Strengthening Nuclear Security Against Post-September 11 Threats of Theft and Sabotage

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Abstract
The appalling events of September 11, 2001, require a major international initiative to strengthen security for nuclear materials and facilities worldwide, and to put stringent security standards in place. This paper recommends a range of specific steps to upgrade security at individual facilities and strengthen national and international standards, with the goal of building a world in which all weapons-usable nuclear material is secure and accounted for, and all nuclear facilities are secured from sabotage, with sufficient transparency that the international community can have confidence that this is the case.

Introduction
The attacks of September 11, 2001, make clear that the threat of large, well-organized global terrorist groups bent on causing mass destruction is not hypothetical but real. Attackers armed with box-cutters achieved horrifying destruction. There can be little doubt that if they had had access to nuclear weapons, they would have used them. Osama bin Laden has called the acquisition of weapons of mass destruction a "religious duty." Indeed, there is evidence that bin Laden's Al Qaeda organization has been seeking nuclear weapons and weapons-usable nuclear material—and that they had procured diagrams of U.S. nuclear power plants, possibly in preparation for an attack on such a facility.[1]

On September 11, the threat revealed itself to be bigger, smarter, better organized, and more deadly than the threats most of the world's security systems were designed to defend against. We must ensure that our defensive response is every bit as intelligent and capable as the attackers of September 11. Fragile modern industrial societies present a wide range of targets for attacks that could cause mass destruction or mass disruption, many of which would be far easier to attack than nuclear weapons, materials, or facilities. Nevertheless, given the horrifying consequences if a terrorist group did manage to acquire a nuclear explosive or destroy a nuclear power plant—or if nuclear weapons or fissile material to make them were to fall into the hands of a hostile state —every reasonable effort must be made to ensure that these materials and facilities are effectively secured.[2]

International Arms Control: Now More Than Ever
This paper focuses on steps to strengthen security for nuclear material and facilities. But for that effort to be fully effective, it will have to be built on a solid structure of arms control and nonproliferation measures binding states to norms and rules of behavior, and to cooperative approaches to security problems. Arms control and nonproliferation agreements bind bureaucracies into implementing good practices, add strength to the arguments of domestic advocates of improved controls, and give governments more authority in regulating facility operators and private enterprises. In the case of nuclear materials, the necessary regime would include a strengthened and adequately funded IAEA safeguards system, international requirements to protect nuclear material from theft and sabotage, a verified cutoff in the production

of fissile material for weapons, international verification of the removal of large quantities of fissile material from military stockpiles, and other measures.[3] Politically, these efforts cannot be a one-way street: if the United States wishes to build international political support for new security measures that will involve constraints and inconveniences for non-nuclear-weapon states, it will have to re-engage on multilateral arms control, including supporting measures that impose some constraints and inconveniences on its own forces and facilities. As George Bush Sr. remarked on September 13, the terrorist attacks should "erase the concept that America can somehow go it alone in the fight against terrorism, or in anything else for that matter."[4]

The Threat of Nuclear Theft

Limited access to fissile materials—the essential ingredients of nuclear weapons—is the principal technical barrier to nuclear proliferation in the world today. As the U.S. Department of Energy has officially warned:

> *"Several kilograms of plutonium, or several times that amount of HEU [highly enriched uranium], is enough to make a bomb. With access to sufficient quantities of these materials, most nations and even some subnational groups would be technically capable of producing a nuclear weapon…"*[5]

Acquisition of such material could shorten a proliferator's bomb program from years to months. The international community could be faced with a new threat with little warning. Reactor-grade plutonium poses nearly as great a proliferation threat as weapons-grade plutonium.[6]

Those seeking to acquire nuclear material will go wherever it is easiest to steal, and buy it from anyone willing to sell. Hence, vulnerable weapons-usable nuclear material anywhere is a threat to everyone everywhere. While security for nuclear material has traditionally been seen as solely a national responsibility, the international community has an overwhelming interest in seeing that all such material is secure and accounted for.

Global stockpiles of such material are large and widespread. A decade after the end of the Cold War, there are still some 30,000 nuclear weapons in the world (more than 95 percent of them in the U.S. and Russian arsenals). The world's stockpiles of separated plutonium and HEU, the essential ingredients of nuclear weapons, are estimated to include some 450 metric tons of military and civilian separated plutonium, and over 1,700 metric tons of HEU.[7] These stockpiles, both military and civilian, are overwhelmingly concentrated in the five nuclear weapon states acknowledged by the nuclear Non-Proliferation Treaty, but enough plutonium for many nuclear weapons also exists in India, Israel, Belgium, Germany, Japan, and Switzerland. [8] In addition, some twenty metric tons of civilian HEU exist in civilian nuclear research facilities in at least forty-three countries, sometimes in quantities large enough to make a bomb.[9] As we will see, levels of security and accounting for both the military and civilian material vary widely, with no binding universal standards in place. Some weapons-usable material is so poorly secured and accounted for that, even if it were stolen, no one might ever know.

This problem is most acute today in the former Soviet Union, where the collapse of the Soviet state left a security system designed for a closed society with closed borders, well-paid nuclear workers, and everyone under close surveillance by the KGB, facing a new world it was never designed to address.[10] Nuclear weapons, which are large and readily accountable objects, remain under high levels of security—though even there, scarce resources for maintaining security systems and paying nuclear guards raise grounds for concern. For nuclear material, the problem is more urgent. Many nuclear facilities in Russia have no detector at the door that would set off an alarm if someone were carrying out plutonium in a briefcase, and no security cameras where the plutonium is stored. Nuclear workers and guards protecting material worth millions of dollars are paid less than $200 a month. As a result, there have been a number of confirmed cases of theft of kilogram quantities of weapons-usable material in the former Soviet Union. Russian officials have confirmed that as recently as 1998 there was an insider conspiracy at one of Russia's largest nuclear weapons facilities to steal 18.5 kilograms of HEU—a theft that was stopped before the material actually left the gates.[11] These are the conditions that led a distinguished U.S. bipartisan panel to warn, as the Bush Administration took office in early 2001, that "the most urgent unmet national security threat to the United States today is the danger that weapons of mass destruction or weapons-usable material in Russia could be stolen and sold to terrorists or hostile nation states."[12]

The problem of insecure nuclear material, however, is by no means limited to the former Soviet Union. Indeed, in the United States itself, which probably has some of the toughest physical protection regulations in the world, there have been repeated scandals going back decades over inadequate security for weapons-usable nuclear material.[13] In some countries around the world, there are research facilities with fresh or lightly irradiated fuel that simply do not have the resources to sustain effective security for this material over the long haul. The problem was highlighted by the 19.9 percent enriched uranium seized in 1998 from criminals trying to sell it in Italy, which appears to have been stolen from a research reactor in the Congo.[14] Theft of insecure HEU and plutonium, in short, is not a hypothetical worry: it is an ongoing reality, not only from the former Soviet Union but from other states as well.

