes, there is no action and the DOE accepts a (presumably small) reduction to the weapon reliability.<sup>27</sup>

DOE data specify the cause of the defect (aging, production, design, etc.) and the effect (reduction in safety, reliability, or operation). We have analyzed the data with a view

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<sup>24</sup> Sandia National Laboratory, *Nuclear Weapon Reliability Evaluation Methodology Guide*, July 23, 1993, p. 1-1 as quoted in Barfield 1996.

<sup>25</sup> In this analysis reliability is used to refer to both reliability (i.e. will a component work) and operation (i.e. will the warhead have the desired yield or greater). This follows from the DOE’s definition of reliability which includes performance.

<sup>26</sup> The data was obtained through a Freedom of Information Act request via communication with Elva Ann Barfield, Department of Energy, Albuquerque Operations Office. Further references to this communication will be referenced as Barfield 1996.

<sup>27</sup> Johnson et al. p. 9. Since the data is by defect *type*, multiple occurrences of the same defect to the same type of warhead are only counted once. There have been over 2,400 individual defects found, but only 800 were distinct. Of these, approximately 400 were considered “Actionable.” The data analyzed in this report are on defect types and not total number of defects. The data also indicate the number of years since the first warhead of that particular type was produced, referred to as “Year after First Production Unit (FPU).” So far as we have been able to determine, the DOE has not kept records on the age of specific warheads in which problems have been discovered. Of the 400 “Actionable” defect types, we have analyzed the 245 which have been associated with safety, reliability, or operation of the warhead.

toward relating the historical experience of safety and reliability problems to the need for current and future SBSS facilities. The aim of this analysis is to examine, so far as available data permit, the validity of DOE's claim that the SBSS program is necessary for the safety and reliability of the existing nuclear arsenal.

There are a number of problems that have occurred in nuclear warheads. Some examples are:

- design or production defects
- metal corrosion
- chemical changes in high explosives
- plastic cracking

Problems can affect a wide variety of components, both nuclear and non-nuclear. Table 1 shows the number of problem types that have occurred and the type of component affected.<sup>28</sup>

**Table 1: Number of Problem Types and Affected Component**

Safety			Reliability		
Primary	Secondary	Non-Nuclear	Primary	Secondary	Non-Nuclear
38	2	26	27	8	151

The Department of Energy has conducted its own analysis of the data. It has concluded that one or two actionable findings, including both safety and reliability, will be found per year in the future, but warns that the number may be higher due to their lack of knowledge of certain materials and aging effects.<sup>29</sup> The historical data indicate that the most common kind of problems are likely to be those affecting non-nuclear components as they relate to reliability.

According to the DOE's data, approximately one-third of "actionable" defect types result in a retrofit or major design change. However, some of these retrofits or major design changes actually resolve multiple problems, so there have not been as many changes as the data would indicate. For those problem types which are not solved by a retrofit or design change, the DOE either accepts the problem or changes something other than the component. For instance, twenty-five percent of the problem types were solved by changing the production process. Forty-five percent were solved by changing the test equipment, changing the specifications of the warhead to conform to the problem, or

<sup>28</sup> Seven problem types affect both safety and reliability. Since we are analyzing safety and reliability as two separate issues, these problem types were considered in both analyses. The number of distinct problem types analyzed is 245, not 252 as Table 1 would seem to indicate, because we have listed seven problems in both the safety and reliability categories. Additionally, eight problem types were the result of aging and another factor such as design or production. In order to be conservative in our analysis of the effects of aging on nuclear weapons we have included these in the category of aging problems.

<sup>29</sup> DOE 1996, p. 2-6. The Stockpile Stewardship and Management Program Draft Programmatic Environmental Impact Statement also states that the stockpile will be older, on average, and contain more components than previous weapon types.

simply accepting the resulting reliability reduction. In all, approximately 70 percent of the problem types do not require any modification to the warhead itself.

The main process for finding problems will continue to be the Stockpile Evaluation program. This program is now part of the Stockpile Management program rather than the Stockpile Stewardship program, and hence does not involve the use of the SBSS facilities at issue in this report.

## **B. Analysis of Safety Issues**

### ***1. Types and Causes of Safety Problems***

The DOE has declared that the nuclear weapons stockpile is currently safe. This has been stated by officials at all levels of the Administration, including Secretary of Energy Hazel O'Leary and Department of Defense officials.<sup>30</sup> This is a plausible claim, since safety issues are an integral part of the certification process before warheads can be transferred from DOE to the Pentagon and put into the stockpile. Modern nuclear warheads are equipped with a variety of safety features to try to minimize the effects of accidents.<sup>31</sup> Recent changes in operational procedures have also reduced the exposure of nuclear warheads to conditions which might increase the chance of an accident.<sup>32</sup>

However, DOE foresees two possible sources of safety problems in the future:

- Aging: Nuclear weapons may develop problems as they age and as the materials in the warhead degrade or change.
- Component Replacement: If a component is replaced with either a re-manufactured component or new replacement in order to fix a safety or reliability problem, it could affect the safety of the warhead.

Safety problems with nuclear warheads can result from a variety of factors. Below are three examples of potential safety problems.

- The warhead design is not one-point safe (see above for the definition of one-point safety).

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<sup>30</sup> Smith 1996

<sup>31</sup> See Drell and Peurifoy 1994 and Kidder 1991 for a description of the various safety features designed to either prevent or minimize the effects of nuclear warhead accidents. These sources also contain a list of U.S. accidents involving nuclear warheads. The majority of accidents can be traced to the large number of flights flown with nuclear warheads during the late fifties and early sixties. Heightened tension led the U.S. to maintain a constant alert with bombers in the air 24 hours-a-day during that period, increasing the chances of an accident. The official claim of safety is presumably in reference to the statistical definition of safety discussed above.

<sup>32</sup> See Drell and Peurifoy 1994 for a discussion of how changes in operational procedures improve the safety of nuclear warheads. One particular example is the loading of warheads into Sea Launched Ballistic Missiles after the missile has been loaded into the submarine. This eliminates the possibility that a missile propellant fire or explosion during missile loading will affect the warhead.

- The use of High Explosives, rather than Insensitive High Explosives to detonate the primary. Insensitive High Explosives are less likely to detonate accidentally.
- The electrical arming, firing and safing system has a fault, such as a bad switch. Systems with Enhanced Nuclear Detonation Safety (ENDS, also known as Enhanced Electrical Isolation, or EEI) systems are unlikely to experience an electrical problem which could result in detonation or plutonium dispersal since these systems rely on a variety of backups and redundancies.

Safety is principally an issue with the primary of the warhead. As noted above, the primary contains the chemical high explosives which compress the plutonium and/or highly enriched uranium to initiate the nuclear explosion process. Without sufficient nuclear energy from the primary, the secondary cannot be ignited. The non-nuclear components do not pose a threat of nuclear yield or plutonium dispersal on their own.

Approximately fifty percent of problem types affecting the safety of the primary require a change to the warhead. For safety problem types that affected non-nuclear components, approximately one-third required a retrofit or major design change.

## ***2. Aging as a Safety Issue***

According to the data, the majority of safety problem types (including all problems with nuclear and non-nuclear components) are due to the design and production of the warheads and delivery systems rather than aging. As a result, most safety related problems are found in the first few years after production. All nuclear-related safety problems originated in design rather than aging.

Figure 1 shows the cause of safety-related problems found with warheads in the stockpile.

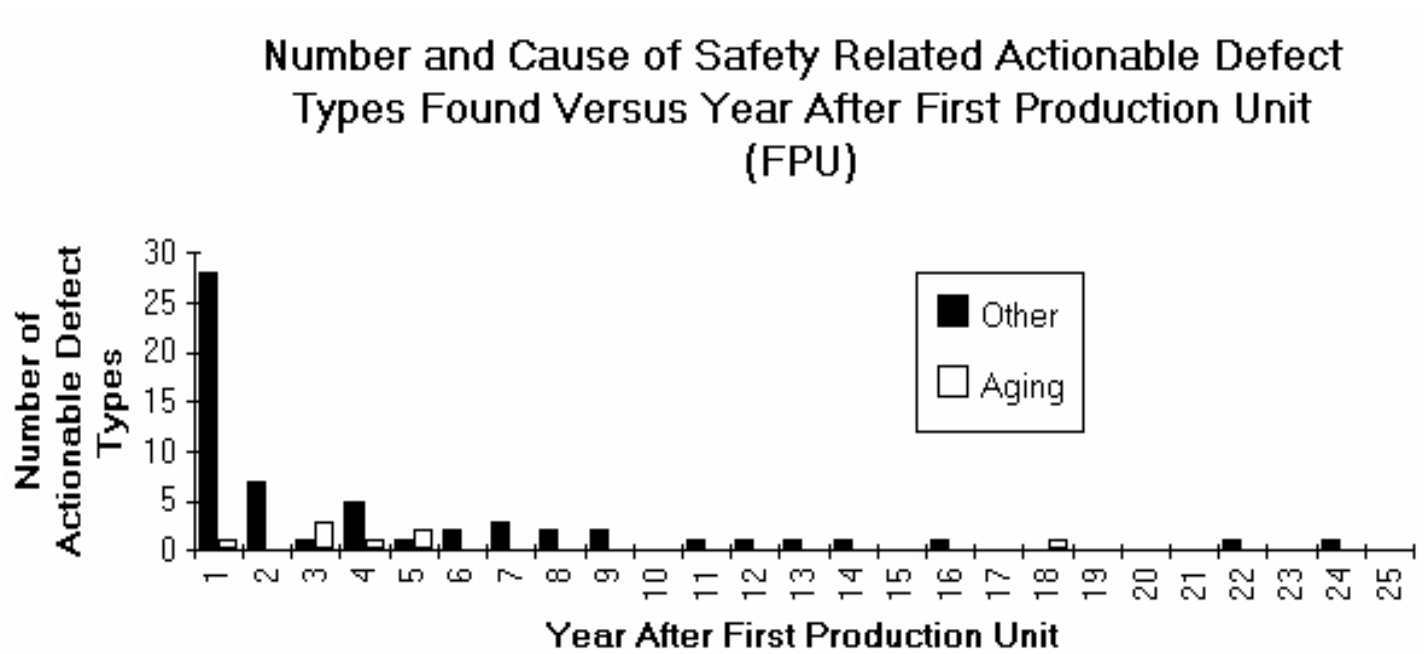
The 66 safety problem types found with warheads can be divided into two general categories:

- Eight were due to aging of the warhead and none of these affected nuclear components.
- Fifty-eight were due to other causes, mainly design defects and production problems.<sup>33</sup>

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<sup>33</sup> Barfield 1996

Figure 1





As can be seen from these data, aging actually accounts for only 12 percent of all safety problem types.<sup>34</sup>

Of the eight safety problem types due to aging, only two were found in warheads scheduled to remain in the arsenal; one of the problem types also involved reliability. One was a problem with the parachute system and the other affected the gas transfer system. Neither the primary nor secondary, the focus of study for SBSS facilities, were affected. Moreover, neither of these problems appears to have required a retrofit or major design change for safety reasons. Additionally, of all the aging problems, only one was found after the fifth year of the warhead's production. Table 2 summarizes DOE's data on the aging-related safety problems that have been found with the nuclear stockpile.

