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An Alternative Framework for the Control of Nuclear Materials

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Abstract

The decade of the 1990s has seen renewed concerns over nuclear proliferation, both horizontal and vertical. While many in the arms control community focus on numbers, it is control that is the most important factor—the detonation of just one nuclear weapon would be an international catastrophe. Rather than concentrating on numbers, the regime defined herein centers on enhancing the safety and security being provided nuclear weapons and weapons-usable fissile materials. The proposal in the paper is called the Nuclear Weapons Control Treaty (NWCT) and referred to as *New Court*. The emphasis is on control rather than disarmament, protection from unintended or unauthorized use rather than elimination. *New Court*, once in place, would provide an environment in which the necessary audits and accountability for undertaking dramatic reductions in the numbers of weapons and the quantities of weapons-usable materials could be made with much greater confidence than exists today. However, it will be decades (if ever) before the number of nuclear weapons goes to zero. In the meantime, it is paramount that comprehensive safety and security be established and maintained.

There are currently more than a thousand metric tons of civilian fuel cycle plutonium, mostly in spent fuel rods, but hundreds of tons are already separated and in storage. Any of this plutonium could be fashioned into a nuclear explosive. There are no practical approaches for disposing of plutonium in periods of time less than decades. Much of the architecture and technology from *New Court* can be applied to the development of international monitored storage facilities (IMSF) for civil nuclear material. The paper outlines the five key requirements an international depository must satisfy: national security for the depositors and the host nation; safety and security of the material; transparency of operations; technology transfer to provide uniform global protection; and precise accurate accountability of the quantities and forms of material deposited. The synergism and conflict among the factors is briefly described. The paper also contains annexes on the current status of some key monitoring technologies and a description of an international “stored weapons standard” for protecting weapons-usable fissile material.

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Summary

A Framework for the Control of Nuclear Weapons and Associated Nuclear Material

The decade of the 1990s has seen renewed concerns over nuclear proliferation, both horizontal and vertical. With the end of the Cold War and collapse of the Soviet Union, questions have arisen about the safety, security, and command and control of the Russian nuclear stockpile. The extensive Iraq nuclear weapon program revealed in the aftermath of the Gulf War and the May 1998 nuclear tests by India and Pakistan fueled increased international pressure for the reduction and eventual elimination of nuclear weapons. A goal to abolish all things nuclear, including the dismantlement of all nuclear weapons, the closure of all nuclear power plants, and the irretrievable disposal of all weapons-usable fissile material, is unattainable in the foreseeable future. Some countries will continue to view nuclear power as the best means for meeting their electrical energy needs. Several states will continue to believe that the possession of at least a few nuclear weapons is essential to their national security. There are no practical approaches for disposing of plutonium in periods of time less than decades. Formal verifiable reductions in the nuclear weapons stockpiles may be very difficult to negotiate. Structures that proved practical in arms limitation, such as the Intermediate-range Nuclear Forces Treaty (INF) and the Strategic Arms Reduction Talks (START), were based on unique features of delivery systems and the relatively straightforward approaches for the verification of their destruction.

At the warhead level, nuclear devices cannot be categorized by any simple functional relationship similar to the operational range for missiles. A warhead can be either tactical or strategic; the distinction is in the application, not the device. National classification to protect the actual numbers of weapons and the form of materials used, as well as details of the design, will present serious obstacles to verification. Suggested first steps calling for the declaration and subsequent auditing of nuclear weapon stockpiles and weapons fissile materials

will have unresolved discrepancies. In a 1996 U.S. Department of Energy report on the U.S. acquisition of weapons plutonium, almost three metric tons, the equivalent of hundreds of bombs, could not be accounted for. It should be anticipated that the Russian records would be much worse. Thus, inventory disclosures may fuel distrust rather than serve as a useful foundation from which to measure acceptable reductions.

Given these problems, this paper presents a different tack. Rather than focusing on numbers, the regime defined herein concentrates on enhancing international assurance of the safety and security being provided to nuclear weapons and weapons-usable fissile materials. The emphasis is on arms control rather than disarmament, protection from unintended or unauthorized use rather than elimination. The proposed regime, once in place, would provide an environment in which future dramatic reductions in the numbers of weapons and the quantities of weapons-usable materials could be made with much greater confidence than exists today. The proposal is called the Nuclear Weapons Control Treaty (NWCT) and referred to as *New Court*.

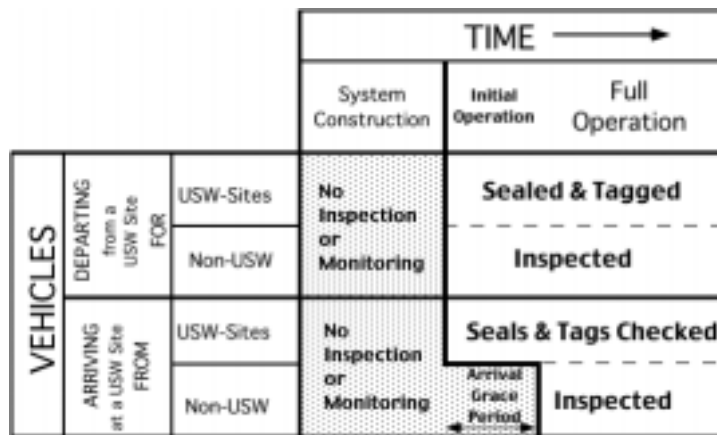
In the New Court regime all locations associated with nuclear weapons and weapons-usable fissile materials (WUFM)* are declared and identified as belonging to one or more of three site types. Locations where a weapon is located with its delivery system (the system is ready to use) are called use sites, denoted U-sites. Storage locations for either warheads or weapons-usable nuclear materials are called storage sites, denoted S-sites. Laboratories; experimental facilities; manufacturing plants; and maintenance, dismantlement, and reprocessing locations associated with working on nuclear weapons or WUFM are referred to as work sites and denoted W-sites. The collection of all locations associated with nuclear weapons or WUFM is referred to as a country's USW-sites. In 1991, the Strategic Arms Reduction Treaty (START I) between the Soviet Union and the United States required disclosure of all bases associated with strategic nuclear weapons as well as test launch sites, and significant facilities for the manufacture and assembly of strategic delivery systems. The Intermediate-range Nuclear Forces Treaty (INF) and the agreements on Conventional Forces in Europe (CFE) also have site disclosure requirements. While these examples demonstrate the feasibility of site declarations, it is recognized that a comprehensive New Court declaration will require intensive negotiation to be accepted by all nuclear weapon states. China and the threshold states, India, Pakistan, and Israel, fundamentally depend on basing secrecy in ensuring system survivability. In the United States, France, and the United Kingdom, the locations of home bases, storage sites, and the supporting complex are well known. Russia may be concerned over a comprehensive declaration of short-range system locations. The Russians have placed increased emphasis on "tactical" nuclear weapons as a balance to NATO conventional superiority. Thus, for New Court to go forward, approaches that reduce perceptions of vulnerability to disarming first strikes and/or threatening conventional superiority must be an integral part of the negotiation process. The strategic arms limitation treaties between the Soviet

* WUFM includes all fissile materials, in any isotopic distribution, that are associated with fission explosives. The material may be contained in weapons, weapon components, or stored military reserve material, at weapons laboratories or located at other weapons production complex facilities. The frequently used term Special Nuclear Material (SNM) includes all plutonium isotopes and uranium enriched in the isotope 233 or 235 (DOE Definitions 42 USC 2019). In the New Court concept the focus is on military-associated fissile material with enrichments to levels usable in nuclear explosives.

Union and United States, negotiated in the hostile atmosphere of the Cold War, demonstrated that obstacles associated with survivability issues can be overcome.

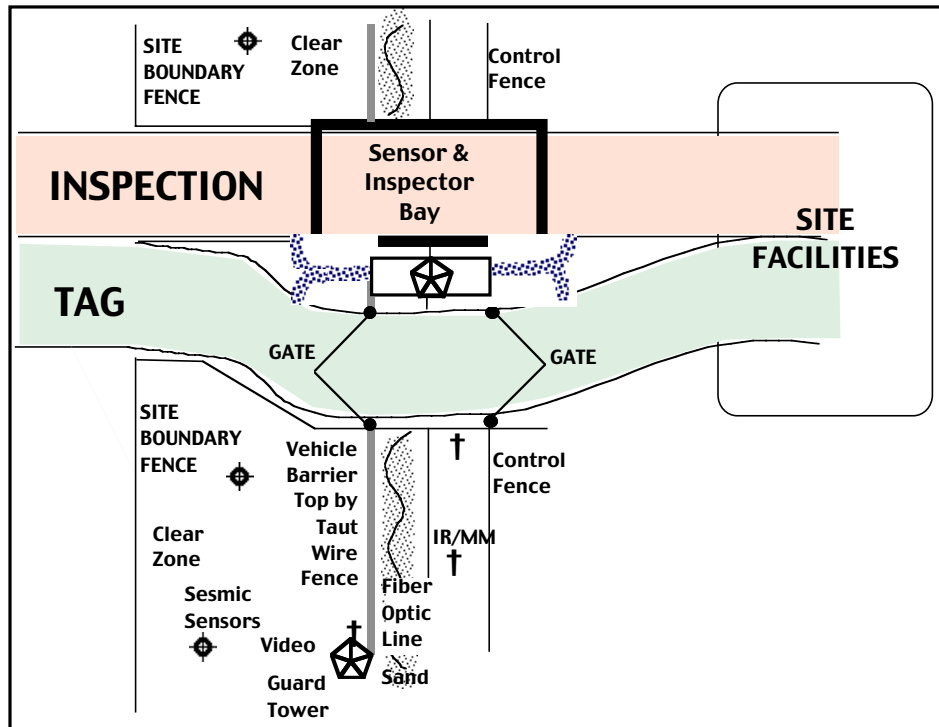
Once the complex associated with weapons and WUFM has been identified, a perimeter/portal monitoring system (PPMS) would be put in place. While the details of the PPMS would vary from site to site, in general PPMS systems would be operated by treaty partner personnel and modeled after the regimes developed in INF and START I. The intrusiveness of the monitoring process would depend on the point of origin and the destination of all vehicles entering or leaving the site. Shipments between USW-sites would be sealed and tagged at their origin and the seals and tags checked upon their arrival. There would be no inspection of the cargo. In this case the amount of material and its form would be unknown (and not determinable) by the site boundary monitors. What would be certain is that the contents remained within the protective net of the New Court system. Any arriving shipment that was not sealed and tagged as coming from another USW-site (i.e., did not originate from a USW-site) or was not departing for another USW-site and, therefore, not sealed and tagged could be subjected to intrusive inspection. These conditions are depicted in Figure S-1. All arriving and departing personnel would be subject to inspection. Note that following the New Court construction phases there would be a negotiated “grace period” during which vehicles arriving from non-USW-sites would not be inspected. This allows for a period during which a national could collect material and weapons and move them within the regime with assurance that the total numbers of devices and the amount of material remain a state secret.

Figure S-1: When a Vehicle Is Inspected or Sealed and Tagged



The United States and Soviet Union set a precedent for perimeter/portal monitoring systems in the Intermediate-range Nuclear Forces (INF) Treaty (1987) and the Strategic Arms Reduction Treaty (START I) (1991). These agreements allow for the continuous presence of inspectors from the other country and define portal monitoring procedures. The unique aspect of the New Court system is the “dual” portal system: Tag Portals for shipments within the system, and Inspection Portals allowing full inspection of personnel and material coming from or going to points outside the system. Figure S-2 depicts a generic portal/perimeter monitoring configuration.

Figure S-2: Dual Portals with a Perimeter Monitoring System



The New Court PPMS provides an environment that would enhance international confidence in the safety, security, and control of weapons and weapons materials. This would go well beyond the IAEA Recommendation for the Physical Protection of Nuclear Materials. Drawing on the safety and security policies and procedures in the nuclear weapon states that were parties to New Court, an international standard for weapons safety and security could be established. An annual meeting among the New Court safety and security experts is recommended. The emphasis would be on safety, security, and use-control philosophy and fundamental architectures. Actual design, which might compromise actual safety and security systems, would not be disclosed. The annual conventions of New Court safety and security experts could also contain demonstrations of commercially available safety and security equipment. These technical exchanges would help ensure continuous improvement in the safety and security provided by all parties to their weapons and materials. A Special Review Commission (SRC) would be formed to resolve compliance and implementation issues. Every two years, each party to New Court would submit a safety and security self-appraisal to the SRC. The peer audit process together with the annual safety and security technology conferences and reports from PPMS operations would provide a foundation for confidence in the continued safety and security of New Court weapons and materials.

What are the major concerns of committing to New Court? As noted above, for several states the most important issue will be the extent that New Court is seen as compromising the survival of their nuclear forces. In the role of nuclear weapons as a foundation for deterrence, confidence in survivability may only be achieved when a country has stealthy platforms such as SLBMs where, as in START I, the homeports are the U-sites in New Court. In

the Cold War when NATO was confronted by massive Warsaw Pact forces and, today, with Russia facing Western military superiority, the approach for deterring conventional aggression has been the capability to employ considerable numbers of nuclear devices on the battlefield. Protection through hardened shelters may be impractical for tactical/theater systems. Because of the number of devices involved and the short range of their delivery systems, protection through movement is costly and reduces safety and security. Some nations may fear that the New Court sites are susceptible targets to disarming surprise attack by precision conventional munitions. A combination of measures and policies could reduce this concern. Prior to entering into the New Court regime, nuclear weapon states are expected to demand of themselves that they retain a nuclear strategic retaliatory capability. Usually this would be in the configuration of forces at U-sites. Any attempt at a disarming attack, conventional or with weapons of mass destruction, on USW-sites could be considered the same as a nuclear attack against a country, justifying nuclear retaliation. Parties to the treaty could take steps similar to those in the CFE agreements to reduce perceived conventional aggressive capabilities. This could reduce the need for forward-deployed short-range systems and a requirement for an extensive number of U- and S-sites. If an aggressive threat should confront a New Court party, the threatened nation could move warheads out of storage and place them with operational units. (There is no constraint in New Court on operational planning or training using non-nuclear practice units.) A deployment from storage would be immediately visible to site PPMS personnel. It would provide an escalation signal in a crisis, which could deter actual confrontation.