At the same time, thousands of people worldwide have critical knowledge related to the manufacture of nuclear

weapons and their essential ingredients. In October 2000, an official of Russia's Security Council confirmed that the Taliban had unsuccessfully attempted to recruit a Russian nuclear expert—and that three of his colleagues had left his institute for countries unknown.[15]

The Threat of Nuclear Sabotage or Radiological Dispersal

A range of means is available by which terrorists might seek to disperse radioactive contamination—with the goal either of causing mass fatalities or simply provoking fear and economic disruption.

By far the most potentially devastating radiological attack (but also the most difficult to accomplish) would be to sabotage a nuclear power plant or spent fuel pool—both of which have huge concentrations of intensely radioactive material, and both for which scenarios exist for generating the nuclear or chemical energy needed for dispersing it widely.[16] Studies sponsored by the U.S. Nuclear Regulatory Commission have projected, in a worst case, over a 100,000 deaths from a beyond design-basis accident, as might be caused by successful sabotage.[17] Unlike many other hazardous industrial facilities, nuclear power plants in some countries are protected by containment vessels several feet thick, are equipped with redundant safety systems, and are protected by armed guards and other security systems. To cause a core meltdown and disperse a substantial fraction of the radioactive material into the atmosphere would require defeating a well-protected plant's security systems and destroying or disabling multiple safety systems simultaneously. Nevertheless, nuclear power plants have been the subject of some terrorist interest: threats or attempts to blow up or penetrate nuclear reactors have been reported in Argentina, Russia, Lithuania, Western Europe, South Africa, and South Korea.[18]

In the United States, the NRC requires that nuclear power plants have armed guard forces and a variety of barriers capable of protecting the plants from a small group of well-armed terrorists, possibly working with one insider at the plant; since 1994, the plants have also been required to be protected against truck bombs (though there is ongoing debate as to whether currently required protections are sufficient, as a 1984 Sandia National Laboratories study concluded that large truck bombs could potentially cause unacceptable damage to critical safety systems even if detonated outside the protected area of some plants).[19] Roughly half the U.S. commercial nuclear power plants have failed tests involving a threat of the kind specified in the regulations (typically involving only a few attackers, and an insider involved only in providing information)—where failure means that the test attackers would have been able to destroy critical safety systems.[20] After such tests, security upgrades are undertaken to correct identified deficiencies.

There appear to be wide variations in national practices with respect to security for nuclear material and facilities. A study of the physical protection practices that were described by experts to two 1997 conferences at Stanford and the IAEA showed great variation in practices from country to country: many countries did not even explicitly identify terrorism or sabotage among the threats their systems were designed to defend against.[21] In a small but more recent Stanford survey of country physical protection practices, six of seven respondents did not indicate having any special plans to deal with sabotage, such as a truck-bomb attack, that was intended to spread radioactive material beyond the protected area of a nuclear facility.[22] Significant variations from country to country in security practices for similar facilities were identified by nuclear experts asked by the IAEA to review facilities in ten countries. The experts reported: "Differences in culture, perceived threat, financial resources and technical resources, and national laws are some of the reasons for variations."[23] Overall, internationally required standards, accompanied by an effective and well-financed effort to assist countries in meeting them, could do much to reduce these differences in practices and improve national standards.

In addition to power plants, spent fuel storage and processing facilities are another target whose destruction could conceivably lead to catastrophic releases.[24] In the case of dry cask stores, while it is certainly possible to imagine scenarios in which one or more casks might be destroyed, the prospects for mobilizing large quantities of radionuclides into the atmosphere seem much more limited. Spent fuel transports are another potential target for sabotage. Anti-tank weapons could be used in attempts to penetrate the spent fuel casks and disperse some of the radioactivity.[25]

Other forms of nuclear terrorism have the potential to cause enormous fear and disruption, given the public fear of anything "radioactive," and could result in large economic and cleanup costs, but would not be likely to result in large numbers of fatalities. In particular, although there are many lurid press accounts of the possibility of radiological "dirty bombs," it would be difficult for terrorists to cause large numbers of fatalities by this means.[26]

Current International Cooperative Efforts to Improve Security, Strengthen Standards

In recent years, there have been substantial international cooperative efforts both to upgrade the security of specific facilities around the world and to put more effective security recommendations and standards in place—and a number of new steps have already been taken or proposed since the September 11 attacks.

The United States has spent hundreds of millions of dollars on cooperative efforts with the states of the former Soviet Union to modernize MPC&A systems at dozens of nuclear sites. Other nations have contributed to this effort as well. Substantial international cooperation has also focused on

improving capabilities to monitor, analyze, and interdict illicit trafficking in nuclear materials. The IAEA has established an International Physical Protection Advisory Service, which offers international expert peer reviews and coordinates donor state assistance for upgrading physical protection at the request of member states. Through that mechanism and others, significant physical protection upgrades have been accomplished in several countries outside the former Soviet Union as well. However, because of inadequate funds, IPPAS has been able to conduct peer reviews in only twelve such countries since it began in 1995.

Standards and recommendations have also been upgraded. A substantial revision of the IAEA's recommendations on physical protection was completed in 1999 (INFCIRC 225/Rev. 4). New initiatives have been undertaken to provide assistance to states in developing design-basis threats for their physical protection systems, and to expand international physical protection training. However, the only treaty in this area is the Convention on the Physical Protection of Nuclear Material, which calls for physical protection measures only for material in international transport (or storage incidental to such transport). Furthermore, its protection requirements are against theft of nuclear material, not against sabotage—and are extremely general.[27] The Convention includes no mechanisms for verification—not even voluntary reports on, or peer review of, physical protection practices.

In 1998, the United States proposed that the Convention be amended to (a) extend its coverage to civilian nuclear material in domestic storage, use, and transport; (b) require that at a minimum, states provide levels of protection comparable to those recommended in INFCIRC 225; and (c) require that states provide reports on their physical protection arrangements every five years, to be discussed at international conferences that would also take place every five years.[28] The IAEA Director General convened an experts' meeting, which recommended drafting an amendment to the Convention. Their pre-September 11 consensus report recommended extending the Convention's coverage to civilian nuclear material in domestic use, storage, and transport; adding a requirement to protect against sabotage of nuclear facilities as well as theft of nuclear material; and stating twelve general principles for physical protection in the Convention. These principles included, for example, a call for each party to the treaty to adopt a national regulatory framework to govern its physical protection practices. The report was welcomed by the September 2001 IAEA Board of Governors and General Conference meetings, and the twelve principles were approved.[29]

The experts' consensus recommendations did not include any specific standards for domestic physical protection. They did not include any requirement that states prepare a report to the IAEA or to other states on their physical protection arrangements and regulations; any mechanism for international peer review of such arrangements; or any reference to the much more detailed IAEA physical protection recommendations (INFCIRC 225/Rev.4), even that these be "taken into account." The experts' "principle" calling for a national regulatory framework also called for an independent national regulatory agency and national inspections to verify compliance with national requirements.[30] This is useful in itself, but some experts have relied on it to oppose international verification and international standards for physical security. In our view, in the aftermath of September 11, the experts' pre-September 11 consensus in these areas should be fundamentally reconsidered: while national sovereignty in the area of nuclear security is important, so is every state's interest in making sure that every other state is carrying out its responsibilities in these areas appropriately.