**Table 2: Aging-Related Safety Problems**

Warhead Number	Affected Component	Year Warhead Entered Production	Years after First Production Unit When Problem Found	Comments
B28	Parachute System	1958	4	Retired
W40	Arm/Safe/Fire	1959	3	Retired. Problem affected both safety and reliability
B43	Parachute System	1961	5	Retired
B43	Structure/Assembly	1961	3	Retired
W58	Structure/Assembly	1964	1	Retired
B61 (CHE) <sup>35</sup>	Radar	1968	18	Retired. Problem affected both safety and reliability
B61 (IHE) <sup>36</sup>	Parachute System	1979?	5	Active. The eleventh modification of this warhead is due to be completed in 1997
W87	Gas Transfer System	1987	3	Active. Problem affected both safety and reliability and was the result of both aging and a design problem

The historical data seem to indicate that safety problems become evident soon after a warhead is produced, even for problems which result from aging. Overall, 87.5 percent of aging-related safety problem types were found within five years of the first unit being produced.

The vast majority of safety problem types are the result of the design or production of the warhead. In general, the physical effects of aging such as metal corrosion or plastic degradation affect reliability rather than safety. For example, the sensitivity of high explosives, a serious safety concern, "does not increase significantly with age," according

<sup>34</sup> Overall, aging-related safety problems account for two percent (2%) of all problem types.

<sup>35</sup> CHE stands for Conventional High Explosives

<sup>36</sup> IHE stands for Insensitive High Explosives

to Dr. Ray Kidder, a retired senior nuclear weapons physicist at Livermore. He also noted that aging affects primarily reliability rather than safety.<sup>37</sup> These data and analyses lead us to the conclusion that the possibility of an accidental nuclear detonation or plutonium dispersal due to impact or fire affecting the high explosive appears not to increase materially with age.<sup>38</sup>

For problems affecting the most crucial nuclear component for safety - the warhead primary - the data are unambiguous in regard to the effect of aging on safety.

Figure 2 shows the cause of safety-related “Actionable Defect Types” and the age of the weapon when the defect was first discovered for primaries only. *The data clearly show that aging has not effected the safety of a single primary. The cause of all safety-related problems with primaries has been the design of the primary. Aging has also had no effect on the safety of secondaries.* That is, the safety of the nuclear components of warheads appears not to be affected by aging. Finally, the majority (80 percent) of safety defect types in primaries have been found in the first four years of a warhead’s production.

Of the 38 safety-related problem types found in primaries, 29 were in warheads put into production between 1958 and 1963.<sup>39</sup> The 1958-1961 U.S.-Soviet testing moratorium led both countries to rush weapons into production both before and after the moratorium. According to Dr. Kidder, warheads developed in this period suffered due to the rush to put them into production and many exhibited post-deployment problems that required correcting.<sup>40</sup> Warheads designed in this period also suffered due to a lack of modern safety features and the extensive design experience that has developed in the ensuing decades.

The warheads that are scheduled to remain in the stockpile have all been extensively tested. The result is that only two design-related safety problem types have been found with primaries in warheads scheduled to remain in the arsenal beyond the year 2000. Both problem types were the result of the design of the warhead. One was found in the second year of production and the other in the eleventh year of production. The problem type found in the eleventh year was on a W78 warhead, scheduled to be removed from active service and placed on reserve, according to the Natural Resources Defense Council (NRDC).<sup>41</sup> The other problem, found on a W88 warhead was fixed by either a retrofit or a major design change.<sup>42</sup>

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<sup>37</sup> Kidder 1991, p. 6

<sup>38</sup> This conclusion is further strengthened by the Sandia National Laboratory’s Institutional Plan, which only discusses design problems and not aging in its discussion of nuclear weapons safety. SNL 1995, pp. 3-9, 3-10.

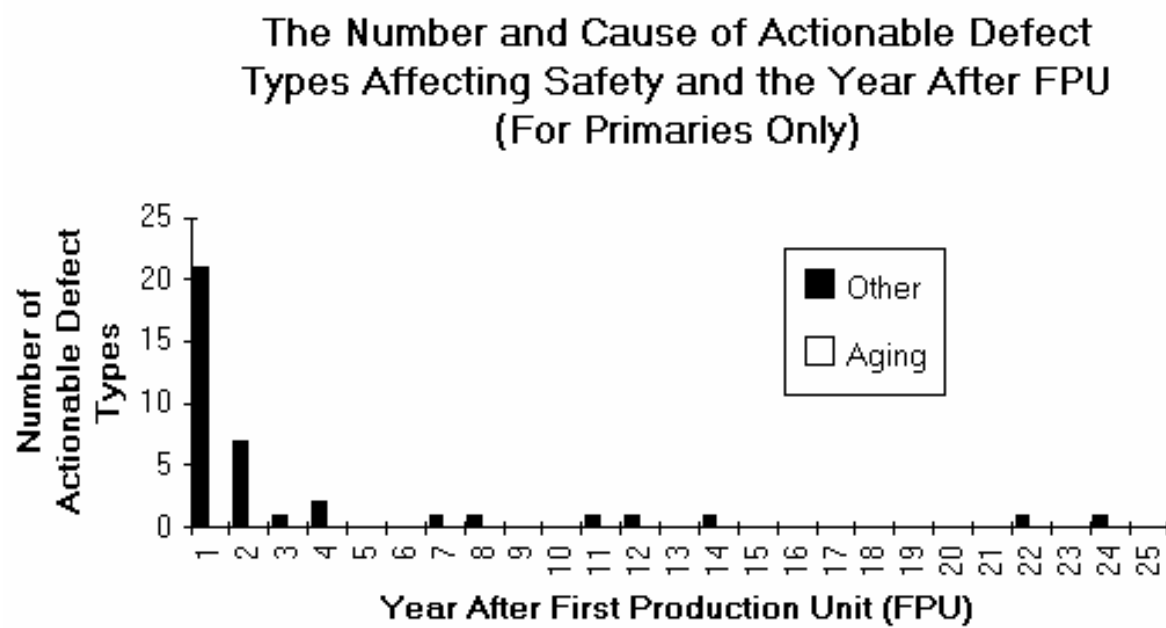
<sup>39</sup> Cochran et al. 1984, pp. 7-9

<sup>40</sup> Kidder 1987, pp. 4, 16-17 and JASON 1995, p. 8

<sup>41</sup> Cochran 1995

<sup>42</sup> The data that we have do not enable us to distinguish between changes made by retrofits or major design modifications.

**Figure 2**



The most recent warhead to enter the stockpile is the W88 which entered production in 1989 and entered the stockpile in 1991. Based on historical trends, the majority of problem types with the W88 should already have surfaced.<sup>43</sup>

### ***3. Component Replacement as a Safety Issue***

Besides aging, the DOE foresees potential safety problems due to the replacement of components. If a problem is found with a warhead or type of warhead, one possible solution is to replace the problematic component. In some cases, it will be possible to replace the component with a spare component or a replica. This is possible even with components in the “physics package,” such as high explosives or plutonium pits. According to a DoD advisory group, among others, it is not even necessary to replicate the exact manufacturing process for plutonium. Rather, it is sufficient to replicate the finished product.<sup>44</sup>

However if re-manufacture of an original component does not solve the problem it is necessary to design a new replacement component. In such a case, the possibility exists that the new component could create new safety problems. Even changes made to correct reliability problems could result in a new safety problem, according to the DOE.<sup>45</sup> For example, changing the high explosive of the primary could have an adverse effect on the one-point safety of the warhead.

To assess whether component replacement could result in safety problems, it is helpful to examine the issue according to component type:

- **Non-nuclear components:** Non-nuclear components can be re-manufactured or new components can be designed without any effect on the safety of the warhead. Laboratory based testing at Sandia National Laboratories can thoroughly test the functioning of non-nuclear components.<sup>46</sup> This is already done as part of the Stockpile Evaluation Program where warheads are dismantled and the non-nuclear components are functionally tested. Since these skills already exist and do not require testing with nuclear components, the SBSS program would provide little, if any, help. By extension, the role of new SBSS facilities would be similarly negligible.
- **Secondaries:** Since nuclear safety is not an issue with secondaries (other than that deriving from accidental primary detonation), it is highly unlikely that changes made to the secondary would introduce nuclear safety problems.

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<sup>43</sup> There have been 8 problem types found with the W88. A design problem with the arming system was found in the first year (no effect on safety or reliability), three design problems were found with the primary within the first three years (one had no effect, one affected safety and the third affected yield performance), a production problem with the radar was found in the second year (no effect), and two design problems were found with the secondary in the first three years (both affected the yield performance of the warhead).

<sup>44</sup> JASON 1994, p. 84

<sup>45</sup> DOE 1995b, p. 2-11

<sup>46</sup> Robinson 1996, p. 9

- Primaries: “Fixes” to the primaries could introduce uncertainties as to the safety of the warhead. It is for this reason that many analysts with extensive nuclear weapons-related experience have argued against modifying nuclear warheads after a test ban.<sup>47</sup> Modifications, especially to the nuclear package, could introduce uncertainties that could not be evaluated without nuclear testing.

The DOE’s plans to use computer models to certify modifications could also create problems. In the past, changes to computer codes have been validated using underground testing. The DOE proposes to change the codes that model the primaries and secondaries based on data from SBSS facilities. Validation of changes to the computer codes will have to rely on previous test data. The possibility exists that, as more changes are made to computer codes based on data from SBSS facilities, the codes will become less accurate when applied to existing warheads. This could adversely effect safety and reliability.

The other option would be to dismantle those warheads which exhibit safety problems that cannot be resolved through the Stockpile Evaluation Program. As noted above, this program has resulted in the discovery of the vast majority of safety problem types. Further, non-nuclear component testing could also resolve most other safety issues. In any case, dismantling warheads when safety-related issues have been identified is a more conservative strategy than changing the nuclear package using the SBSS program. This is because changing the nuclear package could result in compromising safety. The consequences of a mistake in this area could be very high.

#### ***4. Studying the Safety of Primaries***

Let us examine the facilities that DOE has, and intends to build, and their potential relation to safety problems in primaries. According to the DOE, nuclear testing was used in the past in order to identify problems, verify design changes, and resolve problems discovered through other means.<sup>48</sup> Without nuclear testing, the DOE has determined it must obtain the information through other means. In the case of warhead safety, the DOE proposes to use existing and new hydrodynamic testing facilities, as well as advanced computer simulations.