What is the susceptibility of the New Court concept to various forms of “cheating”? A state may clandestinely attempt to withhold weapons or materials from the regime, or to smuggle nuclear warheads to undeclared sites, or to hide a manufacturing and storage capability, and thereby circumvent the treaty to gain a decisive advantage over other states. Keep in mind that New Court is an arms-control agreement, not an arms-limitation agreement. There are no new breakout avenues except if one places false expectations in the agreement. New Court adds a significant degree of difficulty to a nation’s attempt to clandestinely build up nuclear forces. By placing perimeter monitors around sites there will be a general awareness of the level of activity at the site. What are the advantages and the risks in surreptitiously attempting to circumvent the treaty? Since the treaty would not restrict or require declarations on quantities, no party gains a numerical advantage from the agreement per se. In a very real sense, New Court is a zero-option treaty. The agreement would not allow any weapons or material to lie outside the regime. Once the treaty is in full force, anything found outside the system would be a clear violation. A state attempting to maintain systems outside the regime would need to address three challenging problems. First, it would have to maintain a high level of secrecy; one accident, disclosure, or exposure could compromise the strategy. Second, the clandestine stockpile would be part of a very powerful “secret service” and national authorities may have to accept reduced safety and security conditions for the hidden weapons. Third, and most certain, either much of a maintenance/manufacturing complex would have to be clandestinely established outside the New Court system, or, with time, the weapons would decay and lose capability, eventually failing to function at all.

Once New Court is fully in place, the material within the system can serve as the baseline from which to negotiate future stockpile magnitudes. Without controls on the locations and movement of fissile materials and weapons, verification of stockpile declarations will be impossible. Thus, much of the New Court arms-control regime is a necessary condition for verifiable disarmament.

As early as possible, it is desirable that all five of the Non-Proliferation Treaty (NPT) nuclear powers, the P-5, be parties to New Court. There are two potential barriers to full P-5 participation. In the past the United Kingdom, France, and China have been reluctant to enter into nuclear disarmament negotiations. Their position has been based on the small size of their stockpiles with respect to the United States and Russia. New Court does not impose any conditions on stockpile size and, therefore, this should not be an issue. A more significant barrier could be Russian and Chinese reluctance to disclose the locations of all aspects of their weapons complexes and bases, much less allow foreign access to the neighborhood. With the Russians this barrier has been lowered in START and the Lab-to-Lab program. The negotiating lessons learned could help overcome this potential barrier. After the P-5 states demonstrate the value in New Court, the newly declared nuclear weapon states, India and Pakistan, as well as perhaps Israel might be drawn into the agreement. While many in the arms control community are focused on numbers, it is control that is the most important factor—the detonation of, or an incident with, just one nuclear weapon will be an international catastrophe. Within the regime described above, as an open and trusting environment evolves, numbers will come down. There is no reason for a nation to maintain a large weapon stockpile with an expensive supporting complex if it adds little to the state's security. However, it will be decades (if ever) before the number of nuclear weapons goes to zero. In the meantime, it is paramount that comprehensive safety and security be established and maintained.

The framework for a next step in nuclear arms control described in this paper has several advantages over the frequent cries from the arms control and disarmament community for acceleration in the START process. In this proposed new next step for nuclear arms control, there is no requirement for stockpile or material declarations, and, therefore, the inaccuracies that will be inherent in such declarations will not undermine achieving agreement. There is no requirement to survey individual weapons or materials, thus avoiding protracted and questionable verification techniques and/or potential revelation of classified information. The proposed system will reduce the possibilities of reconstitution races. On the whole, it will place weapons in less-threatening deployment profiles. Since New Court places no constraints on strategic systems beyond those already agreed to in the START process, it has no additional impact on national strategic response capabilities, and therefore does not impact the cornerstone of nuclear deterrence. Most importantly, the proposed structure increases global confidence in the safety, security, and use control of nuclear weapons. The added confidence alone would reduce anxieties and improve international relations. Ultimately, the number of weapons would quietly and substantially be reduced.

New Court would not be cheap. A detailed cost analysis needs to be undertaken. The cost will be small compared with that already expended on nuclear weapons. Much of the system is already in place in the United States, the United Kingdom, and France. The other countries, whose participation is a necessary condition for total success of the concept, simply cannot afford even a fraction of the costs to provide PPMS and appropriate transportation safeguards given the amounts of material and number of locations they need to place under safe secure conditions. The United States, Europe, and Japan, together with other economically developed states, will have to accept a substantial portion of the financial burden; the loss of just a few kilograms of fissile material could have catastrophic international implications.

A Framework for the Control of Civil-Weapons-Usable Nuclear Materials

All isotopes of plutonium and uranium enriched to greater than 20 percent U-235 (HEU) can be used to construct a nuclear explosive. Uranium can be blended with U-238 reducing the concentration of U-235 to the point where the material cannot be used in an explosive. There is no currently feasible approach for rapidly disposing of plutonium or transforming it into a state not usable in an explosive. There are currently over a thousand metric tons of civilian fuel cycle plutonium, mostly in spent fuel rods, but hundreds of tons are already separated and in storage. The focus in the concept presented here is on international monitored storage facilities (IMSF) for the material. In order to achieve a high standard of safety, security, and accountability, individual site costs will be high. There are dramatic economies of scale, however: large-capacity sites do not cost much more than small-capacity sites. Therefore, an international storage system will be most cost effective with relatively few sites strategically located around the world.

There are five key requirements an international depository must satisfy: national security for the depositors and the host nation; safety and security of the material; transparency of operations; technology transfer to provide uniform global protection; and precise accurate accountability of the quantities and forms of material deposited. There is synergism and conflict among the factors. Neither placing material in an IMSF nor providing the territory for an IMSF should compromise national security. The most difficult national security issue to resolve will be in guaranteed accessibility of depositors to their material. Safety and security systems can reinforce or conflict with national security. The security system could delay or deny a country's access to its material even when the site is on its own territory. On the other hand, safety and security systems provide barriers to improper acquisition of material. Accountability requires complete disclosure and verification of amounts and forms. The IMSF system cannot be a vault with secret "safety deposit boxes." The accountability requirement places additional stress on security and safety systems. The locations of the facilities and the general process for protecting the public must not be kept secret. Since several sites throughout the world will be required, with a high degree of uniformity in design requirements, there will be a considerable amount of technology transfer involved. Requirements for transparency and transferability could create challenges to national security and site safety and security.

The architecture for the perimeter of an IMSF could be similar to that of the New Court portal/perimeter system. The portals themselves would be dramatically different; there would not be a "two lane" entrance system. A comprehensive inspection of all personnel and vehicles entering and exiting the site and accurate high-precision assay of all deposited and withdrawn material would be necessary. Monitoring the perimeter and portals, assaying the materials, and surveilling the values could involve multiple nations and/or agencies. It certainly should not be the sole responsibility of the host nation. The site and material would be monitored by a system of nested, independent sensor systems. The responsibility for various systems would be distributed among nationals and agencies participating in the IMSF regime. The state or agency responsible for a sensor system could also incorporate an authentication code into its output. The output from all sensors could be made available via the Internet to the public at large. Anyone could then independently monitor the activities at the storage sites. The authentication outputs would assure the parties responsible for the various monitoring functions that their systems had not been compromised and reinforce confidence in the authenticity of the data being provided by other sensors.

Both New Court and IMSF are technically feasible today. Both would substantially improve international confidence in the security and safety of nuclear materials. While there are significant similarities in the supporting systems there are also substantial differences. Beyond the architectures, the most consequential difference is in the number and interests of the parties that would be involved in negotiating and implementing the two regimes.

Section I: Introduction

Long before the first detonation of a nuclear device on the Jornada del Muerto desert in New Mexico, the implications of the bomb for international relations and the feasibility of control were discussed by national science policymakers and scientists of the Manhattan Project. In the fall of 1944 Vannevar Bush and James Conant sent a memorandum to Secretary of Defense Stimson suggesting that unless international controls over atomic matters were instituted an arms race with the Russians would ensue.¹ They also expressed the opinion that the Soviet Union would develop a bomb within three or four years of a successful U.S. test. Conant argued this estimate with General Groves, who estimated at the May 18, 1945, Informal Meeting of the Interim Committee that it would take the Russians at least twenty years.² In November of 1945, Bush proposed a three-step process to international control of atomic technologies.³ The first step was the creation of a scientific agency within the United Nations to be responsible for dissemination of fundamental information in all fields, including atomic energy. Scientists would be allowed unrestricted travel and free access to basic research laboratories, with the exchange of students and open publishing of scientific results. The second step proposed the exchange of information on the applied or engineering aspects of atomic energy, particularly its industrial use. Bush's third step consisted of an agreement to use fissionable materials only for the production of commercial power accompanied by an effective international safeguard scheme.

In April 1946 Bernard Baruch, age seventy-six, was confirmed as the U.S. representative to the United Nations Atomic Energy Commission. On June 14 he presented the American plan for international control of atomic energy. The Baruch Plan, expanding the earlier work of Bush and Conant and many of the concepts in the Acheson-Lilienthal report, made the international agency essentially the owner of the nuclear fuel cycle, not just an inspection body, and emphasized the punishment of violators. Vannevar Bush envisioned that the transition to international control would be a gradual process. The Baruch Plan pushed the pace of all three steps. While Baruch's proposal led to considerable discussion, the commission, due to East/West differences, was unable to agree on any plan for controlling the atom. It is unlikely that the Soviet Union would have accepted even the first stage: open laboratories and unrestricted travel of scientists. Certainly in 1946 the UN failed Bernard Baruch's "test if man can

produce, through his will and faith, the miracle of peace, just as he has, through science and skill, the miracle of the atom.”⁴

The East/West competition fed an arms race in numbers and technological sophistication. Under the dark shadow cast by nuclear dangers, foreseen well before it was known if nuclear explosives were possible, the chief protagonists labored to negotiate agreements in which their security was maintained while at least providing some protection from nuclear hazards. With the collapse of the Soviet empire there was some thought that Russian-American cooperation would result in nuclear disarmament. Events in the 1990s have demonstrated that concerns over hegemony, ethnic identity, and national security remain as barriers to stockpile dissolution, however. Loose nuclear materials in the former Soviet Union, clandestine weapons programs in Iraq and North Korea, and the May 1998 nuclear tests in India and Pakistan demonstrate that some nuclear dangers are increasing even while the likelihood of a massive exchange between the nuclear superpowers has substantially decreased. Various groups have renewed their push to abolish all things nuclear, from the complete dismantlement of all nuclear weapons to the closure of all nuclear power plants and the irretrievable disposal of all fissile materials.⁵ These goals may be unattainable. Many countries view nuclear power as a major means of meeting their energy demands for electricity. Several states believe nuclear weapons are essential to their national security. To date, no practical approach has been identified for disposing of fissile materials in periods of time less than decades. This paper examines the issues from a different perspective. Rather than focusing on numbers, the regime defined herein concentrates on enhancing international assurance of the safety and security being provided to nuclear weapons and weapons-usable fissile material.

Section II: Progress and Problems in Controlling Nuclear Weapons

During the past four decades three approaches have been developed and instituted to constrain nuclear weapons:

1. National or regional decisions to renounce nuclear weapons,
2. Constraints on technical development, and
3. Restrictions on delivery systems.

Nuclear-weapon-free measures have been applied along two paths: nuclear-free zones such as the Outer Space Treaty⁶ and the Treaty of Tlatelolco,⁷ and states agreeing to forgo nuclear weapons as parties to the Non-Proliferation Treaty (NPT).⁸

The second approach attempts to limit nuclear-weapon technology by outlawing some activities in the research and development processes. The principal route has been through constraints on testing. Concerns over fallout with the resumption of atmospheric tests after the Soviet Union ended a thirty-four-month testing moratorium on September 1, 1961, and the renewal of U.S. testing some six months later were the driving force behind the Limited Test Ban Treaty (LTBT), signed in August 1963.⁹ Further steps to influence nuclear weapon development were taken in the Threshold Test Ban (1974), the Peaceful Nuclear Explosions Treaty (1976), and the signing of the Comprehensive Test Ban Treaty in September 1996.

The third approach for formally restricting nuclear weapons has been to place limits on their means of delivery. Limitations have been accomplished through the use of delivery-vehicle counting rules and the banning of certain classes of systems. The Strategic Arms

Limitation Talks (SALT), the ABM and the Interim ICBM Agreements, and the Strategic Arms Reduction Talks (START) I and II contain extensive rules on the number and qualitative characteristics of missiles, constraints on locations allowed, and verification procedures relying on “national technical means.” The Intermediate-range Nuclear Forces Treaty (INF), signed in December 1987, completely bans select categories of delivery platforms. The verified elimination of all prohibited systems was accomplished by June 1991. None of the three approaches actually eliminated nuclear warheads.¹⁰

Fissile material production cutoff has been explored for a number of years as another approach for constraining proliferation. Its focus is on vertical proliferation, constraining increases in the number of weapons in the stockpile of existing nuclear weapon states by capping their inventory of plutonium-239 and highly enriched uranium (HEU). With universal application it would also constrain horizontal proliferation, new nuclear weapon states, by controlling the availability of fissile materials. While no agreements have been based on this approach, it is currently receiving renewed attention at the Conference on Disarmament in Geneva. Under a cutoff regime it is envisioned that all fissile production facilities, reactors, and enrichment plants would be placed under IAEA safeguards. Use of the products from these facilities would be allowed only in approved commercial activities. A fissile material cutoff would impose upon the nuclear weapon states essentially the same conditions that currently exist for the non-nuclear-weapon members of the NPT. It is important to note that a material cutoff would not reduce the number of warheads already in existence. In fact, with improved efficiency in design, stockpiles could actually increase in number while the total amount of fissile material in the weapons inventory remains fixed.

In recent years there has been renewed pressure from a broad international community to reduce the actual number of warheads, particularly of the two nuclear weapon superpowers. Abolition, the complete elimination of nuclear weapons, is again a popular campaign.¹¹ The Canberra Commission on the Elimination of Nuclear Weapons, commissioned by the Australian Government in November 1995, involved experts from many countries. The commission outlined approaches for the elimination of all nuclear weapons and the protection of weapons-usable nuclear material.¹² The commission report, as other thoughtful individuals and studies have also stated, concluded, “the elimination of nuclear weapons will not be possible without the development of adequate verification.”