Several post-September 11 developments are worth noting. First, most major states heightened security for their own nuclear facilities and undertook reviews of their national requirements for protection of nuclear material and facilities from terrorist theft or attack.

For example, the U.S. NRC immediately recommended that all nuclear reactors go to their highest state of alert; national guard forces were called out to protect reactors in some areas; and the NRC has since been conducting a "top to bottom review" of its nuclear security requirements, a review that is leading to new orders to heighten security.[31] France has installed anti-aircraft missiles to protect its La Hague reprocessing facility; Japan has put armed guards in place at its nuclear facilities for the first time.[32]

Second, substantial steps have been taken to expand and accelerate U.S.-Russian cooperative efforts to upgrade security and accounting for nuclear materials. In December 2001, Congress allocated an additional $226 million to DOE nonproliferation programs in the emergency supplementary legislation (including $120 million for MPC&A and nuclear smuggling interdiction bringing that total to $293 million), along with related funds for the Department of State; President Bush, in an important December 11 speech at the Citadel, emphasized the crucial importance of keeping weapons of mass destruction out of terrorist hands, along with the vital role of cooperation with Russia in achieving that objective, and pledged to ask Congress for "an overall increase in funding to support this vital mission,"[33] and the Bush administration completed its review of threat reduction programs with Russia, endorsing most of the efforts and targeting some for expansion.[34] While the budget President Bush sent to Congress on February 4, 2002, represented a reduction in some categories from the substantial sums Congress had voted after September 11, it nonetheless offered substantially more for these efforts than any of the Clinton budgets. And with the new spirit of U.S.-Russian anti-terror partnership following the September 11 attacks, the chances have improved for accelerating implementation of these security upgrades.

Third, international security upgrade cooperation coordinated by the IAEA has also been expanded and accelerated since September 11, and a much larger expansion proposed. In late October, the private Nuclear Threat Initiative announced a $1.2 million three-year grant—which was soon matched by a new U.S. government contribution—to expand and accelerate the IAEA's physical protection review and upgrade program.[35] At the November 2001 IAEA Board of Governors meeting, the IAEA secretariat proposed a broad program of IAEA activities intended to help prevent nuclear terrorism—including efforts to upgrade security for nuclear material and facilities around the world—with an estimated price tag of $30-$50 million per year.[36] The member states are expected to indicate soon how much they are willing to pay for such a program.

At the same time, efforts to negotiate actual amendments to the Convention on Physical Protection have made little progress. Even if these talks succeed, any draft amendment produced by a working group must be formally reviewed by the Convention's parties, a majority of whom must agree to convene an amendment conference; then, two-thirds of the parties must ratify the amendment before it can enter into force.[37] Years are likely to elapse before that can happen.

The Vision: A World of Secure Materials and Facilities

In the aftermath of September 11, our goal must be of a world in which:

- Every nuclear weapon and all weapons-usable nuclear material worldwide is secure and accounted for, to stringent standards;
- All high-consequence nuclear facilities (and high-consequence material transports) are secure from both insider and outsider sabotage and attack;
- Effective measures are put in place to interdict nuclear smuggling;
- There is sufficient transparency to give the international community confidence these steps have been undertaken.

Of course, it is not possible to defend every facility against every imaginable threat. Society has other things to secure besides nuclear material and facilities, and other things to expend its resources on besides security. The debate over "how much security is enough?" is crucial, and has only just begun. While some security facts must be kept secret, this debate must be as transparent as possible, allowing a well-informed public to make judgments as to how much it believes should be spent to reduce the risks, and what remaining risks are acceptable. In the United States, for example, while some have complained that the NRC's physical protection regulations are not strong enough, at least the broad outlines of the requirements are openly published, making them available for public discussion and debate[38]—which is not the case in many other countries.

The stakes justify a significant investment in improving security worldwide. Given that states have been willing to spend billions of dollars on their efforts to produce fissile material—and given that a single bomb could threaten tens of thousands of lives—the level of effort devoted to securing and accounting for stocks of even a few kilograms of fissile material should be higher than that devoted to protecting large amounts of money. This is manifestly not the case at many facilities in many countries today. Indeed, a strong case can be made that the essential ingredients of nuclear weapons should be protected roughly as rigorously as nuclear weapons themselves are, as a committee of the U.S. National Academy of Sciences recommended in 1994.[39]As the DOE regulations on physical protection put it, "use of weapons of mass destruction by a terrorist(s) could have consequences so grave as to demand the highest reasonably attainable standard of security."[40] Safeguards and security today are a small contribution to nuclear costs: To take one example, even at the THORP reprocessing plant, one of the most sensitive civilian nuclear facilities in the world, capital cost was over $5 billion in current dollars, annual operating costs are nearly $500 million—but security costs for all the plutonium operations for THORP and other facilities at the Sellafield site are estimated by BNFL at $15 million per year.[41] Thus substantial security increases could be implemented for costs that are low by comparison to what states are accustomed to spending for military security, or when judged as a proportion of the costs of nuclear-generated electricity.

Priority One: Implementing Security Upgrades

Below, we provide a range of specific suggestions for action in the wake of the September 11 attacks, grouped into two main categories—first, direct steps to implement security upgrades at specific facilities and to interdict nuclear smuggling, and, second, steps to strengthen national and international security standards.

- Every nation state with weapons-usable nuclear materials or high-consequence nuclear facilities should urgently assess its security arrangements and regulations in light of the magnitude of the threat demonstrated on September 11, and upgrade them where necessary. If technical assistance is needed to perform security reviews, the state should request that the IAEA IPPAS program organize a peer review —and if the state does not have adequate resources to carry out needed upgrades, it should request that the IAEA organize assistance.
- Working with Russia, the United States should launch a new initiative to control and secure weapons of mass destruction in both their countries and worldwide. The September 11 attacks have created a security moment as unique as the collapse of the Soviet Union, justifying a new initiative on the scale of the

Nunn-Lugar initiative launched at that time—a new "Alliance Against Catastrophic Terrorism," which could be led jointly by the United States and Russia.[42] As recommended in the Baker-Cutler report of January 2001, the United States should (a) work with Russia to develop a strategic plan "to secure and/or neutralize in the next eight to ten years all nuclear weapons-usable material located in Russia, and to prevent the outflow from Russia of scientific expertise that could be used for nuclear or other weapons of mass destruction"; (b) appoint a senior official to manage the many programs involved; and (c) appropriate the funds needed to implement this effort as rapidly as possible—significantly more than even the expanded Bush requests since September 11.