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<sup>47</sup> Drell and Peurifoy 1994, p. 321. The authors state that “Most importantly, in the case of test ban, one should not tamper with the device hardware once it has been certified.” They go on to say the “hardware modifications must be avoided.” In this article the “device” refers to the primary and secondary of the warhead. It should be noted that Drell and Peurifoy support the SBSS program. Ray Kidder has stated that changes or improvements to the “physics package” of nuclear warheads should not be made for either safety and reliability reasons unless they are unavoidable (personal communication with Ray Kidder, May 2, 1996). Richard Garwin, a long-time advisor to the U.S. government on technical nuclear issues, stated in 1993 that warheads can be maintained for decades through re-manufacture as long as the United States maintains the “organizational control and integrity to replicate but not modify or ‘improve’ the weapons,” (Garwin 1993).

<sup>48</sup> DOE 1996, p. 2-4

One of the facilities that is currently under construction as part of the SBSS program is the Dual Axis Radiographic Hydrodynamic Test facility (DARHT). The Environmental Impact Statement for DARHT defines a hydrodynamic test as a

dynamic, integrated systems test of a mock-up nuclear package during which the high explosives are detonated and the resulting motions and reactions of materials and components are observed and measured. The explosively generated high pressures and temperatures cause some of the materials to behave hydraulically (like a fluid).<sup>49</sup>

Hydrodynamic facilities help weapons designers to determine the physical behavior of uranium and plutonium under the extreme temperature and pressure conditions that prevail during detonation. The term “hydrodynamic” is used to describe such testing because materials tend to behave like liquids under these conditions. Their physical behavior can therefore be modeled by equations that apply to liquids. In technical terms, this is summed up by saying that hydrodynamic facilities test the hydrodynamic operation of implosion systems, including the validity of equations of state of plutonium and/or uranium over relevant temperatures and pressures.

A variety of diagnostic systems are used to analyze the implosion. A “mock-up” of the nuclear package is one of them. It is similar to a primary except that the fissile material inside has been replaced with another material of similar density (e.g., depleted uranium or plutonium-242, a non-fissile isotope of plutonium). Actual warhead primaries are not used in hydrodynamic tests. Even though they use surrogate materials, hydrodynamic tests are among the most realistic of non-nuclear tests, because they can be used to study a warhead up to the point that it would achieve criticality.

The DOE also uses hydrodynamic facilities to conduct experiments with more general relevance to materials science, called dynamic experiments. These subject test materials such as plutonium or uranium to high pressures and temperatures. Information about the material being tested can then be obtained. Dynamic experiments could allow measurement of neutron multiplication in the test material without allowing the material to achieve criticality.<sup>50</sup> The rate of neutron multiplication could provide valuable information for weapons design work.

The DOE proposes to use the information gained from hydrodynamic and dynamic experiments to validate or refine the computer codes used to model warheads. The computer models would be used to predict possible problems with primaries, or as one test of whether a fix would work. Hydrodynamic testing could also be used to certify certain weapons components after re-manufacture or design.

The DOE already operates a variety of hydrodynamic and dynamic facilities at all three weapons laboratories and the Nevada Test Site (NTS), and plans to upgrade facilities and build new facilities as part of the Stockpile Stewardship program. Table 3 lists current and proposed hydrodynamic facilities. Certain facilities have the capability of producing

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<sup>49</sup> DOE 1995b, p. 1-1

<sup>50</sup> Personal communication with Ted Taylor, April 22, 1996.

X-ray “radiographs” of implosions using high energy accelerators. For these facilities, the number of axes determines the number of lines of sight (or views) of the implosion. As is clear from Table 3, all hydrodynamic facilities can be used for new weapons design.

**Table 3: Hydrodynamic Facilities**

Facility Name	Type	Location	Status <sup>51</sup>	Design Capability
High Explosives Applications Facility (HEAF)	New High Explosives Testing	Livermore	Existing	Yes
Big Explosives Experimental Facility (BEEF)	Large-scale experiments	Nevada Test Site	Existing	Yes
LYNER	Hydrodynamic and Hydronuclear	Nevada Test Site	Existing	Yes
Explosive Components Facility	Component Development	Sandia	Completed? (\$27.8 million)	Yes
PERMEX	Single Axis	Los Alamos	Existing	Yes
PERMEX Upgrade	Single Axis, Dual Pulse	Los Alamos	Not Completed	Yes
Flash X-Ray (FXR)	Single Axis	Livermore	Existing	Yes
Contained Firing Facility (CFF), an FXR Upgrade	Single Axis, Dual Pulse	Livermore	Proposed in SSM Programmatic EIS. (\$48.5 million)	Yes
Dual Axis Radiographic Hydrodynamic Test Facility (DARHT)	Dual Axis	Los Alamos	Court Injunction lifted, construction resumed (\$48 million)	Yes
Advanced Hydrotest Facility (AHF)	4-6 Axes	Unknown	Proposed Next Generation Facility (\$422 million)	Yes

The main new hydrodynamic facilities are DARHT (under construction) and the proposed Advanced Hydrotest Facility (AHF). Additionally, the DOE proposes to upgrade the Site 300 facility to make better use of the Flash X-Ray (FXR) facility at Livermore. The new facility, the Contained Firing Facility, would contain the explosive experiments, instead of conducting them in the open as is the case now. It would include the possibility of a second pulse for successive images and increased diagnostics.

According to its proponents, the two main improvements of DARHT over its predecessors are increased resolution and use of two axes instead of one. The second axis allows for two-dimensional imaging of implosions with some information on the third dimension or rapidly successive images. However, Seymour Sack, a Laboratory Associate at Livermore, questions the need for a second axis and argues that current facilities may be sufficient for stockpile stewardship.<sup>52</sup> Sack argues that the information

<sup>51</sup> For proposed facilities, estimated construction costs are provided. These costs do not include operation or decommissioning of the facility.

<sup>52</sup> Sack 1992

that DARHT is supposed to provide can be obtained through small-scale experiments (in the case of the properties of plutonium) or computer calculations. The one justification that Sack does allow for DARHT is the aging of PHERMEX, the other facility at Los Alamos. Sack's solution is either to build only one of DARHT's two proposed axes or for the two laboratories to make joint use of Livermore's FXR after it has been upgraded. Sack does not foresee a "catastrophic loss of capability or flexibility" if DARHT is not approved. The DARHT EIS does not discuss his critique. According to the DOE, the increased resolution and X-ray intensity of DARHT and the second axis are necessary for the diagnostic capabilities the DOE requires.

AHF's six axes would allow for three-dimensional imaging and the ability to produce "movies" of the implosion.<sup>53</sup> The DOE anticipates that AHF's three dimensional imaging will eventually be necessary.<sup>54</sup>

The SBSS program also includes high energy density facilities. These facilities are discussed in more detail below, but we note here that these facilities will not aid in maintaining the safety of the nuclear arsenal for the following reasons:

- These facilities focus on the secondaries of warheads (with some experiments relevant to boosting). Secondaries have exhibited very few problem types historically and most (eight of a total of ten) have affected reliability. The facilities do not aid in understanding the implosion of primaries, which is the principal cause of safety concerns.
- Data obtained using high energy density facilities, including the National Ignition Facility (NIF) and Atlas, the facilities proposed for immediate construction, must be appropriately scaled to be useful in accurately assessing the operation of existing warheads.<sup>55</sup> The volumes of the targets used in these facilities are significantly less than an actual nuclear explosion. In the case of NIF, the most powerful of these facilities, the target volume is millions of times smaller. However, the energy densities are comparable to actual weapons (see Figure 3)
- These facilities can only examine isolated phenomena and are incapable of exactly simulating the complex interplay of a variety of physical processes that occur in a nuclear explosion, such as the dependence of secondary explosions on the primary. This means that NIF would be irrelevant to assuring nuclear safety of existing warheads while enabling advances in the design of new ones.

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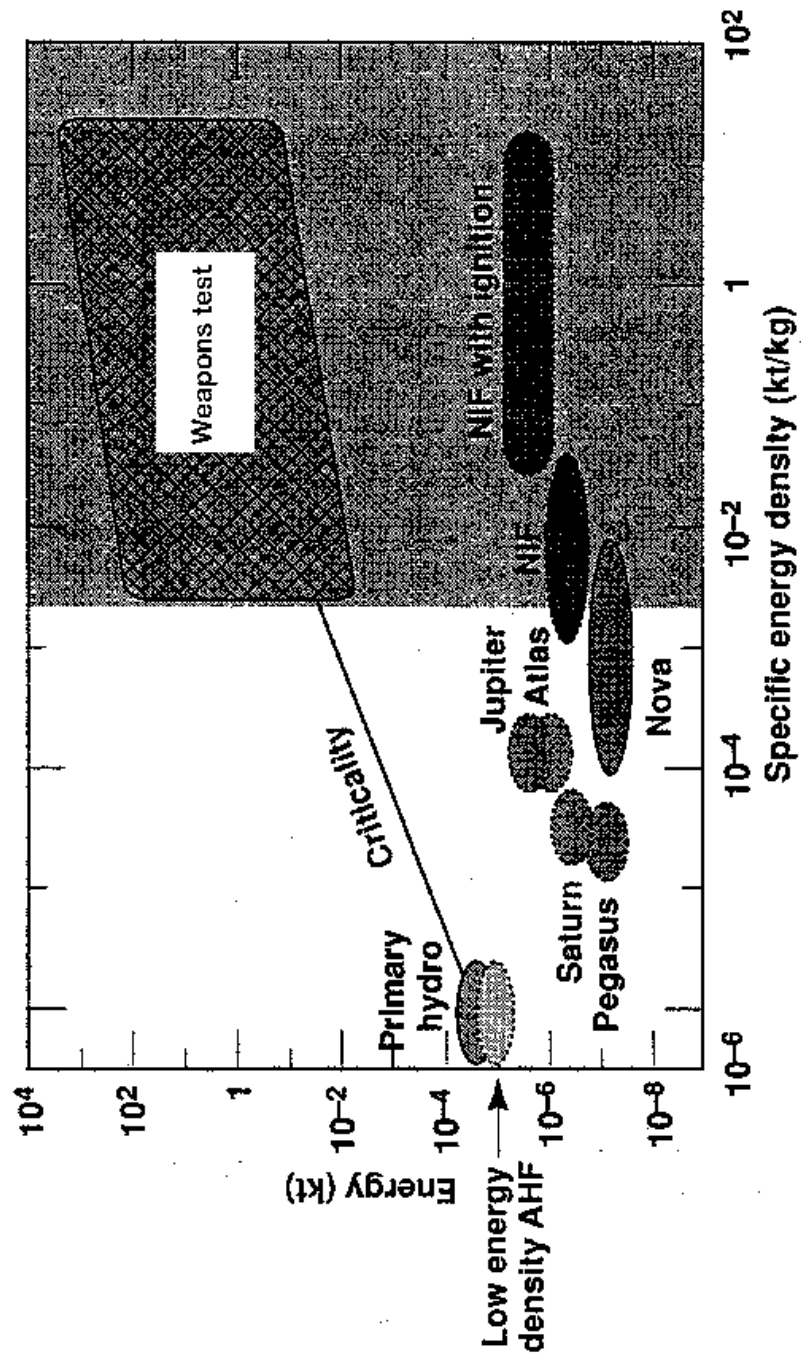
<sup>53</sup> See Makhijani 1995, DOE 1995b for more information on DARHT and AHF.