The movement from simply trying to constrain the development of nuclear weapons to eliminating them has identified three potential paths: the elimination of critical fissile fuels, the abolishment of all delivery systems, and the destruction of warheads. There are significant barriers blocking all three paths. The Canberra Commission’s suggested first step toward warhead elimination was the declaration, and subsequent auditing, of nuclear weapon stockpiles and fissile materials.^{13,14} It is known that stockpile declarations will have unresolvable discrepancies. In 1996 the U.S. Department of Energy reported that the United States had produced or acquired 111.4 metric tons of plutonium from 1944 to 1994.¹⁵ The 1996 DOE/DoD inventory was 99.5 metric tons. A total of 9.1 tons could be accounted for as used in wartime and testing, normal operating waste losses, transfer to foreign countries, etc. There remained a 2.8-ton inventory difference. The account is shown in Tables 1 and 2. The inventory difference of almost three metric tons is equivalent to several hundred weapons of the rudimentary 1945 Fat Man design. The United States has not yet announced the results of an inventory on highly enriched uranium (HEU). Because of the manner in which HEU records were kept, and the variations in the extent of enrichment, the uncertainty percentage is likely to be much larger for HEU than for plutonium. While there are many plausible explanations

for the “missing material,” where it all is will never be known with certainty. It would be surprising if other countries’ records are any better than those of the United States. In particular, it should be anticipated that Russia’s records are much worse. Even with enormous effort and considerable expense it should be expected that the uncertainty in Russian fissile material production would be equivalent to thousands of nuclear warheads. Conspiracy theorists would have a field day with the “missing material.” Inventory disclosure may fuel distrust rather than serve as a useful tool in verification of warhead elimination and the advancement of nuclear disarmament.

Table 1: Sources for U.S. Plutonium: 1944–1994¹⁶

SOURCE	METRIC TONS (MT)	% of TOTAL
Government Reactors	104.0 MT	93.5%
Foreign Countries	5.7 MT	5%
U.S. Civilian Industry	1.7 MT	1.5%
TOTAL	111.4 MT*	100%

*The difference between the sources and inventory total is due to round-off in the values.

Table 2: The U.S. Plutonium Balance in 1994¹⁷

LOCATION	METRIC TONS (MT)	% OF TOTAL
Current DOE/DoD Inventory	99.5 MT	89.2%
Waste	3.4 MT	3.1%
U.S. Civilian Industry	0.1 MT	0.1%
Foreign Countries	0.7 MT	0.6%
Wartime & Tests	3.4 MT	3.1%
Decay	0.4 MT	0.4%
Fission & Transmutation	1.2 MT	1.1%
"Missing" Inventory	2.8 MT	2.5%
TOTAL	111.5 MT*	100%

*The difference between the sources and inventory total is due to round-off in the values.

It is impractical to attempt effective general nuclear disarmament through reductions in delivery systems. There is a popular misconception that aircraft must have unique features in order to deliver a nuclear explosive. Yet there is nothing inherent in the physics of a nuclear weapon that requires a special interface with its delivery vehicle. Some interfacing components are engineered into the weapon design and delivery system to enhance command and control, safety, reliability, and other performance features. However, no amount of intrusiveness in inspection of an aircraft, missile, or artillery piece can confirm that it is not nuclear-capable.¹⁸

Some arms control scholars, drawing upon the experience in START and INF, have suggested that reducing the number of or eliminating delivery platforms could control weapons. It was the unique role and features of the vehicles associated with Cold War strategic delivery and the INF systems (the ground-launched cruise missile and the SS-20 and Pershing long-range theater missiles) that permitted agreements to be reached without the verifiable elimination of warheads. There are many ways a nuclear weapon can be delivered. In his August 1939 letter to President Roosevelt, Albert Einstein wrote, "A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port."¹⁹ Today a crude weapon could be transported by a very small boat, or in a van or pickup truck. All military strike aircraft, such as the F-15, F-16, or F-18, could easily deliver nuclear bombs, and with midair refueling their operational radius can easily be extended to thousands of kilometers. Any transport aircraft configured to airdrop cargo could push out a container with a functional nuclear device. In fact, commercial passenger planes with rear entry, e.g. the Boeing 727, could easily be modified into "strategic bombers" using the rear stairs as a bomb chute. It is inconceivable that any of the major states would reduce its air force to a level where one would have confidence it could no longer consider strike aircraft for delivery of nuclear weapons.

A barrier to reducing nuclear danger through elimination of nuclear warheads is the extensive classification hierarchy associated with nuclear weapons, which makes verification of actual dismantlement a challenging problem. At present the number and type of each weapon, the composition of the (nuclear) materials, and the physical configuration of the warhead are classified. Verification procedures to identify the form and mass of material would reveal details about one or more of these factors. Russian analysis reflects the current U.S. position that "direct monitoring by one party's inspectors of the other party's warhead dismantlement is out of the question."²⁰ The access restrictions required to protect classified information imply that it will not be possible at this time "to implement a 100 percent reliable warhead dismantlement verification system."²¹ The exposure of classified information becomes an even greater problem as one moves from a bilateral to a multilateral environment. In an atmosphere of increasing peace and cooperation between nations, classification barriers may be lowered. One should expect that years of extensive negotiations and technical discussion will have to take place before the nuclear weapon states would feel comfortable with the necessarily intrusive verification procedure (especially in a multilateral environment).

Section III: A New Approach to Nuclear Arms Control

Does a reduction of warhead numbers imply in and of itself a significant improvement in warhead safety? The United States has set quantitative design requirements for nuclear weapon safety. In its normal environment, if a weapon has not received an arming signal the probability of a premature nuclear detonation is not to exceed one in a billion. In an abnormal environment, such as an airplane crash and/or fire, even if the high explosive is detonated at any single point the probability of a nuclear yield greater than four pounds of TNT is not to exceed one in a million.²² The improvement in safety, i.e. the reduced likelihood of an accidental nuclear detonation, through a factor of ten reduction in the size of nuclear stockpiles is outside human recognition. Would a person make a substantial lifestyle change if told that the chance of injury from an external event was now one in a hundred million rather than one in a billion? What could be significant is if there is a design flaw such that a class of weapons is inherently unsafe. In this case, it is not the numbers that matter but whether or not any weapon has such a problem. This, for practical considerations, is independent of stockpile size.

The security of the weapons may be of much greater concern than the safety of their design. To first order weapon security is independent of the number of weapons; the level of concern does not change if control is lost of one out of a hundred, one out of a thousand, or one out of ten thousand. It is the possible lost control of a nuclear weapon that is worrisome. So, with respect to concerns over unauthorized access or use of a weapon, as with safety, numbers are a secondary issue.

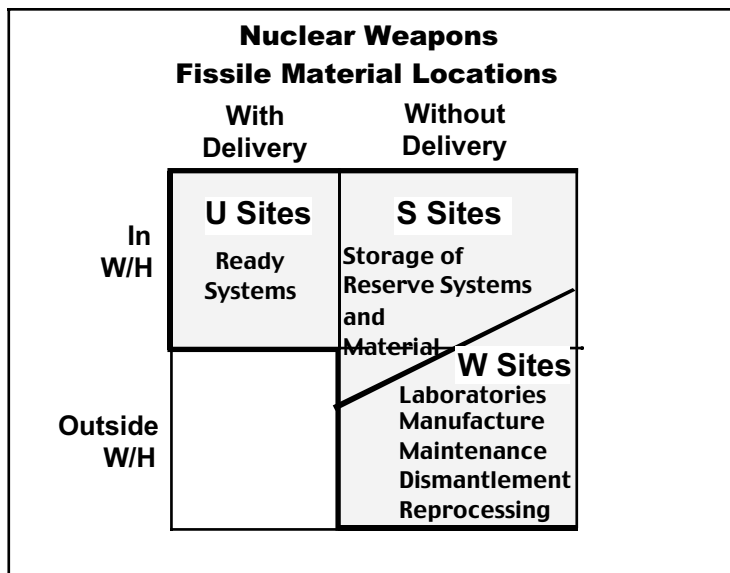
Consideration of the barriers to verifiable stockpile reductions and the weak relationship of weapon safety and security to their numbers led to the identification of the regime presented here. The focus is on providing (international) assurance of the safety and security of nuclear weapons and of weapons-usable fissile materials. The emphasis is on arms control rather than disarmament, safety and security rather than elimination. Furthermore, the proposed regime will provide an environment in which future dramatic reductions in the num-

bers of weapons and the amounts of fissile material could be made with much greater confidence than exists today.

The proposed agreement among nuclear weapon states, the Nuclear Weapons Control Treaty (NWCT), emphasizing the shift in perspective from “classical arms control” treaties to one in which no declaration or verification of numbers or amounts of material is required, will be referred to as *New Court*. The New Court focus is security and safety. Security must include command and control, the effective protection against unauthorized access to, removal, or operation of warheads. Essential elements of such a security system are physical barriers and devices that ensure that only operations and activities directed by the appropriate authorities can be undertaken. If properly developed and practiced, the associated system and procedures for security can also enhance nuclear material safety. Safety includes warhead safety, operational safety, and hazard mitigation.

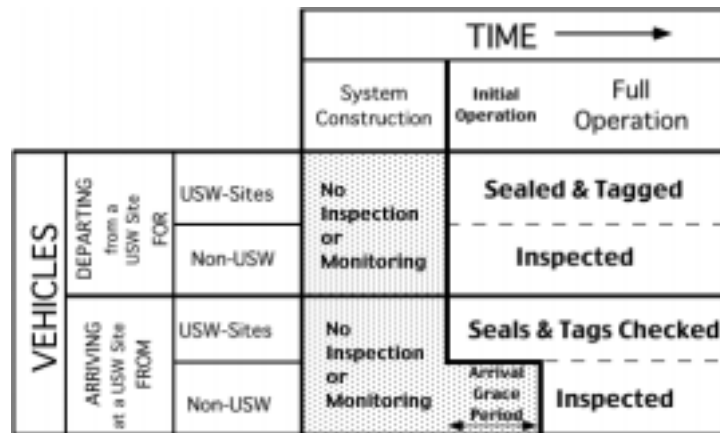
The following taxonomy will be used in describing the New Court system: Locations where weapon and delivery systems are collocated are called U-sites. Storage locations, e.g. warehouses and arsenals, for either warheads or weapons-usable fissile materials are called S-sites. Locations where nuclear devices or weapons fissile material are being worked on, e.g. laboratories, manufacturing, maintenance, dismantlement or reprocessing facilities, etc., are W-sites. Nuclear weapon fissile material declared excess from national security requirements is transferred from storage, S-sites or W-sites, into the civil system. As materials or weapons are moved among the sites or out of the military sector, they are in transport, denoted as a “T-site.” (An international system for the protection and accountability of materials dedicated to civilian use will be described in Section IV.) The simple matrix showing the connection between site designation and whether or not fissile material is in a weapon and with or without a delivery system of material is shown in Figure 1.

Figure 1: A “Matrix” of the USW Taxonomy



In the New Court proposition, all U-, S-, and W-sites would be declared and monitored by the parties to the treaty through perimeter/portal monitoring systems (PPMS). The sites would mirror the construct in the Strategic Arms Reduction Treaty (START) agreement on allowed strategic system locations and monitoring procedures. Similar arrangements to the Russian/American START declaration and verification approach would be required for the USW-sites of all parties to the treaty. The PPMS system will be described in more detail in Section III. In general terms, the PPMS system would be modeled after the regimes agreed to in INF and START I. After accession to the treaty a country would have a period of time to bring its USW-sites and transportation system up to New Court requirements. During the period allowed for New Court site development and PPMS systems installation there is no inspection or monitoring of vehicular traffic except for limited testing of the PPMS and training of the inspectors and site operation's personnel. In this initial period there would be no restriction on the host country for movement of fissile material into or out of the site. There would be no declaration or monitoring of the number of weapons or amounts of fissile material. Following the "construction" period there would be a period in which material arriving at a USW-site would not be monitored or inspected other than to validate tagged shipments from other USW-sites as described below. This window is to allow a party to bring all of its weapons and fissile material within the system without having to reveal the magnitude of its stockpiles or their form. After the construction period, when material or weapons are moved between USW-site locations the transport vehicle would be sealed and tagged by the monitor team. Treaty monitors might also accompany the transport escorts. The weapons or materials themselves would not be monitored or inspected. After the initial construction period, vehicles leaving a USW-site which the host country did not declare as movement to another USW-site (and therefore sealed, tagged, and tracked) could be subjected to intrusive inspection. Untagged vehicles arriving at a USW-site would have an additional grace period before all arriving shipments, except those tagged from another USW-site, could be subjected to intrusive inspection. These inspection/tagging requirements are diagrammed in Figure 2.

Figure 2: When a Vehicle Is Inspected or Sealed and Tagged



For a variety of reasons a treaty party may wish to construct a new facility or adapt a site previously used for other purposes and declare it as an element in the New Court system. It might be desirable to replace obsolete facilities with a totally new site, because of local pressures for land use at existing locations or territorial changes. In any case, the initial construction and grace period rules do not apply. When a new site was declared ready for use it would have to undergo intrusive inspection to verify that it was not being used to bring previously hidden materials under the New Court protective regime. The “virgin” facility would then enter the system under full operation rules, i.e. tagged arrivals from other USW-sites would not be inspected; all other arriving and departing vehicles could be subject to inspection.

Precedents in INF and START

Under New Court all sites where nuclear warheads and/or fissile materials are located would be declared. One of the requirements of the Strategic Arms Reduction Treaty (START) was that the Soviet Union and the United States declare all facilities related to intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), and strategic bombers. The START I agreement between the United States and the Soviet Union sets a precedent for a declaratory and verification process where warheads are collocated with delivery vehicles. Initially the United States declared over forty START-inspectable locations and the Soviet Union over sixty sites.^{23,24} An elaborate set of counting rules limits the total number of deployed ballistic missiles and heavy bombers and the “accountable” number of warheads (6,000). The treaty provides for a dozen measures to verify compliance. These include inspections to confirm the accuracy of data provided in the initial information exchange, update inspections, conversion/elimination inspections to verify the destruction or conversion of treaty-limited items, suspect site inspections to ensure that covert buildups are not occurring, continuous monitoring of mobile ICBM production facilities to confirm the number of mobile missiles produced, measures to distinguish conventional from nuclear delivery systems, and technical confirmation that the characteristics of ICBMs and SLBMs agree with treaty provisions.²⁵ As has been noted before, there is no requirement in START I or START II for the elimination of the nuclear warheads.