- In particular, as part of such an initiative, the United States and Russia should drastically accelerate their joint cooperation to improve MPC&A. Other states should substantially increase their contributions to this effort as well. This would include: (a) substantially increased funding (to a U.S. budget in the range of $300 million for fiscal year 2003, for example); (b) joint U.S.-Russian development of a strategic plan to complete the needed upgrades as rapidly as the job can be accomplished, and to put the initial "rapid upgrades" in place within, for example, two to three years; (c) high-level Russian commitment to sustain effective security and accounting after U.S. and international assistance phases out in the future, with a working group established to work out specific measures and commitments for sustainability; (d) agreement on a drastically expanded and accelerated effort to consolidate nuclear material in fewer buildings and facilities, including providing comprehensive incentives to facility managers to give up their material; (e) agreement on a "rapid accounting" initiative, in which all nuclear weapons and weapons-usable materials would be identified, tagged, and sealed very rapidly, with the more laborious process of actual measurement of the nuclear material following behind;[43] (f) rapid agreement on measures to sweep aside the disputes over access and assurances to ensure that U.S.-funded upgrades at sensitive facilities are implemented appropriately; and (g) a greatly increased focus on achieving security that can be and will be sustained after initial upgrades are complete, including strengthened MPC&A regulation and a wide range of other measures related to resources, organizations, and incentives to sustain MPC&A.[44] The scope of these efforts should be expanded to include physical protection assistance needed to prevent catastrophic sabotage.
- As additional elements of such an initiative, the United States and Russia should also accelerate their other cooperative programs designed to secure, monitor, and reduce stockpiles of nuclear weapons, plutonium, and HEU; downsize nuclear complexes and re-employ nuclear weapons and materials experts; interdict nuclear smuggling; and control sensitive nuclear exports. Here, too, other states should substantially expand their contributions. This would include, for example, measures to accelerate the blend-down of highly enriched uranium, and to place excess weapons plutonium under international verification and transform it into forms no more usable in nuclear weapons than commercial spent fuel.[45]
- The United States and other major nuclear states should provide substantial funding—at least several tens of millions of dollars for the coming year—to finance MPC&A upgrades and assistance for sustaining high levels of security in other countries around the world—focused both on securing nuclear material and on preventing sabotage. The package the IAEA proposed to the Board of Governors is an excellent start.
- States that in the past have had no armed guards at their nuclear facilities should reconsider, and develop appropriate approaches to deploying armed security personnel at each nuclear facility with weapons-usable nuclear material or whose sabotage could cause a major catastrophe.
- The United States and other major nuclear states should finance a drastic increase in physical protection training around the world, as recommended in the final report of the IAEA-convened experts group. This training should include not only technical training, but discussion of the crucial role of such security in preventing the spread of nuclear weapons and stopping nuclear terrorism. Effective training is crucial to improving security and assuring that improvements are sustained over time.[46]
- The budget and personnel available to the IAEA's physical protection program should be drastically increased—going well beyond the U.S. private and government grants to the IAEA mentioned above—making it possible, for example, to carry out a much larger number of missions to help member states improve security measures, and to provide more effective follow-up to such missions.
- International cooperative efforts to reduce the number of sites around the world where HEU and separated plutonium are stored should be drastically expanded. Small, potentially insecure facilities using HEU or plutonium should be provided with targeted incentives to give up this material, which could include assistance with other research that did not require it, offers to purchase the material, help in decommissioning research reactors and critical assemblies, help in managing

spent fuel and other wastes, and funding for conversion to low-enriched uranium. In particular, the budgets available for converting HEU-fueled research reactors to LEU, taking back fresh and spent research reactor fuel to the country of origin, and developing new higher-density fuels should be substantially increased, so that these efforts can be accelerated—including particularly Russian take-back of Soviet-supplied HEU from vulnerable sites around the world.

- Every state with weapons-usable nuclear materials should review, and strengthen as necessary, the accuracy and effectiveness of its state system of accounting and control—as control and accounting systems are an important part of preventing and detecting insider theft. Non-nuclear-weapon states party to the NPT already have state control and accounting systems reviewed by the IAEA, as it implements safeguards. The nuclear weapon states should each undertake a self-audit, identifying the quantities and locations of all of its weapons-usable nuclear material, and matching these to historical production and use (comparable to the audit the United States undertook as part of its Openness Initiative).[47]
- Firms in the nuclear industry should drop their opposition to more stringent security standards; this opposition is "penny wise and pound foolish." While increased security measures will cost money, successful theft of nuclear material for a nuclear weapons program, or successful catastrophic sabotage of a nuclear power plant, would be a gigantic disaster for the nuclear industry in all countries, wherever it occurred.[48]
- The nuclear industry should establish a cooperative industry organization focused on improving security standards worldwide through peer review and assistance, comparable to the role the World Association of Nuclear Operators (WANO) has played in improving nuclear safety.
- All relevant states and the IAEA should undertake dramatically increased efforts to interdict nuclear smuggling and control sensitive nuclear exports, including: (a) far-reaching sharing of intelligence and law-enforcement information; (b) ensuring that every relevant state has at least a small unit of the national police trained and equipped to deal with nuclear smuggling, and other law-enforcement and border-control units are trained to contact them as appropriate; (c) ensuring that every relevant country has a unit of its national intelligence service focused on, trained to deal with, and cooperating with other states on, the nuclear smuggling and illicit export threats; (d) providing equipment and training for detection at key border crossings, airports, ports, and at potential key nodes within countries as well (e.g., major highways near nuclear facilities, train stations in Moscow); and (e) substantially improving international nuclear forensics capabilities to examine seized samples and determine their origin.
- The United States, the countries of the European Union, Japan, and other states should increase their assistance for measures to assist the states of the former Soviet Union in re-employing weapons of mass destruction experts in non-weapons jobs, downsizing the WMD complexes, and strengthening controls on exports and transfers of sensitive technologies.

Priority Two: Strengthening National and International Standards

In addition to immediate upgrades, strengthened standards are needed if security is to be improved consistently worldwide and sustained over the long haul.

National Standards and Regulations

- Every state with weapons-usable nuclear material or high-consequence nuclear facilities should move urgently to put in place effective national security standards (including clear regulations, strong and independent regulators, appropriate inspection programs, and effective enforcement) reflecting the threat as perceived after September 11.
- Every state with weapons-usable nuclear material or high-consequence nuclear facilities should incorporate design basis threats into its regulations. These threats should take into account the global reach of terrorist organizations such as that which struck on September 11. At a minimum, it is difficult to argue that there is any country with major nuclear facilities where an attack by a small group of well-armed, well-trained terrorists, using at least a truck bomb and having the assistance of one insider, is not a plausible threat against which security systems should be prepared to defend.
- National standards and regulations should include regular, realistic, independent testing of the performance of security systems in defeating intelligent, well-trained insider and outsider efforts to overcome them. The IAEA's physical protection advisory service should be expanded to include helping countries to carry out such tests and establish such domestic testing programs.[49]
- Every relevant country should put in place strong legal and regulatory frameworks to deal with the problem of theft and illicit trafficking in nuclear material.