<sup>54</sup> DOE 1996, p. 3-21

<sup>55</sup> The accuracy required in scaling is lower if the facilities are used for the preliminary design of warheads.



## NIF energy densities will begin to overlap weapons



Science-based stockpile stewardship focuses on improving predictive capability by doing high energy density experiments

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Adapted by IEER from an LLNL image

Figure 3

The DOE itself has stated that NIF and Atlas will have little or no relevance to maintaining the safety of nuclear weapons. For example, the Stockpile Stewardship and Management Programmatic EIS states that “the principal safety issues for a nuclear weapon that involve the high explosive and fissile material implosion ... could not be addressed in NIF.”<sup>56</sup> The same document, in discussing the need for Atlas, only mentions weapons performance and reliability.

### **C. An Analysis of Reliability Issues**

As with safety, Department of Energy and the Department of Defense officials have declared the nuclear weapons stockpile to be reliable. However, the DOE also foresees aging and component replacement as creating possible future reliability problems.

Reliability problems can result from a variety of factors and affect all component types as the examples below illustrate:

- Faulty design of a switch in the arming system could prevent the electrical signal which arms the warhead from being conducted.
- Problems in production of the secondary could affect the yield performance.
- Metal corrosion or deterioration of plastics could impact the reliability of the particular component to function as designed.

Approximately twenty-five percent of reliability problem types require a retrofit or major design change.

#### ***1. Aging as a Reliability Issue***

A majority of the defect types found with nuclear weapons affect the reliability of the warhead (see Table 1 above). Figure 4 shows the number and cause of reliability problems for all components. The pattern is similar to problems with safety: the majority of problems are found in the early years after the introduction of a new weapon. However, unlike safety, DOE data indicate that aging accounts for a significant number of reliability problems - about 24 percent in all.

Also, unlike safety problem types, the majority of reliability problem types occur in the non-nuclear components of warheads. This can be seen in Figure 5, which shows that 81 percent of reliability problem types occurred in non-nuclear components.

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<sup>56</sup> DOE 1996, p. I-8

Figure 4

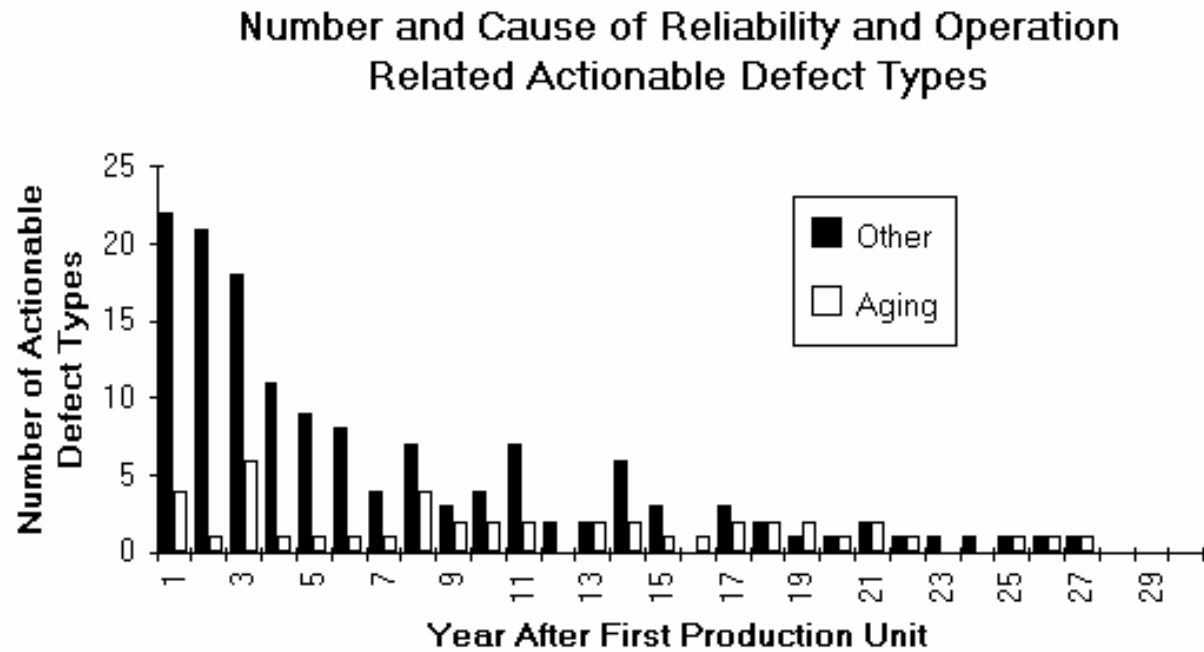
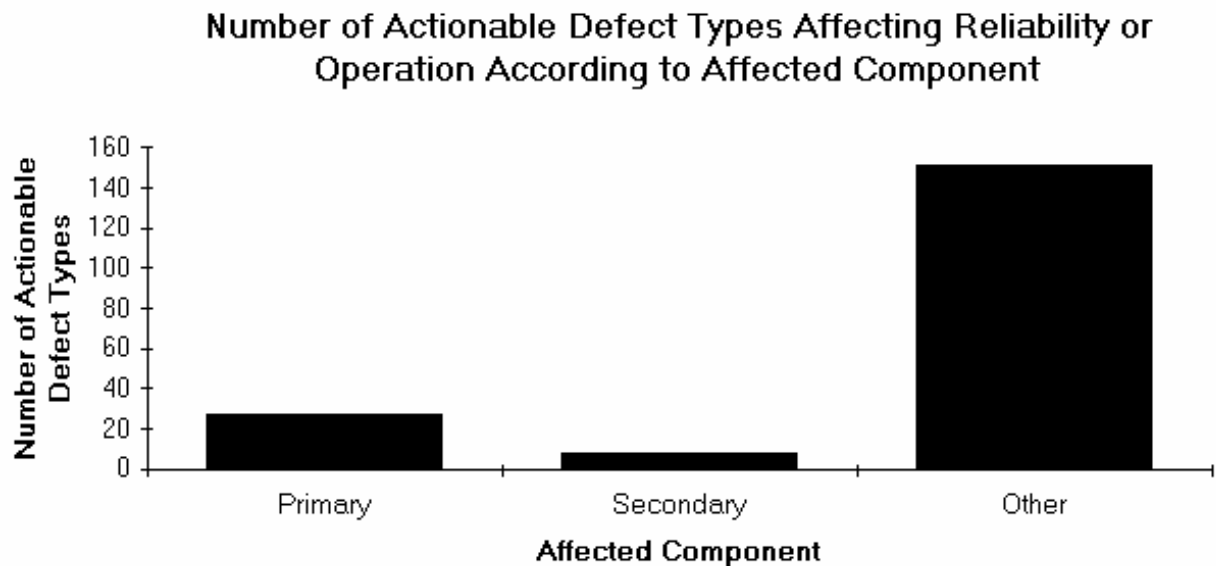


Figure 5



Thirty-five out of 186 (19 percent) of reliability problem types are associated with primaries or secondaries. The detailed breakdown is as follows:

- 27 have affected primaries
  - 15 of these problem types affected warhead yield (three were due to aging).
  - 12 have affected reliability, as defined above (five were due to aging).
  - All aging-related problems with primaries occurred in warheads retired from the stockpile.
- 8 have affected secondaries
  - Seven of the problem types affecting secondaries were operation (yield performance) problems. One of these was due to aging.

A majority of the reliability problem types affecting primaries and secondaries affect the operation of the warhead. That is, they would not have affected the warheads ability to detonate but rather would have affected the yield performance of the warhead. Even at reduced yields, nuclear weapons have devastating effects.<sup>57</sup> The question is: what effect will reduced yield of a few percent, in a warhead of several hundred kilotons, have on a U.S. strategy based on retaliatory deterrence rather than warfighting? And should the DOE fix these problems when fixes to the “physics package” could possibly result in increased uncertainties about the safety of the warhead?

## ***2. Component Replacement as a Reliability Issue***

The question of what action should be taken in the case of reliability problems arises in much the same way as with safety problems. Re-manufacture of components, including nuclear components, is one possibility which many experts have stated is possible. If necessary, design of new non-nuclear components could be carried out and functional testing of the components could be conducted at Sandia. The DOE must not only ensure that new components or changes to warheads fix the original problem, but also ensure that new problems are not introduced by the changes.

This becomes more difficult if the DOE plans to make changes to the “physics package” and re-certify the warhead without nuclear testing. Aging of high explosives and plutonium in the primary could have an effect on the reliability of the warhead. As noted above, re-manufacturing of components, including nuclear components such as pits, has been considered a reasonable approach to maintaining nuclear warheads. But changes to the “physics package” should be avoided because they can introduce uncertainties and potentially adversely effect safety. Rather than make a basic decision to refrain from making non-safety-related changes to nuclear components, the DOE’s SBSS program, with its focus on nuclear components, is designed to aid in making changes to the “physics package.” It is difficult to justify this if safety is the primary objective.

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<sup>57</sup> Kidder 1987, p. 6.. Kidder notes that even a 30% reduction in yield only results in a 10% reduction in blast radius (correction to original made per personal communication with Ray Kidder) for single stage fission weapons.

Changes to warheads raise questions about the certification of the warheads that have been modified. Certification is a formal process by which the DOE guarantees the safety and reliability (performance) of a warhead at the time it is transferred to the DoD. The DoD has demanded that DOE be able to certify new warheads without underground testing, and the DOE has provided assurances that this will be possible, with some limitations. Currently, a new program is being implemented in which warheads are certified every year by both the DOE and DoD.

### 3. *Reductions in Reliability*

The existence of a “reliability defect” does not necessarily mean that the reliability of the warhead will be significantly affected. According to the DOE there are “164 ‘Actionable’ defect types with reliability reductions associated with them.”<sup>58</sup> However, only nine of those defect types reduce reliability of the warhead by more than ten percent:

**Table 4: Reliability Reductions**

<b>Percent Reduction in Reliability</b>	<b>Number of Defect Types</b>
zero to one percent	112 defect types
one percent to five percent	37 defect types
five percent to ten percent	6 defect types
over ten percent	9 defect types

In other words, for warheads with the other 155 defect types, there is still over 90 percent probability that the warhead will perform as expected.