In one sense New Court is less constraining on sites than START in that there are no limitations in the proposed regime on the number of warheads that can be located at a U-site. The significant additional requirement in New Court is that all U-sites’ perimeters and portals can be monitored. The Intermediate-range Nuclear Forces (INF) Treaty in 1987 established a precedent for this requirement. The INF Treaty permitted up to thirty inspectors to continuously monitor the perimeter of an intermediate-range missile assembly or production plant on each other’s territory.²⁶ The inspectors visually observe all vehicles exiting the sites and inspect any vehicle large enough to contain a treaty-limited item. The United States uses a radiographic imaging system called CargoScan and Russia uses human observation to inspect the material leaving the plants. The START I agreement contains a similar provision allowing up to thirty inspectors to monitor the perimeter and portal of an intercontinental missile final assembly site.²⁷ Figure 3 shows the perimeter portal at Votkinsk in Russia.

Figure 3: A Perimeter Portal at Votkinsk²⁸



Establishing a Standard for Safety and Security

Given the numbers of potential treaty parties, the quantity and variety of sites involved, and the goal of improving international confidence in the safety and security of fissile materials within nuclear-weapon-state military sectors, the New Court agreements will be voluminous.²⁹ Much of the groundwork has been done, however. New Court can capitalize on earlier international efforts in START and INF. The earlier treaties provide a foundation for the definition and verification of declared sites and the operation of PPMS. There are several sources from which to develop site and transportation safety and security guidelines and a “nuclear weapons standard.”³⁰ The IAEA has negotiated a Convention on Nuclear Safety.³¹ For peaceful nuclear materials the IAEA established a Convention on the Physical Protection of Nuclear Materials (PPC)³² while in international transport. The PPC has no verification provisions, however, and there is no binding international agreement for the security of nationally located nuclear materials (military or peaceful).³³ The agency has provided Recommendation for the Physical Protection of Nuclear Materials³⁴ and the IAEA is exploring standards for the physical protection of nuclear materials in general.

The governments of the nuclear weapon states that may be initial parties to New Court are likely to have safety and physical security policy statements, guidelines, and standards for their weapons and fissile materials. The United States, the United Kingdom, and France have physical protection standards for nuclear materials that are known to exceed the IAEA recommendations in INFIRC/225.³⁵ The Russians have submitted a draft Convention on the Suppression of Acts of Nuclear Terrorism, a great deal of the language of which could be applied to New Court safety and security policy.³⁶ In the United States, the Department of Energy has an established policy, with assignment of responsibilities and authorities for the protection and control of safeguards and security of the special nuclear materials in the department’s custody.³⁷ The requirements are detailed in the *Manual for Protection and Control of Safeguards and Security Interests*.³⁸ The U.S. Department of Defense also has extensive documentation of its security policy for protecting nuclear weapons and guidelines for the design of physical security facilities.^{39,40,41} George Bunn, IIS consulting professor at Stanford University, has written a draft “Stored Weapons Standard Requirements” based on U.S. Department of Defense directives and related governmental regulations (see Annex II). Utilizing established safety and security policies and guidelines as a foundation, an International Com-

mittee of Security Experts (ICSE) would develop an international safety and security policy statement, manual, and guidelines to be applied to the treaty. Recent international negotiations, such as those related to the Chemical Weapons Treaty and bilateral discussions on nuclear issues between the United States and Russia, have demonstrated success through such a process.

The treaty negotiation process would determine the initial monitoring methods and responsibilities. Of critical importance for international assurance of fissile material safety and security will be the acceptance of the monitoring procedures and the approach for reporting on weapon safety, security, and use control. This would be accomplished through five inter-related activities. Annually, experts from the parties to New Court would meet at a closed conference on safety and security. These conferences would not address details that might compromise safety and security system performance or design details involving the nuclear explosives. The emphasis would be on safety, security, and use control philosophy and fundamental architectures. The annual safety and security experts' conference could contain demonstration of commercially available equipment. Every two years there would be announced inspections of the security and safety systems at the declared sites by a team from the parties to the treaty. The procedures would be similar to those created to support the START agreements. The weapons and fissile material at the facilities could be blocked from view and measures would be allowed to protect national security requirements. Any party to New Court could request a special access visit (SAV) to any site to resolve concerns that cannot be addressed by other means. The party subject to the request is obligated to try to resolve the concern, but may refuse to grant the SAV request. A Special Review Commission (SRC) with delegates from all parties to New Court would be formed to resolve compliance and implementation issues. Every two years each party to the treaty would submit a self-appraisal of its safety and security system performance to the SRC. This audit process, together with the announced inspections, the annual safety and security conference documentation, and the reports on the PPMS operations, will provide the foundation for confidence in the system. Additionally, the SRC would provide a summary report to the UN, perhaps through the IAEA. Every five years a review conference would be held to assess the New Court system performance and negotiate any modifications.

A Canonical New Court Site Description

In the New Court system there exist two generic types of portals: the Inspection Portal (IP) and the Tag Portal (TP). Both types are fundamentally similar to locks on a canal. As vehicles or personnel enter from one side the other side is closed. The side they entered from then is closed and after the vehicle or person is cleared for passage the second side is opened and they can pass through. In an Inspection Portal vehicles and personnel can be monitored by instruments and intrusive procedures are permitted to ascertain that undeclared material is not entering or leaving the site. At a Tag Portal the host nation declares that the vehicle is going to, or coming from, another USW-site in the New Court system. There is no monitoring of the contents of a vehicle passing through a TP. (Vehicle crews may have to proceed through an Inspection Portal.) If the vehicle is leaving the site through a TP, monitoring personnel may place seals and tags on the vehicle and record its destination. Monitoring personnel may also accompany the shipments with the escort team to verify that vehicles proceed directly to a declared USW-site. Shipments arriving at a Tag Portal will have their tags and seals verified and recorded before passing into the site. Again there will be no al-

lowed inspection of the contents of the shipment. These sealed and tagged shipments among USW-sites are analogues to couriers with diplomatic pouches; the vehicles can be tracked and their arrivals and departures monitored, but there is no disclosure of their contents. Thus, neither the amount of fissile material nor the number and types of warheads at any USW-site is revealed by the New Court system.

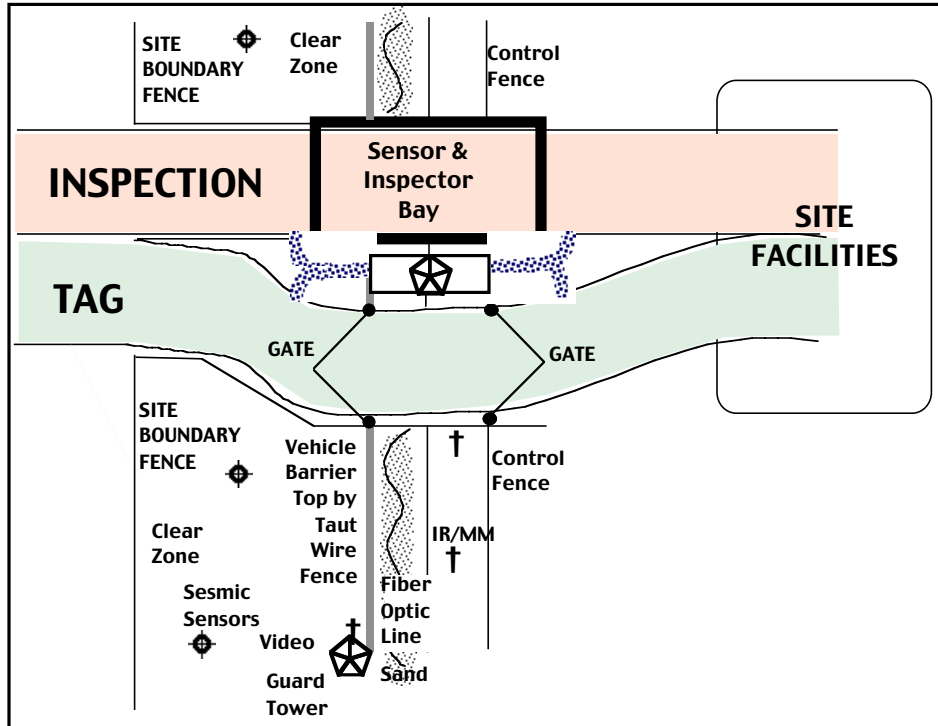
The Inspection Portals and Tag Portals do not have to be co-located. There need not be equal numbers of IP and TP points at a site. Each site must have at least one Tag Portal or else all arriving and departing vehicles can be intrusively inspected. It is impractical from a site operations and maintenance perspective not to have an Inspection Portal. Without an Inspection Portal all vehicles must be sealed, tagged, and tracked, and come from or go to another New Court site. Furthermore, for both material control and site security, personnel would have to pass through IP monitoring stations.

Inspectors would be restricted to the nuclear weapon states that were a party to the treaty. Restricting monitoring responsibilities to the treaty parties adds a barrier against inadvertent disclosure of any information that might aid other states in the development of a nuclear explosive device. New Court would set a limit on the number of foreign perimeter/portal monitor personnel allowed at any one site. Each signatory to the agreement would be permitted at least a minimum number. If the allowed number in the treaty of foreign personnel at a site were “N” and the number of parties to the treaty were “P” then each state should have the option of placing at least $N/(P-1)$ monitors.⁴² If a country chooses not to provide its full complement it could transfer all or any part of its allowance to another party to the treaty. There would be no limit on the number of escorts and additional inspectors and perimeter monitors that the host country could provide. Each nation would be responsible for fully funding all costs associated with its personnel.

New Court would define minimum standards for USW-site perimeter protection in terms of barriers and monitoring approaches. This perimeter standard would be one of New Court’s major contributions to assuring the security of weapons and materials. Figure 4 shows an example of how a standardized perimeter/portal architecture might appear.⁴³ The perimeter would be defined by an outer site-boundary fence and an inner perimeter-control fence. These two barriers would run roughly parallel to each other with approximately a twenty-five-meter separation. Typically, these two would be three-meter-high chain-link fences with barbed-wire “Y” tops and extend twenty-five to fifty centimeters into the ground. The purpose would be threefold: (1) They would define the perimeter region for the treaty. (2) They would reduce false alarms from animals and windblown debris in the perimeter sensor field. (3) They would provide low-level barriers to prevent “innocent” intruders from stumbling into the perimeter field from either the outside or inside of the site. From the site boundary fence there could be a fifteen-meter-wide clear zone to a vehicle barrier topped by another two-meter fence. The vehicle barriers could be like the concrete dividers used down the centerline of many roadways. Seismic sensors would be placed in the ground between the boundary fence and the vehicle barrier. These would signal any vehicle penetration of the outer fence and most cases of trespassing personnel. The seismic sensors could also detect attempts at tunnel penetrations. Some five meters inside the vehicle barrier control fence would be a “taut wire” fence. The zone between the vehicle barrier and the taut wire fence would be filled to a depth of one or two meters with sand or gravel with several fiber-optic sensor lines. Between the taut wire fence and the inner control fence an electrified fence might be located. The overall zone would be fully illuminated and monitored by video systems and infrared and millimeter microwave sensor systems. Finally, observation towers would be placed at

critical nodes along the perimeter, providing positions for armed guards as well as detection equipment.

Figure 4: A New Court Site Portal/Perimeter Monitoring Configuration



Section IV: New Court Concerns

Treaty Circumvention

The most plausible reason a nation would attempt to clandestinely abrogate New Court would be under the assessment that it could assemble a strategic force capable of disarming or decapitating an enemy through a surprise attack. These are exactly the same conditions, however, under which a nation might abrogate START-like agreements. As noted before, all parties to New Court may have to accept verification and transparency measures with regard to strategic forces (i.e., U-sites) similar to those in the U.S.-Russian START accords. Today, non-strategic warheads, especially bombs, could be reconfigured to a strategic role with little or no visible signature. New Court does add a degree of difficulty to how the nation would go about clandestinely building up its strategic forces. A nation could move warheads in the form of bombs or reentry vehicles from S- or W-sites but they must go to a U-site (to strategic bases). As “tagged and tracked” shipments, the contents would not be inspected, but changes in traffic patterns could be monitored and New Court would reinforce the START accords.

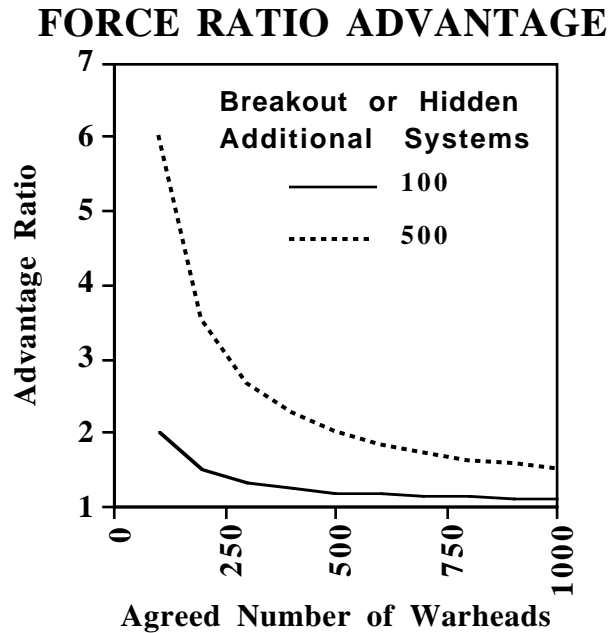
Territorial Deployment Issues

The combination of the USW-site requirements and the PPMS system monitoring by teams of inspectors from other nuclear weapon states, as well as the New Court negotiation process itself, may require that all sites be on the territories of the participating nuclear weapon states. This is currently only an issue for the United States and, because of the U.S. foreign deployments, for America's NATO allies. On the one hand, a requirement that all weapons must be on their owner's territory (or in international waters or airspace) may be a negotiating lever with the Russians and Chinese. On the other hand, removal of U.S. weapons to sites within the states would weaken America's extended deterrence policy. Thus, in the pre-negotiation stages, it is important that the United States involve NATO in establishing the U.S. position on the details of this arms-control proposal. Since NATO's membership includes three of the P-5 nuclear weapon states⁴⁴ and NATO is currently reexamining its strategic concept, involvement of the North Atlantic Alliance in the formulation stage could be of considerable benefit and help assure rapid progress toward a ratified agreement. Broadening the negotiating process beyond the nuclear weapons states to include non-nuclear hosts, i.e. states such as Germany where American nuclear weapons are stationed, could add major complications. What role would non-nuclear states have in the treaty negotiation process? What role would such states have in the design, construction, and operation of New Court sites on their soil? Could such participation compromise nuclear design information?