International Recommendations and Agreements

- Every state with weapons-usable nuclear material or high-consequence nuclear facilities that has not already done so should sign and ratify the Convention

on the Physical Protection of Nuclear Material.

- Every state with weapons-usable nuclear material or high-consequence nuclear facilities should voluntarily commit to provide security for its facilities comparable to or better than that recommended in INFCIRC 225/Rev. 4. Major wealthy nuclear states such as the United States, France, the United Kingdom, Japan, and Germany should join in making a politically binding commitment that they will provide the levels of security recommended in INFCIRC 225/Rev. 4 (or some other stringent standard on which they can all agree—perhaps a performance-based one) for all their nuclear material and facilities, military and civilian; that they will report to the IAEA on their regulations and procedures; that they will allow managed peer review of physical protection at selected facilities; and that they will encourage other states to make comparable commitments (including requiring that foreign facilities that they supply or contract with demonstrate that they are meeting the agreed standard). The United States, in particular, should extract itself from the embarrassing position of opposing its own previous proposal to create an obligation to meet INFCIRC 225 standards by investing the resources necessary to bring its own facilities up to these standards and working to convince other states to do likewise.[50]
- A new review of INFCIRC 225 should be initiated, to make whatever modifications are necessary given the new understanding of the threat in the aftermath of September 11.[51]
- The Convention on Physical Protection of Nuclear Material should be amended as rapidly as practicable, to expand its coverage to domestic material and make the other improvements recommended by the experts' group.
- At the same time, in the aftermath of September 11, some of the experts' group's conclusions should be reversed. Parties to the convention should work to build support for an amendment that would include obligations to: (a) provide levels of security against both theft and sabotage at least comparable to those now recommended in INFCIRC 225/Rev.4 (with some provision for raising standards in the future without going through the time-consuming treaty amendment process); (b) provide some carefully managed and appropriately confidential form of international peer review; and (c) report to the IAEA on national legislation and regulations adopted pursuant to the Convention.
- Every nuclear supplier state should undertake steps to examine whether security in its recipient states is adequate, and if not, work with the recipient states to ensure that effective and sustainable security measures and regulations are put in place, including providing assistance where needed. The Nuclear Suppliers' Group should adopt more stringent requirements prohibiting exports to countries that do not provide levels of security comparable to those called for in INFCIRC 225/Rev. 4. Either peer reviews by the supplier state or international peer reviews organized by the IAEA could be used to confirm that such requirements were being met.
- Major nuclear states should adopt a policy that their governments and firms will not enter into contracts with nuclear facilities that fail to provide effective security and accounting for their nuclear material—making this part of the "price of admission" for doing business in the major nuclear markets.

Transparency

- Every state with weapons-usable nuclear material or high-consequence nuclear facilities should take care to keep confidential details of its physical protection arrangements that would be useful to terrorists seeking to overcome them.
- At the same time, sufficient information should be made available to enable informed public debate and build public and international confidence that sufficient steps are being taken.
- In particular, the IAEA's member states should support the IAEA's efforts to seek information on each country's physical protection practices. No international agreement requires submitting such information to the IAEA (even on a confidential basis), and countries have been very reluctant to provide the information unless they needed advice and asked for IPPAS peer review or financial help. As a result, no one knows where the worst problems are. As IAEA Director General Mohamed ElBaradei has said, "the most immediate task is to achieve a more complete picture of nuclear security worldwide, to enable a rapid response to the most urgent needs, and to develop a coherent plan for longer term action."[52] To help resolve that problem, every state with weapons-usable nuclear material or high-consequence nuclear facilities should voluntarily report to the IAEA on the steps it has taken to strengthen security and put in place effective national regulations. Major nuclear states should take the lead in taking particularly stringent measures and being among the first to report them to the IAEA.
- Voluntary peer reviews of physical protection arrangements, such as have been organized in recent years by IAEA assistance programs, should become, over time, a regular, normal part of doing business in major nuclear facilities—just as safety peer reviews have become. Toward that end, major nuclear states such as the United States, France, Japan, Britain, and

Germany should not only provide greater funding for such peer reviews but should invite peer reviews at selected facilities of their own. A new industry-led international organization comparable to WANO could eventually provide effective physical protection peer reviews.

- New cooperation should be established between the IAEA's safeguards inspectors and its physical protection experts. The IAEA's safeguards inspectors should be instructed to provide relevant information observed during their inspections to the physical protection office (while keeping the information safeguards-confidential). The IAEA's inspectors should be provided limited physical protection awareness training to facilitate this.
- Using information from all available sources, the IAEA physical protection office should work to establish a confidential data base on the state of physical protection for nuclear materials and high-consequence nuclear facilities around the world, with a view toward identifying the facilities most in need of security upgrades.

Rethinking the Design Basis Threat

The September 11 attacks require a fundamental rethinking of the threats that nuclear security systems must be designed to address. The September 11 threat consisted of nineteen well-trained attackers operating in four independent but coordinated teams; who were both suicidal and bent on causing mass destruction; who came from an organization with access to heavy weapons, explosives, and extensive combat training and experience; who attacked without warning; and who appear to have planned, trained, and collected intelligence for the attack for more than a year. Even without the addition of the use of large civilian aircraft fully loaded with jet fuel, this is a threat far larger and more capable than most nuclear security systems (at least civilian facilities) are designed to cope with. Countries around the world will have to rethink what threats are plausible and must be defended against, asking questions such as these:

- What, if anything, should be done to protect nuclear facilities from attack by aircraft? An IAEA spokesman has acknowledged that current nuclear power plants were never designed to withstand attack by "a large jumbo jet full of fuel," and some national regulatory authorities have acknowledged that their security requirements did not foresee such threats.[53] Can it now be assumed that large civilian airliners will become sufficiently difficult to hijack that the threat of a fully-fueled airliner attack on a power plant can be safely ignored? Or should we consider deploying anti-aircraft defenses at such facilities? [54] What about smaller planes, such as middle-sized jets that operate from unregulated airports and might be packed with explosives?
- How many people attacking on the ground, with what training, attack vehicles, and weaponry, should design basis threats now include? What would be the cost of providing effective protection against threats on the scale of September 11?
- Should facilities be protected against attackers arriving and departing by unconventional means designed to overcome delays at the perimeter, such as helicopters, or by boat?