Most reliability problem types have a minor effect: almost seventy percent reduce reliability by *one percent or less*. The majority of reliability problems do not need any corrective action or can be resolved through production changes. As a result, only 24 percent of the “actionable” defect types affecting reliability result in a retrofit or major design change. The question again is what effect such small reliability reductions have on the U.S. nuclear deterrence? And should reliability problems be corrected through design of new nuclear components when that could introduce uncertainties about the safety of the arsenal? Or should reliability problems be addressed through re-manufacturing?

It is important to note that DOE has a very narrow definition of reliability. If there is even a small chance that an explosion could be slightly less than the rated yield, it is considered a reliability problem. As we note below, such a strict definition of reliability appears not to be pertinent to a retaliatory deterrence strategy, but only to a first strike strategy. DOE data we have do not permit detailed analysis of how many reliability problems might remain if the reliability were defined to suit a retaliatory deterrence

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<sup>58</sup> Barfield 1996 p. 4. Note that these 164 defect types in Table 4 list only strictly reliability defect types, while Table 1 shows yield performance problem types as well.

strategy. On the face of it, the data indicate that 12 of the nuclear-related reliability problem types may be material to such a definition. Far more detailed nuclear testing data on reliability would need to be made public to do a definitive analysis.

The above data lead to the following conclusions:

- The DOE often accepts reductions in the reliability of a warhead. It is not possible to compare DOE's acceptance of reliability reductions in many cases to its rejection in others without more detailed data. If this was done in the past without detriment to the national security of the United States, as defined by the nuclear establishment, then it is reasonable to assume that the DOE would also do so in the future unless there were a motive other than reliability at work.
- Only a twenty-five percent of reliability problem types require changes to the actual warhead. This reduces the potential relevance of the SBSS facilities which the DOE argues are necessary in order to maintain reliability.

#### ***4. Studying Reliability***

Reliability problems can arise from the primary, secondary, and/or the non-nuclear components of a warhead. For primary reliability, the DOE proposes to use the hydrodynamic facilities discussed above in the section on safety. However, for the reliability of secondaries, the DOE plans to expand its experimental capabilities in high energy density facilities.

High energy density facilities, such as laser fusion devices, can be used to study thermonuclear (fusion) phenomena in secondaries and in boosting. However, these facilities can only simulate individual physical processes that occur in a nuclear explosion and at much lower overall volumes, requiring the results to be scaled to the volume of actual warheads in order to apply them to improve safety or reliability. Further, fusion phenomena occur in these facilities without the complications that link the fusion reactions in warheads to other physical and chemical processes.<sup>59</sup> The DOE proposes to use data from high energy density experiments to modify or validate computer modeling codes. Those computer codes would then be used to either predict problems or validate changes made to fix problems in warheads.

Current high energy density facilities include accelerator, pulsed power, and laser facilities:

- Accelerators are used to produce neutrons in order to study fission. According to the DOE, one existing facility, the Los Alamos Neutron Scattering Center (LANSCE), is also being tested for possible use for neutron radiography of dismantled warheads to test for aging effects.

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<sup>59</sup> DOE 1995d, p. 15

- Pulsed power facilities use bursts of electrical energy, sometimes amplified by high explosives, to study implosions, X-rays and weapons effects.
- Lasers can be used to produce X-rays and study fusion at low volumes. Lasers are used in Inertial Confinement Fusion (ICF) experiments to heat and compress Deuterium-Tritium capsules. Figure 6 provides a schematic diagram of how ICF works. The main new laser facility that the DOE proposes to construct is the National Ignition Facility (NIF).

Below is a table describing current and proposed high energy density facilities.

**Table 5: High Energy Density Facilities and Accelerators**

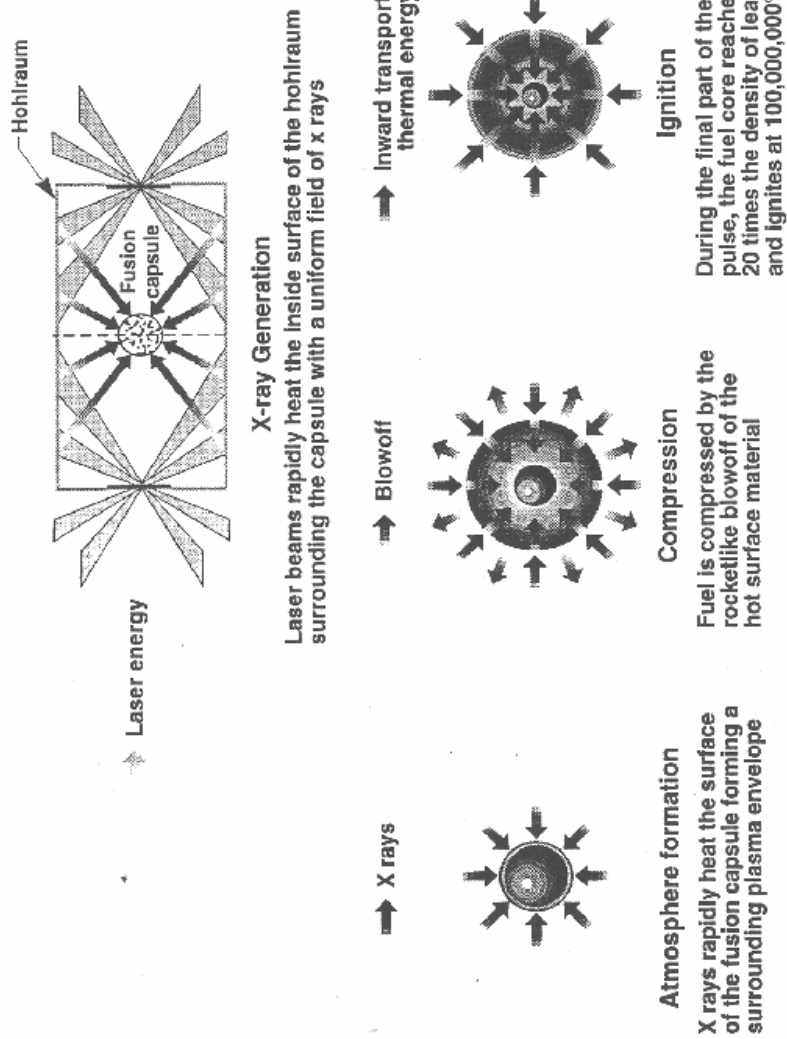
Facility Name	Type	Location	Status <sup>60</sup>	Design Capability
Nova	Inertial Confinement Fusion (ICF) Laser	Livermore	Existing	Yes
Pegasus II	Capacitor-Bank Pulsed Power	Los Alamos	Existing	Yes
Procyon	High Explosive Pulsed Power	Los Alamos	Existing	Yes
Trident	Laser	Los Alamos	Existing	Yes
Bright Source II	Laser	Los Alamos	Existing	Yes
Ultra-Short Pulse	Laser	Livermore	Existing	Yes
Los Alamos Meson Physics Facility (LAMPF) <sup>61</sup>	Accelerator	Los Alamos	Existing	Yes
LANSCE II program to convert LAMPF <sup>62</sup>	Accelerator	Los Alamos	Proposed (\$650 million)	Yes
National Ignition Facility	ICF Laser	Livermore is the preferred location	Proposed in SSM Programmatic EIS (~\$1 billion)	Yes
Atlas	Capacitor Bank Pulsed Power	Los Alamos	Proposed in SSM Programmatic EIS (\$48.4 million)	Yes

<sup>60</sup> For proposed facilities, estimated construction costs are provided. These costs do not include operation or decommissioning of the facility.

<sup>61</sup> This facility does not reach the energy densities of the other facilities on this list, but is included in order to show the range of facilities at DOE's disposal.

<sup>62</sup> *ibid.*

# Inertial Confinement Fusion process



This approach, called indirect drive, is the leading target concept

Figure 6



The DOE proposes to use existing structures at Los Alamos to build a new pulsed power facility called Atlas.<sup>63</sup> Atlas would use electrical and magnetic energy to implode small metal targets (on the scale of cubic centimeters).<sup>64</sup> According to the DOE, Atlas is necessary because it provides performance improvements over previous facility (e.g. ten times the pressure of Pegasus II). According to the DOE, “the energy of Pegasus II is insufficient to reach the pressures and volumes needed to accurately benchmark weapon-related computational predictions.”<sup>65</sup> However, the small volumes in which the reactions occur would require the DOE to scale the information up to that of an actual nuclear explosion.

The National Ignition Facility (with a total life-cycle cost estimated at \$4.5 billion<sup>66</sup>) would provide higher energy densities than Nova.<sup>67</sup> NIF is considered, by the DOE, to be one of the cornerstones of the SBSS program. NIF will have 40 times more energy than Nova<sup>68</sup>, and is designed to achieve “ignition,” meaning that the fusion reaction is self-sustained and releases more energy than is required to produce the reaction.<sup>69</sup> In other words, the fusion reaction in NIF would be a net producer of energy. While both Nova and NIF operate at very small volumes and energies, NIF would operate at energy densities far greater than Nova and comparable to the levels in nuclear explosions. However the overall volume of the reaction in NIF would still be a million times smaller than a nuclear warhead.<sup>70</sup> Figure 7 shows several aspects of the performance of NIF relative to parameter values in a nuclear explosion. Therefore, these experiments have the “scaling” problem mentioned above in relation to accurately modeling problems in existing warheads.

According to the DOE, both NIF and Atlas are necessary because they provide different information. Laser experiments are performed using very small targets for a short period of time, but at extremely high temperatures and pressures. Pulsed power experiments occur in larger volumes, for longer periods of time, but at lower pressures and temperatures. Yet, neither type of facility can be used to directly test or fix an existing secondary or test a new secondary.