Breakout Concerns

A general concern with arms control and/or disarmament treaties is the possibility that a potential adversary will break out of the agreement. Breakout is most significant in situations where there exist small weapon stockpiles. If the number of warheads in an active strategic stockpile is small, a breakout utilizing warheads from "reserve" storage, or tactical bombs clandestinely deployed strategically, could result in sizable imbalances in strategic force ratios. Figure 5 depicts force ratio sensitivity to small numbers. Under New Court the strategic condition, with respect to possible breakout deployments, would be no different than it is today. If deployments from the monitored storage sites imply a strategic advantage, then there are inherent problems in disarmament agreements such as START where there is no monitoring of weapon storage sites or delivery systems or weapons outside the START rubric, e.g. tactical bombs.

Figure 5: For Small Stockpiles, an Advantage in Hiding Warheads



A breakout may be clandestine, done with stealth and deception, or it may be in the form of a sudden action with the expectation that the momentum of the breakout will provide the sought advantage. Even in the latter case, the preparation for breaking out of an existing condition will generally be covert. The Soviet breakout from a nuclear test moratorium on September 1, 1961, was preceded by elaborate covert preparations for an extensive nuclear test series. It was not until seven months later that the United States was ready to respond in the South Pacific with Operation Dominic. The Soviet breakout from the test moratorium cast a long shadow over all subsequent negotiations on nuclear matters. An extensive verification regime is generally mandatory for treaty confirmation and there is a tacit requirement that any U.S. position be examined from the perspective of the potential failure of verification conditions to detect preparations for a breakout or of a country clandestinely abrogating a treaty. With regard to the Nuclear Weapon Control Treaty proposal in this paper, two questions are addressed: (1) What advantages might be gained by breaking out of the proposed agreement? (2) How might a breakout be undertaken?

The most destabilizing circumstance would be if a breakout enabled a country to gain a decisive strategic advantage. The proposed New Court concept does not constrain the number of warheads or delivery systems. It is an arms-control agreement, not an arms-limitation agreement. New Court does require the identification of all locations where nuclear warheads are in close proximity to potential delivery vehicles. Thus, New Court requires that participants agree to a START-like structure and verification procedures, identifying the locations and perimeter/portal monitoring of all their nuclear weapon delivery systems, i.e. declaring all U-sites. As New Court avoids the numbers problem, it should not be a difficult

proposition to negotiate with Great Britain and France, since the location of their nuclear bases is well known. At the other extreme, it may require extensive multilateral negotiations with China.

There is no new strategic breakout avenue created by the nuclear weapons control treaty proposal New Court, except if one places false expectations in the agreement. The possibilities outlined here would be of continued concern whether or not New Court was successfully instituted. Aircraft delivery is a particularly troublesome strategic breakout route. Consider airfields that are not declared as U-sites. There are thousands of military aircraft with crews trained to drop bombs which could easily be configured to deliver a nuclear bomb. For example, the United States F-15 Eagle and F-16 Fighting Falcon, supersonic strike aircraft with aerial refueling capability extending combat ranges over thousands of miles, have nuclear-capable configurations. More than three thousand F-16s have been built. They have been deployed in sixteen countries including Pakistan and Israel. Furthermore, thousands of commercial aircraft and military transports could be configured, with no external signature, to deliver a nuclear device.

A number of nuclear bombs could be removed from declared storage sites (S-sites) and moved to manufacturing/maintenance facilities (W-sites). At the W-site, if necessary, the bomb's arming, fusing, and firing systems and its safety and command and control systems could be adapted so that it could be dropped by strike aircraft, or even commercial planes, that were not "nuclear capable." These weapons could then be included in a declared shipment of bombs to a "U" airbase and covertly airlifted to non-"U" airbases, perhaps outside the territory of the state. The airfield runway as a portal will be very difficult to monitor, especially if airborne alert is not banned by treaty. (How many weapons were actually on board when a plane took off and how many when it returned?) Sites associated with SLBMs could also provide a clandestine deployment channel, offloading warheads at sea for redeployment to non-declared locations. Without a pervasive verification system, internal to the U-sites, breakout would be possible in the sense of redeploying, perhaps a large number of warheads, to non-declared sites. Such breakout routes exist with the START regime but the likelihood was deemed sufficiently low that, with the treaty's benefits, they were acceptable risks.

A concern unique with regard to New Court is the possibility of a nation gaining advantage by withholding weapons from the monitored sites. Consider the case where a state did not move all its weapons to declared USW-sites, but attempted to hide significant numbers of warheads at unmonitored locations. The rationale might be that a strategic advantage could be achieved with warheads mated to delivery systems such as "conventional" strike aircraft, as described above, and avoid the risk of detection in removing the warheads from the USW-site triangle. The country attempting such a path would encounter three problems. First, it would have to maintain a high level of secrecy: one accident, disclosure, or exposure could compromise the strategy with extremely negative international reaction. Second, the clandestine stockpile could be part of a "secret service" and national authorities might have to accept reduced safety and security conditions (safety, security, and command and control) for the hidden weapons. Third, the limited life components in the weapons will decay and the devices will lose capability and eventually fail to function if not regularly serviced. Either much of a maintenance/manufacturing complex will also have to be kept secret outside the New Court system, or the nation must run the continuing risk of exposure in moving weapons in and out of the system.

New Court does not prevent a nation from withdrawing its weapons from storage and in effect placing them on alert. The PPMS will only provide essentially instantaneous warning

that a state is moving nuclear weapons outside predesignated locations. Other nuclear weapon states could immediately respond, conducting a similar mobilization of their weapons from storage sites. In fact, states could use the movement of weapons out of the storage sites in a positive sense as a strong signal that they viewed an evolving situation as extremely threatening, i.e. the redeployment would be equivalent to moving to a very high DEFCON level.

Resolving the Strategic/Tactical Identification Dilemma

At the Helsinki Summit President Clinton and President Yeltsin recognized the problem tactical weapons presented for further arms reductions. They “agreed that in the context of START III negotiations their experts will explore, as separate issues, possible measures relating to nuclear long-range sea-launched cruise missiles and tactical nuclear systems, to include appropriate confidence-building and transparency measures.”⁴⁵ Identifying weapons as strategic or tactical will be a challenging and often ambiguous issue. While bombs themselves may be labeled as strategic or tactical there is no necessary difference in their configuration that mandates such identification. Figure 6 shows a strategic and a tactical version of a U.S. nuclear bomb. Externally the two look identical. The difference to a target is only in the tens, hundreds, or thousands of kilotons of destructive force delivered against it.

Figure 6: A Strategic and a Tactical Nuclear Bomb. Can You Tell the Difference?



The differentiation of warheads as strategic or tactical is not required for New Court. In fact, New Court offers an alternative that in later disarmament processes can preclude the need to identify warheads as strategic or tactical. In New Court weapons are classified by the site where they are located. Weapons at a U-site could be called “D-weapons,” ready for delivery. They are the ready-to-use retaliatory systems, the foundation of nuclear deterrence. Weapons in storage are reserve weapons, and could be called “R-weapons.” In the United States this collection includes today’s strategic reserve and all but some bombs of the American tactical stockpile.⁴⁶ Weapons that are in transport or at W-sites are in the pipeline and could be referred to as “P-weapons.” This well-defined structure avoids the ambiguity of the strategic or tactical classification and provides transparency that may be required in future verifiable nuclear arms reductions.

The Role of Stored Weapons

While New Court does not introduce any new breakout security issue, a reciprocal question must also be addressed: Does placing systems under New Court reduce the military utility of stored systems (the R-weapons)? Consider three plausible missions for which one might use nuclear devices or weapons from storage in the New Court system (R-weapons): (1) To attack targets for which conventional weapons are incapable of providing sufficient assured destruction, e.g. biological or chemical storage or manufacturing facilities or deeply buried structures. (2) To shape the environment, e.g. to create barriers or disrupt the electromagnetic environment. (3) As an equalizer, to balance battlefield capabilities. The first two classes will rarely require more than a very few devices. Furthermore, personnel trained and exercised for nuclear missions with a missile or high-performance aircraft would usually carry out the strikes. A weapon might be removed from storage and transported to a U-site, but these “tactical” operations would be planned for and carried out by D-weapons.

The major military roles for R-weapons would be the “battlefield” equalizer mission and as reserve to the D-weapons.⁴⁷ Within a decade of their development, nuclear weapons were identified as an approach for offsetting conventional shortfalls. In order to counter the perceived overwhelming conventional capabilities of the Soviet empire, NATO nations trained troops and procured equipment with thousands of nuclear warheads. The battle of the Fulda Gap is perhaps the most studied non-battle in military history. General MacArthur developed plans for atomic attacks on Chinese troops in Manchuria to reduce the pressure on outnumbered UN troops in the Korean War. Today, Russia sees the use of non-strategic weapons as one means of countering NATO’s conventional superiority. A concern with New Court could be that consolidation in a few well-known sites of all non-strategic nuclear assets would seriously weaken a country’s ability to withstand attack by a conventionally superior adversary. Could a surprise strike by precision-guided conventional munitions on the nuclear storage sites destroy nuclear capabilities? The answer could be “yes, it could.” Therefore, it must be an international understanding that even for a conventional attack on nuclear-weapon storage sites (S-sites) a country would be justified in retaliating with the full commitment of its survivable configured U-site (strategic) forces. That is, an attack on the S-sites must be considered similar to a nuclear strike against a nation’s U-site forces. Since New Court, along the START model, does not impact retaliatory force survivability, these forces’ fundamental role in deterring hostile action applies to the scenario above. If another state mobilized a conventional threat against a New Court party, the party could go to an alert posture, moving warheads out of storage sites, and through the deployment also send a very strong signal of concern.

Section V: Movement from New Court to Disarmament

One of the major factors driving the New Court initiative is that today the determination of initial inventories of weapons and weapons-usable materials with acceptable accuracy and precision will be difficult (to impossible) to accomplish. Once New Court is fully in place for a moderate amount of time, the material within the system can serve as the baseline from which to negotiate future stockpile magnitudes. While New Court would determine where audits should be undertaken, it will not resolve how they should or could be accomplished.

Given the sensitivity to classification this issue could be difficult to resolve. On the other hand, without controls on the locations and movement of fissile materials and weapons, verification of stockpile declarations will be impossible. Thus, much of the New Court arms-control regime is a necessary condition for verifiable nuclear disarmament.

Section VI: An International Safeguarded Storage Regime

The Transfer of Excess Nuclear Weapons Material

Both the United States and Russia have announced their intention to transfer a considerable amount of weapons fissile material to the civil sector or to final disposition.⁴⁸ Furthermore, the two countries are working with the IAEA to develop an acceptable regime through which the IAEA can safeguard materials designated for future civil use. An essential feature of the transfer process would be the transport of the excess weapon material from facilities in the New Court system to internationally monitored storage facilities (IMSF). Material leaving a New Court facility would be tagged in the manner outlined above; however, the declared destination would be an IMSF. The shipment would be tracked and upon arrival the contents would undergo a comprehensive assay. The IMSF would be the entry point for excess weapons material into the civil sector as well as the storage of reprocessed plutonium from civil power reactors.

Fissile Material in the Civil Sector

Independent of the transfer of excess weapons fissile materials, there are very large amounts of plutonium in the civil sector. Commercial-reactor-produced plutonium can be used to make a nuclear explosive.^{49,50} Table 3 presents projections of the amounts of material that will accumulate by 2010. All concepts for the disposition of the material will take many years, probably many decades, to complete. Thus, continued storage will be necessary. A National Academy study defined two storage environments:⁵¹ A “Spent Fuel Standard” (SFS) level of protection was envisioned as radiation barriers similar to that provided to spent fuel rods stored at commercial reactors. The Department of Energy’s Office of Fissile Materials Disposition is developing a rigorous definition of the SFS.⁵² The National Academy’s other fissile material protection environment was for weapons-usable material not protected by a radiation barrier, the “Stored Weapons Standard” (SWS). This standard would require material protection “approximating as closely as practicable the security and accounting applied to intact nuclear weapons.”⁵³ Professor George Bunn at Stanford’s Center for International Security and Cooperation has developed a *Description of “Stored Weapons Standard” for Protecting Weapons-Usable Fissile Material*.⁵⁴

**Table 3: Civilian Fuel-Cycle Plutonium
(Metric Tons)**

Material	1990 ^a	12/31/93 ^b	2000 ^a	12/31/00 ^b	2010 ^a	12/31/10 ^b
Total Plutonium	654	847	1391	1400	2100	2100
In Spent Fuel Rods	532	703	1081	1123	1554	1663
Separated in Storage	122	144	310	277	546	437

a: Nuclear Control Institute, <http://www.nci.org>.

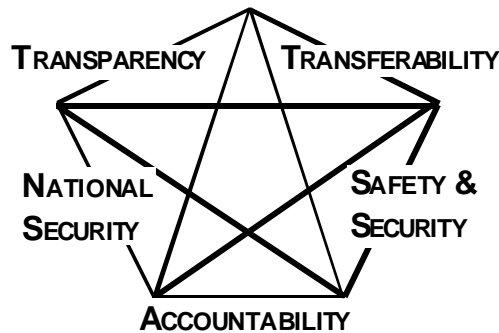
b: Albright, Berkhout, and Walker, *Plutonium and Highly Enriched Uranium 1996*. A SIPRI Publication. Oxford University Press, 1997.