While this reconsideration has only just begun, a few things do seem clear already. First, high-consequence nuclear facilities should be designed to survive truck bomb attacks. Second, it is unsafe to rely on the assumption that there will be prior warning before an attack. Third, terrorists are clearly willing to commit suicide attacks by crashing aircraft or trucks on their targets.

Impact on the Future of Nuclear Energy

After September 11, the possibility of terrorist attack will inevitably be one factor that utilities, publics, and governments weigh when considering nuclear energy in comparison to other energy sources. Beyond that, September 11 has implications for specific nuclear energy choices:

- The desirability of reactors with "inherent safety" features, designed so that no plausible set of circumstances can lead to a core melt and large-scale dispersal of radioactivity, appears even higher than before.
- However, proposals that such reactors can be built with no containment vessels—a key part of the projected favorable economics of the ESKOM pebble bed system, for example—are likely to be as dead as the race to build ever-taller office buildings.
- The concept of underground nuclear reactors should be explored again, to see if such systems can provide energy at reasonable cost.
- Most controversially, perhaps, we believe that there should be a phased-in moratorium on current approaches to reprocessing and recycling plutonium. Whatever safeguards and security measures are put in place, a world in which tens of metric tons of plutonium are being separated, processed, fabricated, and shipped to dozens of locations around the world every year is a world that poses significant risks above and beyond those of a world in which that is not occurring. Nuclear power's future will be best assured by making it as cheap, as safe, as secure, as proliferation-resistant, as simple, and as uncontroversial as possible—and current reprocessing and recycling technologies point in the wrong direction on every count. [55]

Conclusions: Preparing for a New World

The events of September 11 created a new world—a world in which we know for certain that there are highly capable terrorist groups with global reach bent on mass destruction. At the same time, the aftermath of September 11 is demonstrating that we are living in a world where far-reaching international cooperation toward common objectives could be a reality.

This new world calls for new approaches for securing much of the fragile infrastructure of modern industrial societies—including nuclear materials and facilities. A major new international initiative is needed to improve security for nuclear materials and facilities worldwide. The first priority must be to upgrade security for the least secure nuclear material and high-consequence nuclear facilities, in the former Soviet Union, the United States and worldwide; strengthened international standards will likely take longer to achieve (though the momentum from September 11 should not be lost).

These steps will cost money. Many of them have been blocked or slowed in recent years because of lack of political priority, bureaucratic obstacles, penny-pinching budgets, reluctance to make commitments that would cost money in the future, and the like. In the aftermath of September 11, governments and industry should work together to sweep these obstacles aside and take the steps needed to ensure that nuclear materials and facilities do not become the tools of terrorists. The costs and risks of failing to act are far higher than the costs of acting now.

Endnotes

1. See, for example, David Albright, Kathryn Buehler, and Holly Higgins, "Bin Laden and the Bomb," Bulletin of Atomic Scientists (Jan.-Feb. 2002), p. 23; Mike Boetcher and Ingrid Arnesen, "Al Qaeda Documents Outline Serious Weapons Program," CNN, January 25, 2002, (available at http://www.isis-online.org/pbulications/terrorism/cnnstory.html); and Seth Borenstein, "Disclosure by Bush Raises Concern on Nuclear Plants," Pittsburgh Post-Gazette, January 31, 2002.
2. For a useful, though somewhat dated, overview of measures to deal with nuclear terrorism, see Paul Leventhal and Yonah Alexander, eds., Preventing Nuclear Terrorism (Lexington, MA: Lexington Books, 1987). A selection of internet resources on the subject is available at http://ksgnotes1.harvard.edu/BCSIA/MTA.nsf/www/N-Terror.
3. For outlines of such an international regime to improve controls over nuclear weapons and materials worldwide, see, for example, Committee on International Security and Arms Control, Management and Disposition of Excess Weapons Plutonium (Washington, DC: National Academy Press, 1994), esp. pp. 101-102 and 123-139; David Albright, Frans Berkhout, and William Walker, Plutonium and Highly Enriched Uranium 1996: World Inventories, Capabilities, and Policies (Oxford, UK: Oxford University Press for the Stockholm International Peace Research Institute, 1997), esp. Chapter 15; and William Walker and Frans Berkhout, Fissile Material Stocks: Characteristics, Measures, and Policy Options (Geneva, Switzerland: United Nations Institute for Disarmament Research, 1999).
4. Steven Mufson, "For Bush's Veteran Team, What Lessons to Apply? War Doctrines Tough to Call on in Fight Against Terrorism," Washington Post, September 15, 2001.
5. U.S. Department of Energy, Office of Arms Control and Nonproliferation, Final Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives, DOE/NN-0007 (Washington, DC: DOE, January 1997), p. vii. For the most authoritative unclassified discussion of whether terrorist groups could plausibly build nuclear explosives, see the chapter by a group of U.S. nuclear weapons designers representing a range of views on the subject: J. Carson Mark et al., "Can Terrorists Build Nuclear Weapons?" in Paul Leventhal, and Yonah Alexander, Preventing Nuclear Terrorism (Lexington, MA. Lexington Books, 1987).
6. See DOE, Final Nonproliferation and Arms Control Assessment, op. cit, pp. 37-39.
7. For a detailed review of these stockpiles, see Albright, Berkhout, and Walker, Plutonium and Highly Enriched Uranium 1996, op. cit.; civilian plutonium figures (increasing by many tonnes every year) have been updated for these totals on the basis of declarations to the IAEA since then.
8. David Albright and Mark Gorwitz, "Tracking Civil Plutonium Inventories: End of 1999," ISIS Plutonium Watch (Washington: Institute for Science and International Security, October 2000, available at http://www.isis-online.org/publications/puwatch/puwatch2000.html).
9. Albright, Berkhout and Walker, Plutonium and Highly Enriched Uranium, 1996, op. cit., p.398. This estimate includes fresh, in-core, and irradiated HEU. Inclusion of irradiated HEU is appropriate in this context because at many research reactors the fuel was only lightly irradiated, has been cooling for many years, and is in fuel elements of modest size, meaning that the fuel elements are not sufficiently radioactive to be self-protecting against theft—especially by terrorists for whom death is part of the plan, such as those of September 11.
10. See Matthew Bunn, The Next Wave: Urgently Needed New Steps to Control Warheads and Fissile Material (Washington DC: Carnegie Endowment for International Peace and Harvard Project on Managing

the Atom, April 2000, available at http://ksgnotes1.harvard.edu/BCSIA/Library.nsf/pubs/Nextwave).