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<sup>63</sup> DOE 1996 K-1

<sup>64</sup> DOE 1996 K-2

<sup>65</sup> DOE 1996 K-2

<sup>66</sup> Weida 1996, p. 3

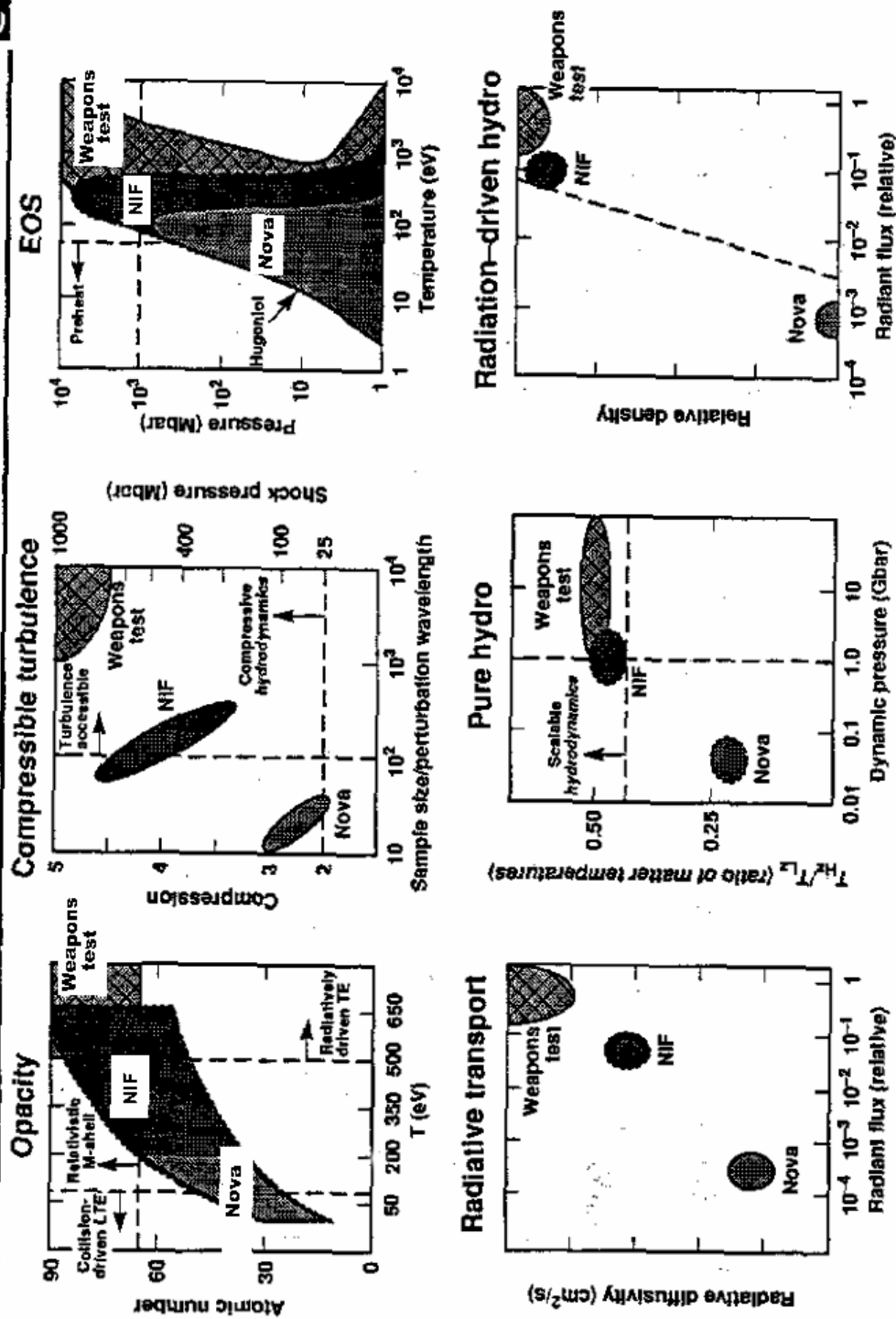
<sup>67</sup> A glass laser generates a highly coherent beam of light. The energy of the beam is then deposited on the target, creating the high temperatures and pressures necessary for fusion.

<sup>68</sup> DOE 1995d, p. 11

<sup>69</sup> DOE 1996, p. I-1

<sup>70</sup> DOE 1995d, p. 15

# Weapons physics scaling: highest energy density works best



If you want to achieve weapons conditions you need a larger laser

05-00-0884-3334  
STEM/chem

Adapted by IEER from an LLNL image

## ***SBSS Program and Military Capabilities***

### **A. Deterrence and Reliability**

As mentioned above, reliability is not only a technical issue, it is a political issue. The role of nuclear weapons in U.S. strategic policy plays a role in determining the level of necessary reliability.

Assuming the role of nuclear weapons is restricted to retaliatory deterrence, that is nuclear retaliation in response to a nuclear attack, a credible deterrent is possible at lower reliability (given DOE's existing narrow definition of reliability). According to this definition, a warhead is considered unreliable to some extent if there is a possibility that it could perform even slightly below rated performance, both in terms of yield and "circular error probable" (CEP). The CEP measures how far a warhead lands relative to the intended target. For instance, warheads that detonate with the expected yield or higher and land within their rated CEP with near certainty would not be required for retaliatory deterrence because nuclear weapons have devastating consequences at anything near rated yield and CEP. No country would risk retaliation by the United States on the chance that the U.S. nuclear arsenal may not produce the rated yield.

On the other hand, if the purpose of the nuclear arsenal is to actually wage a nuclear war with the option of striking first to disable an opponent's nuclear forces, a very high degree of reliability may be necessary. This is because land-based strategic missiles are generally stored in "hardened" underground silos that might survive a nuclear explosion if it were too far away from the silo. A small CEP (tens of yards, for instance) is considered desirable for a first strike strategy aimed at destroying an opponent's nuclear forces. The potential for a disarming first strike scenario was at the center of debates regarding Soviet land-based missiles and the US deployment of the MX missile. It appears that most reliability problems may be relevant only to a strategy of a nuclear first strike against an adversary with a large nuclear arsenal. So far as we have been able to determine, 12 nuclear-related reliability problem types may be relevant to retaliatory deterrence. However, as noted earlier, we currently do not have enough data to accurately assess the effect of the definition of reliability on the SBSS program. DOE should declassify the data necessary to enable a serious public debate on this important issue.

### **B. Weapons Design**

The purpose of the SBSS program, according to the DOE, is to maintain the existing arsenal, not to design new weapons. However, according to a draft Los Alamos National Laboratory Institutional Plan for FY 1996-2000, above-ground experimental facilities "have long played a central role in Laboratory studies of the way nuclear weapons

work.”<sup>71</sup> One may reasonably infer from this statement that these experiments contributed significantly to weapons design.

The DOE’s new experimental facilities and computer simulation capabilities could allow the laboratories to design new warheads with greater confidence. SBSS facilities could be used to both explore new concepts in weapons design and to test some components of a warhead. Coupled with computer simulations of the entire warhead and the manufacturing capabilities provided by the Stockpile Management program, new warheads could be prototyped and placed on “stand-by.” This may not constitute a completion of the design process in DOE’s definition, but such warheads would be a very long way toward a finished product. For instance, the National Ignition Facility can replicate most parameters of a nuclear weapons test on a small scale, as can be seen in Figure 7. While the total energy is anywhere from 10,000 to 1 billion times less, the energy density is approximately the same. Similar temperature and pressure conditions also prevail. This would allow weapons designers to explore these high energy densities in a laboratory environment and gain information on new concepts without nuclear weapons testing.

Various official documents discuss the possibility of continuing weapons design even after a Comprehensive Test Ban treaty is signed:

- The DARHT EIS states that should the President and Congress approve new weapons development, “Hydrodynamic testing, along with many other tools could be used to assist in weapons development.”<sup>72</sup> DARHT was initially proposed in the 1980s as a weapons design facility.<sup>73</sup>
- President Clinton’s Presidential Decision Directive of November 1993 stated that “Hydrodynamic testing is also needed to support a development program necessary to help retain and exercise weapon design engineering skills...”<sup>74</sup>
- One of Livermore’s goals for restructuring the weapons complex is the ability to resume “weapons design, development and production should these be necessary in the future.”<sup>75</sup>
- The Draft Accelerated Strategic Computing Initiative (ASCI) Program Plan claims that  
ASCI will create virtual testing and prototyping capabilities based on advanced weapons codes and HPC [High Performance Computing]. The program will provide the ability to analyze, evaluate, maintain, and prototype nuclear weapons and weapons components in the absence of underground nuclear testing and with drastically reduced weapons manufacturing infrastructure.<sup>76</sup>

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<sup>71</sup> LANL 1995, p. 14

<sup>72</sup> DOE 1995b, p. 2-16

<sup>73</sup> DOE 1995b, p. 3-20

<sup>74</sup> Presidential Decision Directive as quoted in DOE 1995b, p. 2-6

<sup>75</sup> LLNL 1994, p. 30

<sup>76</sup> “Draft Accelerated Strategic Computing Initiative (ASCI) Program Plan.” Internet homepage of the Department of Energy’s Defense Programs Office. The page was last updated on 12 June 1995. A introduction to the page added after June 12 stated that the contents of the homepage did not reflect official DOE policy. The homepage was taken off the Internet in March 1996.

- The Department of Defense's Nuclear Posture Review requires the DOE to retain the "capability to design, fabricate, and certify new warheads."<sup>77</sup>
- A review of the SBSS program by the JASON group, a high level group that advises the Department of Defense and other government agencies, assumes that the "U.S. nuclear infrastructure under the SBSS will retain a capability to design and build new weapons, which could be deployed should the need arise and lead to the resumption of nuclear testing..."<sup>78</sup>

Perhaps one of the clearest views into the laboratories' long-term plans for weapons design work comes from testimony by C. Paul Robinson, director of Sandia National Laboratories, in mid-march of 1996. It is worth quoting at length:

...many of the systems in stockpile will require replacement at about the same time at some point in the first half of the next century. The engineers and scientists who will do that work are probably entering kindergarten this year. No old-timers will be around in 2025 who have had actual experience in designing a warhead. We must find ways to qualify these people. They need to work on real systems. We cannot expect them to acquire critical design skills merely by performing piecemeal component replacement work and development simulations. They have to design whole systems with real deliverables to fully develop their capabilities. Ideally, we would like to train our junior weapon design engineers alongside experienced engineers, but this will not be possible during a decades-long hiatus of no weapon development. The Russian laboratories, by contrast, will be able to pass along their critical weapon design skills to a new generation under their announced plans to rebuild thousands of weapons each year.<sup>79</sup>

The lack of underground testing to certify the reliability of new warhead designs is noted as a major impediment to any new design.<sup>80</sup> However, DOE could largely design new weapons using the SBSS facilities and keep the test site ready to explode them for final testing. Thus, the SBSS program would allow the U.S. to develop warheads and greatly reduce the time required to introduce and test new warheads. This capability is especially deleterious for non-proliferation when coupled with other aspects of the current U.S. position on the CTB. Specifically, the Nevada Test Site is to be kept open and in a state of readiness to undertake full-scale nuclear tests on short notice. This would allow prototypes could undergo final testing and modification in a very short time, if the United States were to withdraw from the CTB under the "supreme national interest" clause.

In sum, the SBSS program would allow the U.S. to introduce new weapons into the arsenal far more quickly and easily than without it. In fact, this potential is already being realized because the laboratories are in the process of developing manufacturing and prototyping capabilities which will be integrated with the design process. According to Sandia National Laboratories Institutional Plan for FY 1996-2001, the future of computing and manufacturing will allow "designs to be validated in virtual factories

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<sup>77</sup> Medalia 1994, p. 4

<sup>78</sup> JASON 1994, p. 12

<sup>79</sup> Robinson 1996

<sup>80</sup> DOE 1995d, p. 4

before they are approved for release.”<sup>81</sup> One has only to note the success of such laboratory and computer design in complex endeavors in civilian industry such as airplane design to realize the powerful proliferation potential of the SBSS program. The Boeing-777, for instance, was largely designed using computers and wind tunnels.