There is a general concern over the security of weapons-usable nuclear material. With total global inventories in hundreds of metric tons, and only a few kilograms being necessary for a nuclear explosive, the possibility of theft or “embezzlement” is a worry for everyone. Several international conferences and workshops have been held to explore the dangers and to develop an understanding of possible regimes that could reduce the risks.⁵⁵ In the approach presented here the safety and security provided by IMSFs is essentially the same as protection at New Court facilities in the nuclear weapon states. An extension to the NPT would require that all weapons-usable material is protected to agreed safety and security standards. Nuclear weapon states would satisfy the safety and security requirement for fissile material in their national security community if they were parties to New Court. Storage of quantities greater than an IAEA-determined threshold (a few kilograms) would be in IMSFs or at reprocessing or fuel fabrication facilities, satisfying similar safety and security requirements. International safety and security requirements would also apply to transportation of weapons-usable fissile material from one fuel-cycle facility to another. A configuration for material storage will be addressed in more detail.

IMSF Design Requirements

Can a repository be developed which provides appropriate protection (safety and security) and accountability and in which the depositors (and the international community in general) do not have to unduly trust the state where the facility is located? There are five key issues that an international storage facility must simultaneously satisfy: national security, safety and security, transparency, transferability, and accountability. Synergisms and conflicts among the factors can either support or challenge successful operation of the IMSF. The material storage management star in Figure 7 depicts the five features.

Figure 7: Fissile Material Storage Management Star



National Security

Neither placing material in the IMSF nor providing the territory for an IMSF should compromise national security. It is extremely unlikely that any nuclear weapon state will place a sizable fraction of its nuclear-weapons-usable materials in a repository in another country. It should be expected that fissile material from weapon programs that has been declared excess from nuclear weapon requirements, even with declarations that it will not be used in weapons, will be kept “at home” unless it is sold to another party for commercial use. Thus, nuclear weapon states that are parties to the IMSF convention will be themselves likely hosts for IMSFs. For facilities within nuclear weapons states, some nations may require that the design permit rapid withdrawal of their material should they feel the need to “reconstitute” their former weapons capability. The international community will wish this were not the case; it would prefer that material had truly been permanently removed. In the near term this may not be a practical goal if universal participation to the convention is desired. The “safeguard” requirement that should be met is that removal of material from an IMSF is not possible clandestinely, even by the host country. Neither the “banker” nor the “depositor” should be able to withdraw material without immediate exposure. (This visibility is the pre-eminent element of the transparency requirement.)

A second aspect of the national security requirement is that any material delivered for deposit in an IMSF, either by its form, its packaging, or its delivery system, can not threaten the facility, its contents, or the surrounding territory. The IMSF system should not provide a means for hostile action against a state. A hostile nation might try to use the system to introduce nuclear weapons rather than nuclear material into a country. It might hide in a shipment the means to deny other countries access to material already stored at a site. A hostile state might try to plant explosives to scatter nuclear material deposited at the site, creating a radiological hazard over a large area. The transportation system, containers, and material form will have to meet rigorous international standards and be subjected to extensive verification procedures. (These requirements and procedures are a fundamental element of the safety and security system.)

Perhaps the most difficult national security issue to resolve is in guaranteed accessibility for all states to material they have deposited. A depositor must be able to withdraw material without undo difficulties. States agreeing to host an IMSF should not later set their standards for withdrawal. Concerns over availability could lead to pressures in each state possessing

weapons-usable material to build its own IMSF. This would compound the problems for achieving consistent international standards; a proliferation of storage sites would increase international operations costs as well as the total global investment in the facilities.

Safety and Security

The need for codifying international standards for safety and security has been discussed earlier. Safety and security specifications can be developed from current IAEA standards with the integration of requirements from participating nations. In any event, each IMSF will have to meet all local and national safety, security, and environmental protection standards of the host community. As noted above, safety and security systems can reinforce and/or conflict with the national security issues. The security system could delay or deny a country's access to its own material even if the site was on its own territory. On the other hand, safety and security systems provide barriers to improper acquisition of material.

Accountability

National governments and international agencies will require that the IMSF system accurately and continuously account for the quantities, condition, and location of all material under its control. The IMSF system must be more than a vault of "safety deposit boxes" where only the owner of the contents knows what is in his container. Criticality considerations, much less international assurance that parties have deposited what they stated, make a confidential storage approach unacceptable. Accountability requires obtrusiveness, access in one form or another to the material, and this can compromise security and safety. Access provides opportunities for diversion and exposure to fissile material radiation has health risks. A comprehensive assay of the material and verification of its packaging will be required for all material deposited in and removed from the storage facility. An international body would conduct the assay, with the process observed and perhaps verified by the host state.

Transparency

The fissile materials management system must be visible. The locations of facilities and the general process for protecting the public can not be secret, the province of a special caste with a "trust us" philosophy. The system should provide the international community with virtually real-time access to the status of all the stored material. Unless care is taken in the design of the facilities and the development of procedures, transparency could clearly compromise site security and safety. In the last few years technological advancements in the information sciences have provided approaches for resolving conflicts with the transparency requirement. Authentication techniques; information compression; pattern recognition algorithms; technological advances in storage, power supply, and communications; and international information access via the World Wide Web could form the basis for a transparent yet safe and secure material-management system.

Transferability

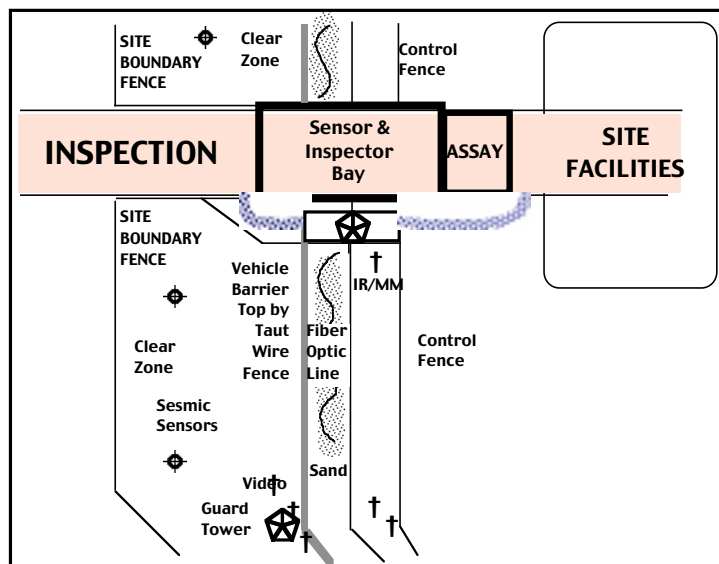
The IMSF system will be of limited value if it is not truly international. The technologies and procedures involved in the system must be broadly transferable. Initially IMSFs may be located at a very few sites. But, if the system is to meet its "global" objective, and with the

projections of substantial material growth in storage needs over the next few decades, many sites throughout the world will be required. Not only the policy and procedures underlying the IMSFs but the supporting technologies themselves will have to be transferred to a considerable number of nations and international bodies. Therefore, the IMSF designers must recognize that essentially full details of the system may be available to parties with “evil” intentions. In the banking analogy this corresponds to sharing the knowledge of how to design bank vaults without making it easier for the bank robbers. Yet transferability could provide a degree of deterrence if through the dissemination of the system’s features potential acts of theft, diversion, or sabotage were dissuaded.

A Candidate Architecture for an IMSF

The host countries will select the sites for IMSFs. The basic storage structures may also be built by the host nation with the construction process monitored by an international body such as the IAEA. The perimeter of an IMSF would have similarities to the New Court portal/perimeter architecture. A representation of an IMSF portal configuration is given in Figure 8. The notable difference is that there would not be a “two lane” entrance/exit system. Most likely transportation standards would require that all shipments be sealed and accompanied by an escort team. Excess fissile material arriving from nuclear weapons programs would meet New Court transportation standards. These materials would be tagged and tracked with the material deposit recorded in the New Court system. Every arriving and departing shipment would be subjected to intrusive inspection. An accurate, high-precision assay would be conducted of material being transferred into or out of the site. No outside vehicles would be allowed to proceed to the storage vaults. Material for deposit would be offloaded and moved into the storage vault by site-dedicated units. The site would be designed such that only specially designed handling equipment could physically access the vaults.

Figure 8: An IMSF Portal/Perimeter Monitoring System



The site, from the perimeter to the containers in the vaults, would be monitored by a system of nested, independent sensors. Eight levels are listed in Table 4. The host nation would have the option of taking responsibility for Class I and perhaps many of the Class II, VI, and VII sensors. The IAEA would be responsible for the assay equipment, Class VIII sensors. Other nations participating in the nuclear material storage program could be responsible for Category III, IV, and V, and perhaps some sensors in Category II, VI, and VII. Countries responsible for the various sensors and providing on-site inspectors would be selected on the basis of three criteria: (1) Nations that are willing to develop, install, and take responsibility for operation and maintenance of sensors; (2) Nations that are depositing material into the IMSF; and (3) Nations that are hosts to other IMSFs.

Table 4: IMSF Sensor Categories

LEVEL	SENSOR LOCATION
I	Sensors inside or in contact with the fissile material containers
II	Sensors external to but focused on individual containers
III	Sensors collecting data on the collective fissile material environment
IV	Sensors monitoring activities inside the vault
V	Vault access sensors
VI	Site portal sensors
VII	Site perimeter sensors
VIII	Assay equipment

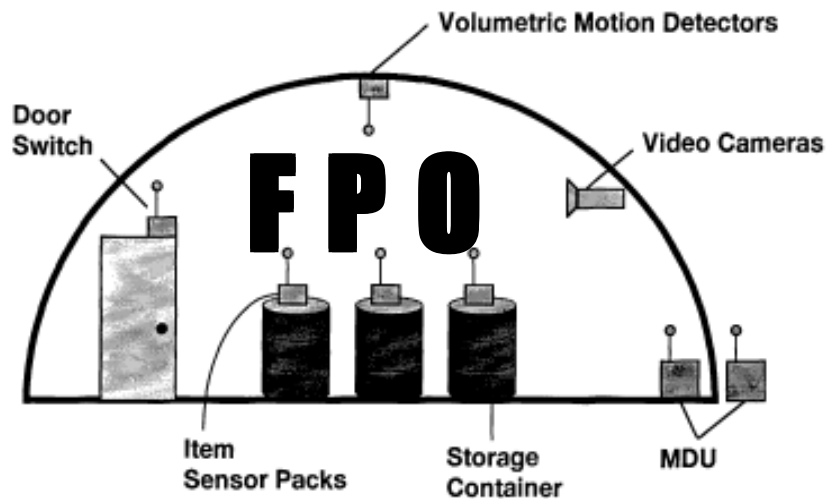
Each sensor may be contained within a tamper-proof cocoon. The state or agency responsible for a sensor could also incorporate an authentication code enabling verification that the report the sensor was sending was indeed coming from the sensor and that it had not been tampered with. With different sensors, designed and built by different nations or international agencies, the host country and the custodial international agency would be allowed to verify that the sensors contained no features that had not been approved. The output from all sensors would not only be transmitted to the site operators and security force but to all participants in the system and potentially via the World Wide Web to the public at large. Anyone could then independently monitor the activity at the storage site.

On-site inspectors, with routine, random, and demand inspections, would still be a necessary element of the system. They not only serve as a check on the unmanned sensor systems but as the rapid response to sensor-system failures and investigate suspicious events. The technological developments from the information science revolution make the IMSF possible today whereas it would have been of questionable feasibility just a decade ago. Parallel, independent, protected sensors with high reliability, small size, and long lifetimes using real-time broadband communications are the heart of the system. The U.S. Department of Energy is currently developing the basic elements of such a system. One proof-of-principle experi-

ment for monitoring the storage of weapon fissile material components called “Straight-Line” is being conducted together with Russia.⁵⁶

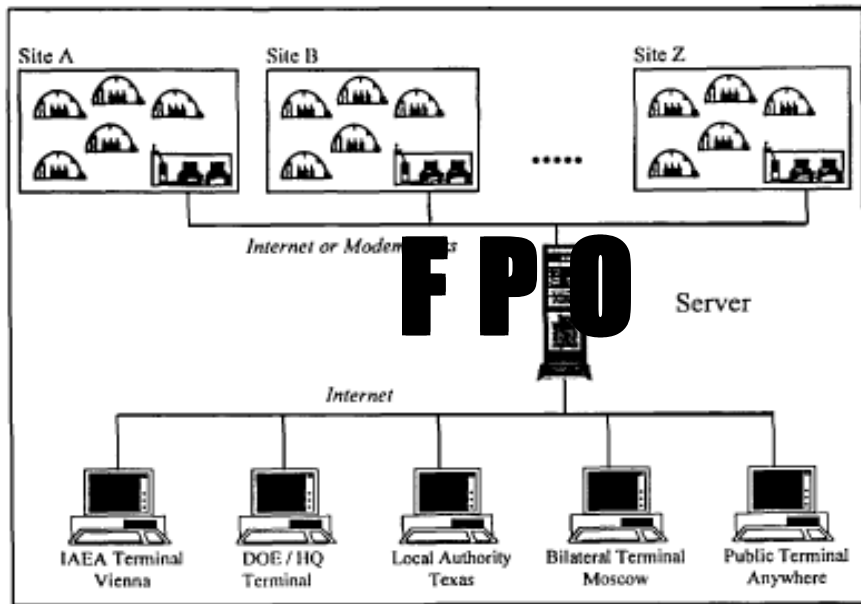
The focal point for Straight-Line is nuclear material containers in a storage vault. Figure 9 illustrates how a vault in the experiment is configured.

Figure 9: A Straight-Line Vault Configuration



A variety of sensors send information to a vault data relay, which transmits the observations to the site central control station. The use of a vault data relay minimizes the number of penetrating antenna (and cost) of vault instrumentation. The sensors would use wireless communication, greatly simplifying installation and the deposit or withdrawal of material. Sensors on the nuclear material containers monitor container and ambient temperature, motion of the container, radiation, pressure, acoustic signatures, and any gas escaping the package. Vault sensors monitor motion, light, sound, and temperature. Video cameras provide real-time pictures from inside the magazine. Door switches also detect entry. Data from the sensors is processed at a site-control station and displayed to inspectors and site security personnel. Simultaneously, the raw data, with authentication codes, is transmitted to the laboratories and sensor observations are made available on the World Wide Web.⁵⁷ Figure 10 depicts the network.