11. See discussion and references in Bunn, The Next Wave, op. cit.
12. Howard Baker and Lloyd Cutler, co-chairs, A Report Card on the Department of Energy's Nonproliferation Programs with Russia (Washington DC: U.S. Department of Energy, Secretary of Energy Advisory Board, January 10, 2001, available at http://www.hr.doe.gov/seab/rusrpt.pdf).
13. For a recent critique of U.S. nuclear weapons facility security, based on large numbers of internal documents, see U.S. Nuclear Weapons Complex: Security at Risk (Washington DC: Project on Government Oversight, October 2001, available at http://www. pogo.org/nuclear/security/2001report/reporttext.htm); a short version of their findings, with some updates, can be found in Danielle Brian, Lynn Eisenman and Peter D.H. Stockton, "The Weapons Complex: Who's Guarding the Store?" Bulletin of the Atomic Scientists (Jan.-Feb. 2002), p. 48. For a brutal official review (including a long history of past negative assessments), see President's Foreign Intelligence Advisory Board, Science At Its Best, Security At Its Worst: A Report on Security Problems at the Department of Energy (the Rudman Report), (Washington DC: President's Foreign Intelligence Advisory Board, June, 1999, available at http://www.fas.org/sgp/library/pfiab/).
14. Fritz Steinhausler and Lyudmila Zaitseva, Stanford Institute of International Studies, Data Base on Nuclear Smuggling, Diversion and Orphan Radiation Sources (2001).
15. "Security Council Official Says Afghan Taliban Tries to Access Nuclear Technologies," Interfax, October 7, 2000. In 1998, a weapons expert from one of Russia's premier nuclear weapons labs was arrested on charges of spying for Iraq and Afghanistan, in this case, dealing with advanced conventional weapons. "Nuclear Center Worker Caught Selling Secrets," Russian NTV, Moscow, 16:00 Greenwich Mean time, December 18, 1998, translated in BBC Summary of World Broadcastes, December 21, 1998.
16. For a useful (though dated) overview of this issue, see Bennett Ramberg, Nuclear Power Plants as Weapons for the Enemy: An Unrecognized Military Peril (Berkeley, CA: University of California Press, 1984).
17. See, for example, Nuclear Regulatory Commission, Supplement to Draft Environmental Statement Related to the Operation of San Onofre Nuclear Generating Station, Units 2 & 3, NUREG-0490, January 1981, especially Figure 7.1.4-4, "Probability Distribution of Acute Fatalities."
18. Oleg Bukharin, "Problems of Nuclear Terrorism," The Monitor: Nonproliferation, Demilitarization and Arms Control (Spring 1997), p. 8; Oleg Bukharin, "Upgrading Security at Nuclear Power Plants in the Newly Independent States," The Nonproliferation Review (Winter, 1997), p.28; Three Mile Island Alert Security Committee, http://www.tmia.com//sabter.html.
19. See NRC Weekly Information Report to NRC Commissioners, April 20, 1984, enclosure E, p.3, describing the results of Sandia National Laboratory, Analysis of Truck Bomb Threats at Nuclear Facilities (1984), cited in Daniel Hirsch, "The Truck Bomb and Insider Threats to Nuclear Facilities," in Leventhal and Alexander, Preventing Nuclear Terrorism, op. cit.
20. See, for example, Union of Concerned Scientists, "Briefing: Nuclear Security," available at http://www.-ucsusa.org/energy/br_safenplants.html.
21. See George Bunn, "Raising International Standards for Protecting Nuclear Materials from Theft and Sabotage," Nonproliferation Review (Summer 2000), pp. 146, 148; Kevin J. Harrington, "Physical Protection of Civilian Nuclear Material: National Comparisons (Livermore, CA.: Sandia National Laboratories, 1999).
22. See Matthew Bunn and George Bunn, "Nuclear Theft & Sabotage: Priorities for Reducing New Threats," IAEA Bulletin, v. 43, no. 4 (Dec. 2001), p. 8.
23. Mark Soo Hoo, David Ek, Axel Hageman, Terry Jenkins, Chris Price, Bernard Weiss, "International Physical Protection Advisory Service: Observations and Recommendations for Improvement," Proceedings of the 41st Annual Meeting of the Institute of Nuclear Materials Management (Northbrook, IL: INMM, July 2000).
24. A spent fuel accident that led to the loss of cooling water could, if the temperature reached over 900°C , lead to a zirconium fire that could disperse a large fraction of the cesium and other potentially volatile radionuclides to the surrounding atmosphere. NRC, Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants, October 2000. For an extensive critical discussion, see "Declaration of 31 October 2001 by Dr. Gordon Thompson in Support of a Motion by CCAM/CAM," affidavit in a lawsuit involving the security of the spent fuel pools at the Millstone nuclear power plant.
25. For a provocative discussion, see Edwin S. Lyman, "A Critique of Physical Protection Standards for Transport of Irradiated Materials," in Proceedings of the 40th Annual Meeting of the Institute for Nuclear Materials Management, available at http://www.nci. org/e/el-inmm99.htm.
26. Explosive dispersal of either several kilograms of plutonium or several kilograms of spent fuel, even in a heavily populated area would not be expected to cause any near-term deaths; hundreds of long-term deaths could occur if weather conditions were right, though

these would be difficult to detect against the substantial background rate of cancer. See Steve Fetter and Frank von Hippel, "The Hazard from Plutonium Dispersal by Nuclear-warhead Accidents," Science and Global Security, Vol. 2, No. 1 (1990), pp. 21–41; and Lyman, "A Critique of Physical Protection Standards for Transport of Irradiated Materials," op. cit.