The DOE has stated that, as a matter of policy, the laboratories are not developing new warheads.<sup>82</sup> The exact implications of this are unclear however because a halt to “development” does not necessarily mean a halt to the design of new nuclear warheads. Traditionally there have been seven stages in a warhead lifecycle. Stages one and two are conceptual design stages; warhead development does not begin until stage three. Further, the halt on “development” of new warheads is not necessarily permanent. In fact, it is described by some DOE officials as resulting simply from a lack of new orders from the Pentagon.<sup>83</sup> Should the Pentagon decide that a new warhead is desirable, the prohibition on design and development may be lifted. Further, according to the Sandia National Laboratories Institutional Plan, the Pentagon may never need to actually order new nuclear weapons since, “[a]s a form of deterrence, the [nuclear weapons] complex will need to demonstrate the capability to get new designs into production quickly.”<sup>84</sup>

The DOE’s position regarding design is rather disingenuous. In a way, it is similar to India claiming that its 1974 nuclear test was for “peaceful purposes.” Most accounts agree that India did not actually test a deliverable warhead, yet it is reasonable to conclude that the 1974 test was a part of a nuclear weapons development program. India possesses nuclear weapons capability whose credibility derives in considerable measure from the 1974 test. Similarly, it is difficult for the United States to argue that the SBSS program is to only maintain safety and reliability without nuclear testing or weapons development when these same facilities have been used in design, when huge design teams are being maintained, and when plans go so far and deep as to reach down into kindergarten to make sure that a sufficient supply of weapons designers will be maintained for the indefinite future.

The DOE plans to continue conceptual design work on nuclear warheads. The DOE’s Congressional Budget Request for FY 1997 includes a section on Core Stockpile Stewardship. One of the components is Conceptual Design and Assessment, defined as the “exploration of concepts and technologies that offer potential options for meeting future national security requirements and missions. Although these activities do not involve formal hardware development, they may include a limited amount of prototyping or experimentation to assess or demonstrate conceptual feasibility.”<sup>85</sup> One of the Conceptual Design and Assessment activities for FY 1997 will be to “perform weapons analysis and experiments for future stockpile options.”<sup>86</sup> In addition to some “enhanced safety features,” the areas of current interest listed are “advanced electromagnetic

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<sup>81</sup> SNL 1995, p. 2-13

<sup>82</sup> DOE 1995d, p. 8, DOE 1995b, p. 2-1, and DOE 1995c, p. 2-7

<sup>83</sup> Hecker 1996

<sup>84</sup> SNL 1995, p. 2-12

<sup>85</sup> DOE 1996b, Vol. 1, p. 78

<sup>86</sup> DOE 1996b, Vol. 1, p. 78

radiation and stealth.”<sup>87</sup> Moreover, the budget request clearly states that these are not the only areas of interest.

The program has already gone beyond mere potential because there are at least three warheads currently undergoing modification<sup>88</sup>:

- The W76 is being re-certified
- The W88 pit is being rebuilt
- The B61 is being modified to replace the aging B53<sup>89</sup>

The last example deserves more discussion. The B53 is an older warhead with a very large yield which does not have modern safety features. The DOE is replacing it by modifying another warhead, the B61 “mod” 7, by enhancing its “earth-penetrating” capabilities. This will compensate for the B61’s lower yield by making it more effective against underground installations. This modification is not being implemented to upgrade the safety (or even the reliability) of the B61. Instead, the new warhead, the B61 mod 11, will have new military characteristics. In statements to the press, DOE officials have stated that the modification was approved for development, but not deployment. However, this new warhead has recently been suggested for use against a possible Libyan chemical weapons factory by Defense Department officials.<sup>90</sup> The Defense Department has since denied that the U.S. may use the B61 against Libya.

The technical and human infrastructure necessary to design warheads will be expanded under the SBSS program. The policy restrictions on weapons design cited by the DOE do not change the capability to design. Policy decisions can be reversed as long as the capability exists. The SBSS program, a few years hence, with its large cadres of new weapons designers who will never have seen their designs tested and who may face scrutiny about their relevancy, will have great incentives to pressure for a reversal.

### ***1. Further Evidence of DOE Design Intentions***

The inherent technical design capability of the SBSS program is only one of the many indications that the DOE intends to go beyond the maintenance of the current weapons stockpile. In its Draft Programmatic EIS on Stockpile Stewardship and Management the DOE explicitly ruled out re-manufacturing or maintenance as an alternative to the SBSS program without giving them due consideration.

Re-manufacturing: The DOE states that precise replication is not always possible and therefore re-manufacturing is not a reasonable alternative. Additionally, the Programmatic EIS states that the emphasis is on “nuclear components which can no longer be functionally evaluated by nuclear tests.” The elimination of this option fails to take into account several key points:

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<sup>87</sup> DOE 1996b, Vol. 1, p. 78

<sup>88</sup> Reis 1996

<sup>89</sup> The modification is not to the primary or secondary of the warhead.

<sup>90</sup> Associated Press, April 23 1996.

- A number of experts, including former nuclear weapons designers, such as Ray Kidder, J. Carson Mark, and Richard Garwin, have stated that re-manufacture is a reasonable method to maintain the nuclear arsenal after a Comprehensive Test Ban.<sup>91</sup>
- The failure to consider systematic ways to deal with safety and reliability issues arising from non-nuclear components is an egregious omission because such problems could be solved by re-manufacturing.
- The Programmatic EIS does not consider the implications of a recommendation that “fixes” to the primary should be avoided, even if meant as “improvements.” Kidder, Mark, and Garwin, among others, have stated that re-manufacturing is preferable to changes in the “physics package” of warheads.

Maintenance: This approach is the most similar to the proposed SBSS program. The major difference seems to be that new experimental facilities would not be constructed, while surveillance of weapons would be enhanced. Existing experimental facilities would continue to be used. Eliminating this option makes it clear that this Programmatic EIS is biased towards one outcome, the construction of new facilities that would expand design capability.

By eliminating reasonable alternatives, such as the ones mentioned above, from its comparative environmental assessment, the DOE has indicated its determination to build new facilities regardless of their relevance for maintaining arsenal safety.

### **C. Weapons Effects**

In addition to weapons design capabilities, the DOE plans to retain and expand its capabilities in weapons effects testing. Weapons effects facilities simulate environmental conditions during and immediately after nuclear explosions. The experiments are designed to test whether warhead components could survive the extreme conditions (such as high electromagnetic fields) that nuclear detonations create. The DoD requires the DOE to certify that warheads will perform reliably and weapons effects testing is part of that certification.

The DOE considers continued weapons effects testing an essential component of its program to maintain the existing arsenal. In this scheme of things new components that DOE manufactures for existing warheads would undergo weapons effects testing to be certified. However, the same set-up can be used to test components for new warhead designs.

Weapons effects testing is usually conducted using accelerators or reactors.<sup>92</sup> These provide X-rays, gamma rays and neutrons at varying intensities. Currently all eight

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<sup>91</sup> Kidder 1987, pp. 6-9, 27-29 and Garwin 1993, pp. 10-11.

<sup>92</sup> SNL 1995, PP. 3-21 - 3-22.



facilities are located at Sandia National Laboratories because of Sandia's primary responsibility for non-nuclear components and "weaponization" of warheads.<sup>93</sup> Sandia is therefore primarily responsible for ensuring that components will be able to survive the effects of nuclear explosions. Sandia currently operates four X-ray facilities and four facilities for both gamma and neutron radiation experiments. Another X-ray facility is being constructed by the Defense Nuclear Agency at Arnold Air Force base in Tennessee (DECADE). An X-ray facility called Jupiter has been proposed for Sandia. In addition, most of the high energy density facilities discussed previously can produce X-rays for weapons effects testing. The DOE wants to eventually build the Jupiter facility because it would "provide a class of unique x-ray environments that otherwise would be obtained only in underground nuclear tests."<sup>94</sup> The JASON study on the SBSS program disagrees with the need for Jupiter, though it highly approves of the SBSS program overall.<sup>95</sup>

There are no indications in any of the DOE documents that we have studied that weapons effects testing has any relevance to maintaining the safety of the existing arsenal. Weapons effects testing is conducted to ensure that weapons will perform reliably during a nuclear war. Safety is not an issue at that point. Testing can be done on individual components. While most problems with nuclear weapons have been reliability problems affecting non-nuclear components, this does not necessarily mean continued weapons effects testing and new facilities are necessary. Existing components and warheads have already been certified. There are also no indications in the DOE documents that aging will create problems for the durability of components.

Weapons effects facilities could also be used in weaponizing prototypes designed using SBSS facilities. Components could be certified for weapons effects before actual testing of the warhead. According to the Sandia National Laboratories Institutional Plan for 1996-2001, with construction of the Jupiter facility, Sandia believes it could "certify weapon non-nuclear subsystems without underground testing."<sup>96</sup> This was not stated in the context of replacement components, but rather in a discussion of certifying "future or reconfigured strategic systems."<sup>97</sup>

Beyond testing components for existing warhead designs, weapons effects facilities could be used to conduct radiation testing for new weapons designs. Weapons concepts that could be developed using weapons effects facilities include directed energy weapons or weapons designed to destroy electronics and communications. In 1993 a high powered radio frequency (HPRF) warhead was in the second stage of a feasibility study.<sup>98</sup>

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<sup>93</sup> SNL 1993, p. 7-15. Weaponization involves designing the non-nuclear components of the warhead and integrating them with the nuclear explosive systems designed by Los Alamos or Livermore. This is done according to the requirements provided by the Department of Defense for weapons performance.

<sup>94</sup> DOE 1996, 3-22

<sup>95</sup> JASON 1994, p. 79

<sup>96</sup> SNL 1995 p. 3-22

<sup>97</sup> SNL 1995, p. 3-22

<sup>98</sup> SNL 1993, p. 7-18

## ***Potential Strategic Consequences of the SBSS Program***

The purpose of the SBSS program of the United States is to maintain both nuclear warheads and weapons designers indefinitely. Further, it would actually increase the capabilities of the DOE in conducting above-ground experiments which could be used in designing new warheads. This could have serious repercussions for nuclear non-proliferation. At issue are (i) durability and viability of the Comprehensive Test Ban as an instrument for nuclear non-proliferation and (ii) nuclear disarmament and the adherence of the nuclear weapons states to the spirit of Article VI of the nuclear Non-Proliferation Treaty (NPT). Article VI calls for “good faith” negotiations towards disarmament. It states:

Each of the Parties to the Treaty undertakes to pursue negotiations in good faith on effective measures relating to the cessation of the nuclear arms race at an early date and to nuclear disarmament, and on a treaty on general and complete disarmament under strict and effective international control.