Figure 10: The Linkage of IMSFs to Integrate and Monitor All Storage Vaults



Section VII: Conclusion

As early as possible, it is desirable that all five of the Non-Proliferation Treaty (NPT) nuclear powers, the P-5, be parties to New Court.⁵⁸ It is hoped that newly declared nuclear weapon states India and Pakistan as well as Israel would be drawn into the agreement after the P-5 states demonstrate its value. While many in the arms-control community are focused on numbers, it is control that is the most important factor—the detonation of, or an incident with, just one nuclear weapon will be an international catastrophe. Within the regime described above, in a more open and trusting environment, numbers will come down. There is no reason for a nation to maintain a large weapon stockpile with an expensive supporting complex if it adds little to the state's security. However, it will be decades (if ever) before the

number of nuclear weapons goes to zero. In the meantime, it is paramount that comprehensive safety and security be established and maintained.

The framework for a next step in nuclear arms control described in this paper has several advantages over the frequent cries from the arms control and disarmament community for acceleration in the START process. In this proposed new next step for nuclear arms control, there is no requirement for stockpile or material declarations and therefore the inaccuracies that will be inherent in such declarations will not undermine achieving agreement. There is no requirement to survey individual weapons or materials, thus avoiding protracted, and questionable, verification techniques and/or potential revelation of classified information. The proposed system will reduce the possibilities of reconstitution races. On the whole, it will place weapons in less threatening profiles. Since New Court places no constraints on strategic systems beyond those already agreed to in the START process, the impact on national strategic response capabilities can be acceptable, and therefore not impact the cornerstone of nuclear deterrence. The New Court proposal does not eliminate all safety and security dangers. The "insider" threat is still serious. A renegade command could take over weapons at a U-site and threaten to employ them. However, the proposed structure would increase global confidence in the safety, security, and use control of nuclear weapons. The added confidence alone would reduce anxieties and improve international relations. New Court would support an environment in which future measures could substantially reduce the number of weapons and stockpiles of weapon fissile materials.

The storage problem posed by the large, and rapidly growing, stockpile of commercial plutonium and weapons-grade fissile material is reasonably well understood. National and international panels of experts have repeatedly shattered the politicians' dream of a simple, cheap, permanent solution. Fissile material must be safely and securely stored for a considerable number of years. Simultaneously satisfying the requirements for storage, national security, safety and security, accountability, transparency, and transferability will require adroit handling of local, national, and transnational political factors. Cooperative diplomacy and agreement on universal standards will be necessary in developing an IMSF system. Defining the boundary for international bodies and operational responsibilities and providing the necessary funding will be a challenge. However, an international monitored storage system, providing a high level of security and safety, is technically feasible today. The system will require cooperation to establish but not an undue amount of trust to operate.

New Court and IMSFs will not be cheap. A detailed cost analysis needs to be undertaken. In Annex IA some costs for individual sensor systems are presented. They represent a small fraction of the cost of constructing and operating the facilities outlined in this paper. On the other hand, the cost will be small compared with that expended on nuclear weapon programs and nuclear power. Several of the countries whose participation is a necessary condition for success of the systems simply cannot afford even a fraction of their share based on the amounts of material they need to place under safe secure conditions. The major industrial nations will have to accept a substantial portion of the financial burden; the loss of just a few kilograms of fissile material could have catastrophic global implications.

Annex I: Perimeter/Portal Monitoring Technologies

The precedent for the general structure for perimeter/portal monitoring systems (PPMS) in the Nuclear Weapons Control Treaty (New Court) has been established by the United States and Soviet Union in the Intermediate-range Nuclear Forces (INF) Treaty in 1987 and the Strategic Arms Reduction Treaty (START) in 1991. The INF Treaty permitted the continuous monitoring of portals by up to thirty inspectors at a U.S. Pershing II plant and a Soviet SS-20 plant. The START I agreement allowed portal inspection at a Peacekeeper missile final assembly plant in Utah and an SS-25 assembly plant in Votkinsk, Russia, and an SS-24 plant in Pavlograd, Ukraine.⁵⁹

Since a New Court treaty will limit the number of inspectors permitted at a site, the perimeter monitoring systems rely heavily on instrumentation. Given that the fundamental purpose of the treaty is to provide all participants confidence in one another's safety and security systems, it is expected that the perimeter monitoring system would be integrated with the site boundary security system. The usual fences could contain embedded sensors, cleared zones could contain heat and motion detectors, and video surveillance cameras could watch over the site. Perimeter system seismic sensors could detect underground tunneling and radars and acoustic detectors could monitor airborne ingress and egress from the site. Appropriate, relatively cheap technologies for all these devices are available. Local and global networking can be secure, reliable, and low in cost to acquire and operate.

Annex IA: Technologies for Perimeter Monitoring⁶⁰

Infrared (IR) and microwave (MW) detection systems have been used for over two decades for perimeter security. Infrared sensors use an invisible beam between transmitters and receivers up to one hundred meters apart. Using multiple beams a vertical plane can be created. When the IR beam is broken the sensor generates an alarm. The system can detect individuals or vehicles creeping, crawling, or moving at relatively high speeds. The thin width of the detection plane is advantageous for monitoring narrow zones. Current costs are about \$10,000 for a set of transmitters and receivers covering a one hundred meter zone. With a photovoltaic power supply and radio frequency alarm the cost is approximately \$16,500. A disadvantage of IR systems is the degradation of performance in adverse weather and nuisance alarms due to windblown debris.

Microwave sensors are either monostatic or bistatic. In monostatic MW systems the transmitter and receiver are in a single housing, i.e. a radar. The detection zone is teardrop-shaped with a range of about one hundred meters. In bistatic systems the transmitter and receiver are at opposite ends of the detection zone. The detection zone is cigar-shaped, typically six to twelve meters wide and up to two hundred meters long. The MW systems have very low power requirements and can operate from batteries for days without recharging. The units are relatively cheap, \$3,000 to \$10,000 to cover a one hundred meter zone depending on whether an independent power supply and an RF alarm link is needed. Microwave sensors have similar disadvantages to IR systems.

Fiber-optic sensors can be added to existing fencing or buried in the ground. When a fiber is even slightly bent it changes the way it conducts light. Fiber-optic cable is undisturbed by lightning or high-voltage environments. Ground installation in gravel or sand can be used to

detect individuals or in paved roads to detect vehicles. Signal processing of the light can provide a high level of disturbance discrimination. Ground installations offer the advantage of being out of sight and eliminate many sources of false alarms. The sensor monitoring unit costs about \$2,500. The fiber cable costs two to three dollars a meter. High winds are a potential problem when placing the fiber in fences or other open areas.

Because of the simple design, flexible application, and low nuisance alarm rate, taut wire sensor technology has been used in perimeter intrusion detection systems for years. The systems can be installed on an existing fence or they can be freestanding. The sensor works on the premise that a wire will function as a spring over a wide temperature range. A sensor is located at the midpoint of the wire tightly strung between two anchor posts. If the wire is deflected by someone climbing over it or spreading it the sensor is displaced and causes an alarm. Cutting the wire causes the sensor to move because of the tension on the other side. The taut wire sensor is not disturbed by most environmental conditions and thus has low nuisance alarm rates. The wire can follow minor terrain variations. When built into a fence it acts as a barrier defining the perimeter boundary. The wires can be barbed and the sensed fence also becomes a deterrent. A two-and-a-half-meter-high taut wire fence with a one-meter barbed wire outrigger costs approximately \$200 per meter.

Another class of perimeter sensor is based on the measurement of ground motion. These seismic sensors were developed during the Vietnam War to monitor the traffic on trails. Today there exist algorithms and cheap small integrated processors that can do a great deal of discrimination on the source of seismic signals. However, while various forms of vehicles can reliably be identified, it can be hard to detect a single cautiously moving individual. There can be high false-alarm rates due to animals in the area. So seismic sensors are best placed in an area between fences or along vehicle routes with a high detection threshold. Seismic sensors also may be very useful for detecting any tunneling operations.

The use of video surveillance cameras is a popular approach for monitoring a zone or perimeter. The boundary inspectors can visually review each camera's signal. More appropriate to continuous operations, today's digital technology can analyze the camera's output for any changes from one frame to another and send an alarm when variations exceed selected criteria. The combination of the video camera with secure videotape systems provides a record that can be reviewed and used as evidence over perimeter violations. In designing an effective system one must take into account many issues, such as field of view, environmental conditions, system resolution, illumination, and tamper resistance. Each camera will have blind areas and overlapping geometries increase costs. The resolution requirements depend on the level of assessment desired: detection that an object has entered or exists in the observation zone, classification of an object—for example, an animal, a person, a car, or a truck—or identification of the type of object or a specific individual or vehicle. Because of experience gained in commercial operations and in the IAEA's monitoring of nuclear industry facilities, it is expected that video perimeter monitoring will be a required element of the overall systems.

Annex IB: Technologies for Portal Monitoring

An essential requirement of New Court is the establishment of portal monitors. The entrances and exits on the perimeter of the permitted facility sites are to be configured with

fissile material detectors, which must provide a reasonably high probability of detecting the passage of plutonium or uranium. This requirement includes both personnel passages as well as portals for vehicles that have not been certified as going to or coming from other New Court sites. There are four forms of radiation from the natural decay of fissile materials: alpha, beta, and neutron particles and gamma rays. Even the most energetic alpha particles (two protons and two neutrons) can be stopped by a single sheet of paper. Beta radiation (free electrons), because of the charge, is easy to stop with several sheets of aluminum foil. Neutron radiation has no charge and it must bounce off several atoms before it is slowed to a stop. The best neutron-shielding materials have low-atomic number materials such as lithium or boron-loaded polyethylene. Gamma radiation consists of high energetic photons and has no mass or charge. It is the most difficult to stop. The best shields consist of heavy elements such as lead or tungsten.

The fissile materials of interest are either uranium enriched to greater than 20 percent of the isotope U-235 (HEU) or plutonium that predominately contains the isotope Pu-239. Passive detection of HEU is a difficult problem; there is no significant neutron signature and its emission of low-energy gamma rays is relatively easy to shield. Complete access to shipping containers and/or active detectors for uranium at vehicle portals will almost certainly be required. Plutonium presents a somewhat easier detection problem. Plutonium emits much more energetic gamma rays. There is also an identifiable neutron emission, principally from the spontaneous fission of Pu-240. Plutonium alpha radioactivity generates a significant amount of heat; thus, infrared detection may be a practical complement to gamma and neutron detectors in some situations. However, all these signatures can be shielded. A 1/8-inch sheet of depleted uranium could reduce the signal by an order of magnitude. The vehicles that would regularly require ingress and egress from the facilities in the proposed system could easily contain several warheads and sufficient shielding to significantly reduce confidence in the passive detection of their presence. Thus, for detecting the presence plutonium, access to the material containers and/or active portal monitoring systems might be required. Note that the active system will have significant environmental and health protection requirements and be expensive to construct, operate, and maintain. Trade-off studies, in terms of operational and personnel costs, will need to be made. One approach is the use of radiation detectors as a screening procedure combined with direct inspection of vehicles whenever the portal monitoring personnel team chooses. Figures A-1 and A-2 show two vehicle portal monitoring configurations. In Figure A-1 passing vehicles are examined by instruments in the poles along the roadway and the observations transmitted to a central station. The configuration in Figure A-2 is a more controlled environment. All sides of the vehicle can be scanned simultaneously. The closed-station portal configuration is the type suggested in the report to inspect all vehicles that are not sealed and tagged for transit to another site within the New Court system.

Figure A-1: A Road Monitoring Portal



Figure A-2: A Vehicle Monitoring Station



Personnel portals will be relatively easy to monitor. Several factors operate in favor of the system. First, and most important, the amounts of material of concern in New Court are relatively large (hundreds of grams). As shown in the Figure A-3, a personnel passage provides a controlled environment, similar to the procedures in airport security installations. These can contain a number of passive instruments to detect metal, heat, and radiation. Tests show that there is 95 percent confidence that the detection probability exceeds 0.5 for fewer than 10 grams of unshielded HEU or 1 gram unshielded plutonium. Shielding would only make detection by a personnel portal more likely.

Figure A-3: A Personnel Portal



Annex II: Description of a “Stored Weapons Standard” for Protecting Weapons-Usable Fissile Material⁶¹

A U.S. National Academy of Sciences (NAS) committee has recommended that “to the extent possible, the high standards of security and accounting applied to storage of intact nuclear weapons should be maintained for [weapons-usable nuclear explosive] materials...” (NAS, “Management and Disposition of Excess Weapons Plutonium,” 1994, p. 31). The U.S. Department of Energy (DOE) has accepted this recommendation: “In other words, the most attractive types of material in the [DOE] graded safeguards system [graded in categories based upon quantity, enrichment, radioactivity, chemical form]—material that could be used directly in nuclear weapons or could be readily converted to such use—will, to the extent practicable, be protected and accounted for just as nuclear weapons themselves are” (DOE, “Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives,” 1997, p. 36.).

Neither of these two reports provides a description of what the stored weapons standard would require for storage of attractive weapons-usable materials. Both apply in principle to processing, use, and transport of such materials as well as to their storage. What follows is a description based upon the Department of Defense (DOD) directive and manual for protecting *stored* weapons (DOD, Directive 5210.41, Security Policy for Protecting Nuclear Weapons, and the Nuclear Weapons Security Manual issued pursuant to the Directive). Some parts of this manual are classified. The most important classified part appears to be the definition of the threat against which physical protection measures are to defend. The description that follows draws upon Nuclear Regulatory Commission regulations that are applicable to civil nuclear facilities and define the threat that should be the basis for designing *storage* protection against theft of “formula quantities” of “strategic special nuclear material,” i.e., 5 or more kilograms of uranium-235 enriched to 20 percent or more, and 2.5 or more kilograms of plutonium (10 Code of Federal Regulations, Part 73, Sec. 73.1 (a) (2) and 73.2). Because of a reference to the possibility of an airborne attack in the DOD manual, the description below adds helicopters to the NRC-assumed possible threat of attacking land vehicles. Otherwise, the design basis threat set forth below is drawn entirely from NRC regulations for protection *during storage* of weapons-usable material, not weapons.

Based upon the DOD manual and these NRC regulations, the “stored weapons standard,” the standard used by the United States Government to measure the adequacy of protection for its weapons against theft, is as follows:

1. *Design basis threat*: Each storage site’s protection must be based upon the assumption of realistic threats of theft from insiders or outsiders, or from insiders and outsiders working together.