The preamble of the NPT also calls for a Comprehensive Test Ban Treaty to end all nuclear testing. The United States, along with other signatories of the NPT, made a commitment at the NPT Review and Extension Conference in May, 1995 to sign a CTB by the end of 1996. This commitment was made in order to facilitate the indefinite extension of the NPT.

A CTB has historically had three purposes. The first was to help stop the spread of nuclear weapons by making it difficult for non-nuclear weapons states to develop nuclear weapons. This seems to be the view the Administration has taken in negotiating a CTB.<sup>99</sup> The second purpose of the CTB has been to halt vertical proliferation -- that is, to stop increases in the numbers, sophistication, and types of nuclear warheads in the arsenals of the nuclear weapons states. The arrest of vertical proliferation has generally been regarded as an essential step towards ending the arms race and towards nuclear disarmament. This is the view taken by most signatories to the NPT. It is also a strongly held position by India, which is a *de facto* nuclear weapons state and not an NPT signatory, but which has historically been among the foremost governmental advocates of a CTB.<sup>100</sup> A third purpose has been to stop further radioactive contamination due to nuclear testing. Groundwater contamination or surface contamination from leaks at underground test sites is a significant concern.<sup>101</sup>

These objectives of “good faith” negotiations towards disarmament and a halt to weapons development have to be compared to the purpose and scope of the Science Based Stockpile Stewardship program.

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<sup>99</sup> DOE 1995b, pp. 2-18 - 2-19

<sup>100</sup> UN 1995 p. 63. This is part of a letter from Indonesia on behalf of the Non-Aligned Movement consisting of over 100 U.N. member states. India recently made the link at the Conference on Disarmament in Geneva negotiating the CTB. “India Counters U.S. Position, Calls for A-Arms Eradication,” Washington Post, Jan. 26, A30.

<sup>101</sup> IPPNW and IEER 1991.

The SBSS program is designed to help the United States maintain an arsenal of nuclear weapons indefinitely. The importance of nuclear weapons to U.S. strategy has been repeatedly stated, including in the Stockpile Stewardship and Management Programmatic EIS which states that “nuclear deterrence will continue to be a cornerstone of U.S. national security policy for the foreseeable future.”<sup>102</sup> In recent testimony before Congress, C. Bruce Tarter, Director of Livermore, stated that a program was underway to extend the life of a particular warhead “so that it may remain part of the enduring stockpile beyond the year 2025 and will meet anticipated future requirements for the system.”<sup>103</sup> Elsewhere, in the same testimony, Tarter states that “the laboratories and plants are developing comprehensive life-extension plans for each weapons system slated for the enduring stockpile.”<sup>104</sup>

A large SBSS program could also create friction between the Western nuclear weapon states and Russia or China. Both Russia and China lack the funds to greatly expand their nuclear design infrastructure. Their inability to compete with the Western powers in above-ground experimentation could lead them to resist progress toward disarmament and may provide an incentive to test in order to make up for their lack of advanced facilities. For instance, Chinese insistence on a provision for “peaceful nuclear explosions” in a CTB could be a part of the government’s strategy to maintain design capability in the face of the U.S. high-tech SBSS program. This would create uncertainty and instability in the international system and make the fulfillment of Article VI of the NPT even more difficult.

Another possible reaction by Russia, and possibly even China, to the SBSS program would be to participate in a form of cooperative stewardship. The United States, United Kingdom, and France already have a history of cooperation on their nuclear weapons programs. A recent official workshop held at Los Alamos on “cooperative stewardship” discussed the advantages of the five nuclear weapons states working together whenever possible. One of the possible advantages, according to a viewgraph from the workshop would be “[a]ssurance among the non-nuclear states that P5 [the nuclear weapons states] will act (usually in concert) to manage the nuclear regime.”<sup>105</sup> While such cooperation could have its advantages in the context of implementation of Article VI of the NPT, cooperation to indefinitely maintain their nuclear arsenal is unlikely to be viewed in a kindly light by many non-nuclear states and by non-signatories to the NPT, notably Israel, India, and Pakistan. These last three countries are unlikely to accede to the NPT or abandon their own nuclear weapons programs under such circumstances.

The situation with SBSS and the CTB is somewhat comparable to another crisis surrounding two other treaties - the ABM treaty and START II. There are many powerful advocates in the U.S. for a partial or total abandonment of the ABM Treaty and

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<sup>102</sup> See Zeriffi 1996 for a discussion of nuclear strategy.

<sup>103</sup> Tarter 1996, p. 11

<sup>104</sup> Tarter 1996, p. 7

<sup>105</sup> Viewgraph from a seminar called “Strategic Relationships Among the Nuclear Weapons Infrastructures” held at Los Alamos National Laboratory, April 3-4 1996.

for the deployment of a missile defense system, popularly called “Star Wars.” But Russia lacks the money to develop such a system, much less to deploy it. Many in Russia view the Star Wars program as being a strategic threat because such a system, were it to become operational, could allow the United States to launch a first strike against Russia while being able to defend itself against a retaliatory attack. Therefore, Russia has linked the ratification of the START II arms reduction treaty by Russia to U.S. adherence to the Anti-Ballistic Missile (ABM) Treaty. In such a situation, the stated motives of the United States, to counter putative missile threats from countries such as North Korea and Iran, are not nearly as important as the potential technical capability of the “Star Wars” system. It was precisely on this point that President Gorbachev rejected President Reagan’s proposal for nuclear disarmament during their Reykjavik summit in 1985.

An SBSS program with a strong nuclear weapons design element already exists in the United States. Proposed new facilities, such as DARHT and NIF, would considerably strengthen these capabilities. It is unlikely that these facilities could by themselves be used to design radically new weapons to the point that the Pentagon would accept them into the arsenal as functional and reliable. However, as we have noted, the current denial that new weapons are being designed is ambiguous, and does not rule out design of components or the creation of new weapons concepts. SBSS facilities could enable most of the design to be carried out. At that point certification could come rapidly after one or a few full-scale tests. Equally important, SBSS facilities can be used to make militarily significant modifications to existing designs. Thus, the SBSS program gives the United States a system that places it far ahead of potential adversaries, should it decide to withdraw from the CTB. This strategic advantage is magnified when viewed in conjunction with the potential abandonment of the ABM treaty and possible development and deployment of a “Star Wars” system.

The combination of the SBSS program with the U.S. conditions for involvement in a CTB is particularly troublesome. Among these conditions are:<sup>106</sup>

- The establishment of the SBSS program with no limits on research and development (Safeguard A);
- The maintenance of nuclear facilities and programs in order to retain and attract new scientists (Safeguard B);
- The maintenance of the Nevada Test Site indefinitely (Safeguard C)<sup>107</sup>;
- The option to withdraw from the CTB if the Department of Energy and the Department of Defense determine that “supreme national interest” was compromised (Safeguard F).

Pork-barrel pressures to maintain these design teams could, in a crisis, intensify. This could lead to a withdrawal from the CTB in order to test nearly-ready new designs to give the U.S. real or imagined advantages in brewing conflicts. Given this potential,

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<sup>106</sup> White House 1995

<sup>107</sup> Maintaining the Nevada Test Site indefinitely not only leaves open the possibility of renewed testing, it also ignores the claims of the Western Shoshone Native Americans to the land.

other nuclear powers are more likely to maintain design capabilities that would give them parity or an advantage if the CTB broke down.

The determination of the weapons laboratories to maintain nuclear arsenals and weapons design laboratories is epitomized by the statement of Sandia National Laboratory's director, C. Paul Robinson, quoted above. Instead of linking a CTB to the creation of a road to nuclear disarmament, he looks forward to the replacement of "systems" in the existing stockpile "in the first half of the next century." He views the CTB and the halt in new weapons production only as a "hiatus" that could be several decades long. In this view new warheads will eventually be designed and built. And he anticipates that Russia will do the same. Such an attitude clearly contravenes the "good faith" requirement in the NPT of progress towards disarmament and lays the foundation for a dangerous and long-term gulf between the nuclear haves and have-nots.

The SBSS program, as part of the U.S. envisaged CTB regime, could create instabilities whose consequences for war and peace have not been explored, much less been vigorously debated. Even the effects of the SBSS program on the stability of deterrence (in the sense of retaliation against nuclear attack) have not been properly explored in the Stockpile Stewardship and Management Programmatic EIS. This is further complicated by the fact that documents such as the DARHT EIS state that the SBSS program is being used to determine whether or not the United States can even comply with a CTB. According to this argument, the SBSS program is necessary in order to determine whether the nuclear deterrent can be maintained under a CTB.<sup>108</sup> If the laboratories determine that SBSS is insufficient to maintain the nuclear arsenal, this could lead the United States to withdraw from the CTB.

Another potential danger of the SBSS program relates to the possibility that it might, rightly or wrongly, lead to a situation in which extensive component changes are deemed necessary for reliability reasons. Such changes could potentially cast doubt on warhead safety to a sufficient extent to create pressures for a withdrawal from the CTB treaty. Moreover, giving the weapons laboratories the power to determine when the U.S. stockpile might be in need of full-scale testing creates an inherent and intense conflict of interest.

We have shown that it is not at all clear from the DOE's own data that an SBSS program is needed for retaliatory nuclear deterrence. So far as the data available to us indicate, an extremely high level of reliability (as currently defined) appears only to be necessary for a first strike strategy. The first use of nuclear weapons inherent in this approach is contrary to the spirit of the NPT and could intensify proliferation pressures. In our view, it also increases the chances for nuclear conflict.

Even supporters admit the SBSS program could be seen by some countries as an attempt by the United States to circumvent the spirit and purpose of the CTB and NPT: to end the development of new nuclear weapons. One report stated that "one worrisome aspect of

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<sup>108</sup> DOE 1995b, p. 2-9

the SBSS program is that it may be perceived by other nations as part of an attempt by the U.S. to continue the development of ever more sophisticated nuclear weapons.”<sup>109</sup>

In sum, the SBSS program and the conditions for U.S. participation in a CTB, coupled with the stated U.S. goal of maintaining a large nuclear arsenal for the indefinite future, could seriously undermine the NPT. Keeping the Nevada Test Site open, holding on to a huge nuclear arsenal through lifetime extension programs and to nuclear weapons design teams for an indefinite period, and building new facilities under the rubric of the SBSS program are likely to be perceived as a violation of the spirit of Article VI of the NPT which requires signatories to negotiate in “good faith” on nuclear disarmament.

The negative impact of the SBSS on the CTB and NPT should be viewed in the context of the escalating pressures to deploy missile defenses and ever present tendencies toward pork-barrel spending for military purposes. Together, these factors could contribute to or result in new and dangerous nuclear instabilities in the post-Cold War World.

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<sup>109</sup> JASON 1994, p. 19

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