The protection system must assume the following threats:

- a) a determined, violent, external assault; or attack by stealth or deceptive actions by an outside group. In each such case, the group may have the following:
 - (i) dedicated individuals with military training and skills;
 - (ii) inside assistance that may include knowledgeable individuals who can provide information, facilitate access and exit, disable alarms and communications, and participate in a violent attack;

- (iii) suitable weapons up to and including hand-held automatic weapons equipped with silencers having effective long-range accuracy;
- (iv) hand-carried equipment including incapacitating agents and explosives for use as tools of entry or destruction or damage to the storage site or its contents;
- (v) land vehicles or helicopters that can be used for transporting personnel and their hand-carried equipment, and the ability to operate as two or more teams; or

(b) an insider individual including an employee in any position within the inside organization responsible for the site.

(c) a conspiracy between insider individuals in any positions who may have access and detailed information about the site and have items that could facilitate theft of weapons (e.g., small tools, substitute material, false documents).

2. *Limited access.* Access to a storage vault for weapons-usable material must be limited to cleared personnel with need for access who identify themselves by badges, face or fingerprint monitoring devices, or other procedures. Armed guards must be present to enforce this requirement.

3. *Two-person rule and record-keeping for vault.* The two-person rule requires that there be present when the storage vault is visited at least two authorized, cleared persons capable of detecting incorrect or unauthorized procedures with respect to the work to be done in the vault. Records should be kept of all visits to the vault and of what is stored there and removed from there. These records should be transmitted to higher authority whenever they are made.

4. *Monitoring of vault.* Access by unauthorized persons should be detectable not just by armed guards and identification devices (see 2 above), but by monitoring sensors such as closed-circuit TV. Removal of nuclear material should be monitored by both armed guards and technical devices such as portal sensors. Redundant communications systems should be installed to assure command and control of guards, notification of suspicious events, and early assistance by a nearby backup force when needed. Such a force should consist of at least fifteen armed personnel.

5. *Vault.* This should ordinarily be “the most secure facility possible” with strong walls and only one entrance.

6. *Boundary barriers around vault.* Around the vault there must be a barrier system consisting of at least two layers of strong perimeter boundary fencing, an area warning system, barriers against ground vehicle and airborne assault, and cleared zones inside and beyond the fences so that intruders have no place to hide.

7. *Monitoring access within boundary barriers and beyond.* An intrusion detection system with electronic sensors must be able to detect movement of people and vehicles within and outside the barrier fences. At night, there must be lighting and night-vision equipment for this purpose. A site boundary detection system (to monitor the area of the site outside the barrier fences) must be able to detect the movement of people and vehicles across the site boundary. This monitoring system combined with the boundary barriers and the guard force must be capable of detecting attempted entry, of deterring unauthorized entry, and of providing sufficient delay to the attacking force so that the guard force combined with the backup force can execute the appropriate response.

8. *Security clearances and training for personnel.* Personnel responsible for the security of weapons-usable material should be selected after extensive screening including full-field background investigations to determine not just their qualifications but whether they might be security risks. This should include factors such as alcohol or drug addiction, unusual financial needs or expenditures, and associations with terrorist groups. These investigations should be repeated periodically. These personnel should be trained to do what they will be expected to do when employed. The training should include the use of individual and crew-served weapons and annual force-on-force exercises.

9. *Inspections.* Vulnerability assessment teams should periodically review the protection provided by physical protection systems. These teams should include security specialists from outside the span of control of the commander of the weapons-usable material storage site. They are directed to concentrate on means to bypass, subvert, overwhelm, or interrupt elements of the security system, including the two-person rule. They should make a written report on their findings to the commander and to higher authority.

Notes

¹ Bush and Conant to Stimson, with encl., Sept. 30, 1944, Records of the Office of Scientific Research and Development, U.S. Department of Energy.

² Records of the Manhattan Engineer District, 1942–1948, World War II Records Division, National Archives and Records Service, Alexandria, Virginia.

³ Memo Bush to Byrnes, No. 5, 1945, Records of the Office of Scientific Research and Development, U.S. Department of Energy.

⁴ Opening address at the first meeting of the United Nations Atomic Energy Commission, UNACE Official Records, June 14, 1946.

⁵ Fissile materials are those whose atomic nuclei can be fissioned by neutrons of all energies. Generally, fissile materials are required to sustain a chain reaction in a weapon. The principal isotopes of interest are uranium-235 and plutonium-239.

⁶ The *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*, signed January 27, 1967, prohibits placing in orbit around Earth any objects carrying nuclear weapons or any other kinds of weapons of mass destruction, installing such weapons on celestial bodies, or stationing such weapons in outer space in any other manner.

⁷ The *Treaty for the Prohibition of Nuclear Weapons in Latin America*, signed in Mexico, February 14, 1967.

⁸ The *Treaty on the Non-Proliferation of Nuclear Weapons* was signed in July 1968 and extended indefinitely in 1998.

⁹ Concern that the world had been on the verge of nuclear war during the Cuban missile crises in the fall of 1962 was the principal driver for the “Hot Line” agreement in June 1963 and further energized the effort toward the LTBT.

¹⁰ South Africa, in unique circumstances, dismantled its stockpile of six u-235 atomic bombs in the early 1990s with the country’s accession to the NPT. Belarus, Ukraine, and Kazakhstan returned the weapons they “inherited” from the collapse of the Soviet Union to Russia. It is reported that Ukraine required the weapons it returned to Russia be dismantled, but there was no international verification.

¹¹ For example, note General (ret.) Lee Butler’s statement at the National Press Club, December 4, 1996, Washington, DC.

¹² The Canberra Commission on the Elimination of Nuclear Weapons report was presented at the Conference on Disarmament by the Australian minister for foreign affairs, Mr. Alexander Downer, Jan. 30, 1997, <http://www.dfat.gov.au/dfat/cc/cchome.html>.

¹³ See also Steve Fetter, *Verifying Nuclear Disarmament*, The Henry L. Stimson Center, Occasional Paper No. 29, October 1996, and *Management and Disposition of Excess Weapons Plutonium*, U.S. National Academy of Sciences Committee on International Security and Arms Control, January 1994, and *Nuclear Arms Reduction: The Process and Problems*, edited by A. S. Diakov, Center for Arms Control, Energy and Environmental Studies, Moscow Institute of Physics and Technology, Oct. 1997, 4.3.1.

¹⁴ A declaration of stockpiles of nuclear weapons and all fissile materials and measures to confirm the declarations was also a principal recommendation of National Academy of Sci-

ences, *Management and Disposition of Excess Weapons Plutonium*, National Academy Press, Washington, DC, 1994.

¹⁵ *Plutonium: The First 50 Years*, Feb. 1996, <http://apollo.osti.gov/html/osti/opennet/document/pu50yrs/pu50y.html>.

¹⁶ *Plutonium: The First 50 Years*, Feb. 1996, from Figure 1: U.S. Plutonium: Where It Came From and Current Balance Statement, <http://apollo.osti.gov/html/osti/opennet/document/pu50yrs/pu50y.html>.

¹⁷ *Plutonium: The First 50 Years*, Feb. 1996, from Figure 1: U.S. Plutonium: Where It Came From and Current Balance Statement, <http://apollo.osti.gov/html/osti/opennet/document/pu50yrs/pu50y.html>.

¹⁸ Some Russians today are concerned that the U.S. B-1B bomber has not been fully converted to a conventional configuration. *Nuclear Arms Reduction: The Process and Problems*, edited by A. S. Diakov, Center for Arms Control, Energy and Environmental Studies, Moscow Institute of Physics and Technology, Oct. 1997, 4.1.1 and 4.1.2.

¹⁹ A copy of the letter appears in Frank H. Shelton, *Reflections of a Nuclear Weaponeer* (Colorado Springs, CO: Shelton Enterprises, Inc., 1988), 1–3.

²⁰ *Nuclear Arms Reduction: The Process and Problems*, edited by A. S. Diakov, Center for Arms Control, Energy and Environmental Studies, Moscow Institute of Physics and Technology, Oct. 1997, 4.3.1.

²¹ *Nuclear Arms Reduction: The Process and Problems*, edited by A. S. Diakov, Center for Arms Control, Energy and Environmental Studies, Moscow Institute of Physics and Technology, Oct. 1997, 4.3.1.

²² DOE Order 5610.10, *Nuclear Explosive and Weapon Safety Program*, October 10, 1990.

²³ A list of the START-inspectable sites can be found at the Web site of the On-Site Inspection Agency, <http://www.dtra.mil/news/facts/stus97.html>.

²⁴ <http://www.dtra.mil/news/facts/stfsu97.html>.

²⁵ The START Treaty, inspection protocols, and definition of terms can be found at the Arms Control and Disarmament Agency web site, <http://www.acda.gov/starhtml/toc.htm#toc>.

²⁶ The U.S. site is the Alliant Plant #1 at Magna, Utah, and the Soviet site is the Votkinsk Machine Building Plant in Votkinsk, Russia.

²⁷ START I permitted continuous monitoring of the portals at the Votkinsk, Russia, and Pavlograd, Ukraine, strategic missile assembly sites. The United States ceased its monitoring of Pavlograd in May 1995. The Soviet Union has the right to monitor operations at the Thiokol plant in Promontory, Utah, but the USSR (now Russia) has not exercised its right. See <http://www.osia.mil/news/facts/stus97.html>.

²⁸ <http://www.cmc.sandia.gov/vtour/ar-missile-monitoring/index.htm>.

²⁹ In order to define the conditions and requirements involved, START is over 900 pages long.

³⁰ The National Academy of Sciences, in *Management and Disposition of Excess Weapons Plutonium*, created the term “nuclear weapons standard” but provided no definition.

³¹ *Convention on Nuclear Safety*, 33 I.L.M. 1514 (1994).

³² *Convention on the Physical Protection of Nuclear Materials*, 18 I.L.M. 1419 (1979).

- ³³ The PPC entered into force in 1987.
- ³⁴ IAEA document, *Recommendations for the Physical Protection of Nuclear Materials*, INFCIRC/225/Rev.2, 1989.
- ³⁵ Bonnie D. Jenkins, "Establishing International Standards for Physical Protection of Nuclear Material," *The Nonproliferation Review* 5, no. 3 (Spring–Summer 1998).
- ³⁶ Bonnie D. Jenkins, "Establishing International Standards for Physical Protection of Nuclear Material."
- ³⁷ DOE ORDER 5632.1C, July 15, 1994, Protection and Control of Safeguards and Security Interests.
- ³⁸ DOE M 5632.1C-1, July 15, 1994.
- ³⁹ DODD 5210.41, Security Policy for Protecting Nuclear Weapons, Sept. 23, 1988, <http://web7.whs.osd.mil/text/d521041p.txt>.
- ⁴⁰ DoD C-5210.41M, Nuclear Weapon Security Manual, classified confidential.
- ⁴¹ Military Handbook: Design Guidelines for Physical Security of Facilities, MIL-HDBK-1013/1A, Dec. 15, 1993.
- ⁴² If the agreed number of at-site inspector/monitors were a total of thirty-six, then for five signatories each foreign country would be allowed at least nine positions; if there were four parties to the treaty then each would be allowed twelve positions; and for three parties the allowance would be eighteen.
- ⁴³ See Annex IA for a description of perimeter sensor and fence technologies.
- ⁴⁴ The P-5 nations are the permanent members of the UN Security Council: France, the United Kingdom, Russia, China, and the United States. They are the nuclear weapon states identified in the NPT.
- ⁴⁵ President Clinton and President Yeltsin, Joint Statement on Parameters on Future Reductions in Nuclear Forces, Helsinki, Finland, March 21, 1997.
- ⁴⁶ In September 1991, President George Bush announced that all U.S. short-range systems and all naval air and ASW weapons would be moved to storage within the United States.
- ⁴⁷ The rationale for reserve weapons (R-weapons) will continue to be as backup if something technical goes wrong with the weapons assigned to delivery systems (D-weapons) or as the immediate response force to a breakout attempt.
- ⁴⁸ On March 1, 1995, President Clinton announced that approximately 200 metric tons of U.S.-origin weapons-usable fissile materials had been declared surplus to defense needs. This included 165 tons of HEU and 38 tons of weapons-grade plutonium.
- ⁴⁹ Management and Disposition of Excess Weapons Plutonium, National Academy of Sciences: Committee on International Security and Arms Control, National Academy Press, Washington, DC 1994, p. 13.
- ⁵⁰ *Can Terrorists Build Nuclear Weapons?* <http://www.nci.org/makeab.htm>.
- ⁵¹ Management and Disposition of Excess Weapons Plutonium, National Academy of Sciences: Committee on International Security and Arms Control, National Academy Press, Washington, DC 1994, p. 4.
- ⁵² DOE Office of Fissile Materials Disposition, *The Spent Fuel Standard*, Rev. 0, Feb. 1995.

⁵³ National Academy of Sciences, Executive Summary, Management and Disposition of Excess Weapons Plutonium, National Academy Press, Washington, DC, 1994, p. 13.

⁵⁴ A copy of Professor Bunn's *Description of "Stored Weapons Standard" for Protecting Weapons-Usable Fissile Material* is presented in Annex III.

⁵⁵ For example, A Comparative Analysis of Approaches to the Protection of Fissile Materials Workshop at Stanford University, July 28–30, 1997.

⁵⁶ <http://www.cmc.sandia.gov/facts/sline.html>.

⁵⁷ <http://magtomag.ca.sandia.gov>.

⁵⁸ Article IX (3) of the Non-Proliferation Treaty states "For the purposes of this Treaty, a nuclear-weapon State is one which has manufactured and exploded a nuclear weapon or other nuclear explosive device prior to January 1, 1967." The five countries satisfying this condition are China, France, Russia, the United Kingdom, and the United States.

⁵⁹ The Russians have not exercised their treaty right to monitor the portals at the Thiokol Peacekeeper facility in Promontory, Utah, and in an agreement with the Republic of Ukraine the United States ceased monitoring the Pavlograd plant in May 1995.

⁶⁰ For a virtual tour of monitoring technologies visit Sandia National Laboratories' Cooperative Monitoring Center web site, <http://www.cmc.sandia.gov>.

⁶¹ Appendix in George Bunn, "U.S. Standards for Protecting Weapons-Usable Fissile Material Compared to International Standards," *Nonproliferation Review* 6, no. 1 (Fall 1998), 141–143.

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