27. See Convention on the Physical Protection of Nuclear Material of 1980, IAEA Information Circular/274/Rev.1, Annex 1.
28. For a discussion of the early stages of these discussions, see George Bunn, "Raising International Standards for Protecting Nuclear Materials from Theft and Sabotage," Nonproliferation Review, Summer 2000; for a review of more recent discussions, see George Bunn and Fritz Steinhausler, "Guarding Nuclear Reactors and Material from Terrorists and Thieves," Arms Control Today, October 2001, and Patricia A. Comella and Burrus Carnahan, "Revising the Convention on the Physical Protection of Nuclear Material," in Proceedings of the 42nd Annual Meeting of the Institute for Nuclear Materials Management.
29. Informal Open-Ended Expert Meeting to Discuss Whether there is a Need to Revise the Convention on the Physical Protection of Nuclear Material, Final Report (May 23, 2001) (to be distinguished from the February working group final report cited in the next note which contains more specific recommendations and the working papers, mostly from the IAEA staff, used by the experts). Another example: "Responsibility for the establishment, implementation and maintenance of a physical protection regime within a State rests entirely with that State." Principle A, IAEA Secretariat Paper No. 13, "Physical Protection Objectives and Fundamental Principles" attached to February 2001 Working Group report. Op cit.
30. Working Group of the Informal Open-Ended Meeting to Discuss Whether there is a Need to Revise the Convention on Physical Protection of Nuclear Material, Final Report of the Working Group (Feb. 2, 2001), Attachment 4, Principle C.
31. See Richard Meserve, U.S. Nuclear Regulatory Commission chairman, "Nuclear Security in the Post-September 11 Environment," remarks to the National Press Club, January 17, 2002, available at http://www.nrc.gov/reading-rm/doc-collections/commission/speeches/2002/s02-001.html. See also "NRC Will Order All Nuclear Power Plants and Key Facilities to Enhance Security," Press Release No. 02-018, U.S. Nuclear Regulatory Commission, February 14, 2002, available at http://www.nrc.gov/reading-rm/doc-collections/news/archive/02-018.html.
32. See, for example, Tatsujiro Suzuki, "Implications of 0911 Terrorism for Civilian Nuclear Industry and its Response Strategy," presentation to the Japan Atomic Industrial Forum-Harvard University Nonproliferation Workshop, January 30-31, 2002.
33. Text available at http://www.whitehouse.gov/news/releases/2001/12/print/20011211-7.html.
34. Office of the Press Secretary, "Fact Sheet: Nonproliferation, Threat Reduction Assistance to Russia" (Washington DC: The White House, December 27, 2001).
35. IAEA Press Release, "United States Backs IAEA Efforts," November 30, 2001.
36. L. Wedekind, "Upgrading Nuclear Security Tops Board Agenda," February 1, 2002, available at http://www.iaea.org/worldatom/Press/News/01022002_news01.shtml; and IAEA Press Release, "Summary of Report on Protection Against Nuclear Terrorism;" November 30, 2001, and IAEA Press Release, "IAEA Outlines Measures to Enhance Protection Against Nuclear Terrorism," November 30, 2001.
37. Convention on the Physical Protection of Nuclear Material, Art. 20.
38. The text of these regulations is in 10 Code of Federal Regulations Part 73. Some U.S. Department of Energy and Department of Defense rules for protecting their nuclear materials are public, but key provisions specifying specific protection standards are not.
39. See Management and Disposition of Excess Weapons Plutonium, op. cit. For a more detailed discussion of what such a standard might entail, see George Bunn, "U.S. Standards for Protecting Weapons-Usable Fissile Material Compared to International Standards," *Nonproliferation Review* (Fall 1998).
40. U.S. Department of Energy, "Protection and Control of Safeguards and Security Interests," Order 5632.1C (Washington DC: DOE, July 15, 1994).
41. Capital cost is reported in BNFL, The Economic and Commercial Justification for THORP (Risley, UK: BNFL, 1993), p. 22; estimates for operating costs for a plant identical to THORP were provided by BNFL in OECD/NEA, The Economics of the Nuclear Fuel Cycle, 1994, p. 113. The $15 million/yr figure is from BNFL input to the BNFL National Stakeholder Dialogue Waste Working Group, Interim Report (London, UK: The Environmental Council, February 28, 2000), Appendix 3 (available at http://www.the-environment-council.org.uk/Dialogue/bnfl_national_dialogue.htm). Total security costs at the Sellafield site since 1985 are estimated at $375 million, converted at a 2000 average exchange rate of 1.5.
42. See, for example, Graham Allison and Andrei Kokoshin, "A US-Russian Alliance Against Megaterrorism," Boston Globe, November 16, 2001.
43. See, for example, the similar Kurchatov-Brookhaven proposal described in Alexander Rumyantsev,

"Collaborative MPC&A Improvements in Russia: An Evaluation," The Monitor (University of Georgia), Spring 2001.

44. See Bukharin, Bunn, and Luongo, Renewing the Partnership, op. cit.; and Matthew Bunn, Oleg Bukharin and Kenneth Luongo, "Renewing the Partnership: One Year Later," in Proceedings of the 42nd Annual Meeting of the Institute for Nuclear Materials Management (Northbrook, IL: INMM, 2001, available at http://ksg-notes1.harvard.edu/ BCSIA/Library.nsf/pubs/oneyear-later).
45. See the Baker-Cutler Report Card, op. cit.; Bunn, The Next Wave, op. cit.; and Matthew Bunn, "New Steps to Secure Nuclear Material in the Bush Administration," in Proceedings of Global 2001: The Back End of the Fuel Cycle from Research to Solutions (Paris, France: CEA, September 9-13, 2001, available at http://ksgnotes1.harvard.edu/BCSIA/Library.nsf/pubs/NewSteps4Bush).
46. George Bunn, Fritz Steinhausler, and Lyudmila Zaitseva, "Strengthening Nuclear Security Against Terrorists and Thieves Requires Better Training," Nonproliferation Review (Fall-Winter 2001), p. 137. A paper by the IAEA Secretariat for the Working Group of the "Expert Meeting to Discuss Whether there is a Need to Revise the Convention on Physical Protection of Nuclear Material" describes IAEA training programs for physical protection. Secretariat Paper No. 9, "IAEA Physical Protection Training Programme," (June 2000).
47. See Albright, Berkhout, and Walker, Plutonium and Highly Enriched Uranium 1996, op. cit., and Walker and Berkhout, Fissile Material Stocks, op. cit.
48. See note 42.
49. In the U.S., which already has NRC performance-testing programs in place, the program should not be turned over to the reactor operators whose performance is being tested.
50. The U.S. has been opposing its own proposal—both because the proposal was unpopular with other countries in the talks, and because the Department of Energy argued that bringing U.S. facilities up to INFCIRC 225/Rev. 4 standards would be excessively costly and have little benefit. See, for example, Marshal D. Koehn and Joseph D. Rivers, "DOE's Involvement in Negotiations on the Question of Whether to Revise the Convention on the Physical Protection of Nuclear Material," Proceedings of the 42nd Annual Meeting of the Institute for Nuclear Materials Management. U.S. regulations are generally performance-based (rather than the rule-based approach that is still emphasized in INFCIRC 225), and generally offer even higher levels of security than called for by INFCIRC 225. DOE regulations, however, have a different categorization approach that provides for much lower levels of security than called for in INFCIRC 225/Rev. 4 for mixed materials containing less than 10% by weight plutonium or U-235, such as mixed-oxide fuel. As noted earlier, however, there are strong arguments for changing these regulations. Particularly in the aftermath of September 11, the United States would be better off taking the lead in building toward strong global standards than undermining progress toward that end to save money in its own complex.
51. It would be useful to shift increasingly to a more performance-based and less rule-based approach. In addition, among many other modifications that should be considered, it would be desirable to add a recommendation that barriers be put in place to protect against truck bombs.
52. Quoted in Wedekind, "Upgrading Nuclear Security Tops Board Agenda," op. cit.
53. William J. Cole, "Global Atomic Energy Agency Confesses Little Can Be Done to Safeguard Nuclear Power Plants," Associated Press, September 19, 2001.
54. Nuclear Control Institute and Committee to Bridge the Gap, press release, "Nuclear Power Reactors are Vulnerable to Terrorist Attack, Watchdog Groups Warn," September 25, 2001, available at http://www.nci.org/01nci/09/pr92501.htm.
55. For a discussion, see, for example, John P. Holdren, "Improving U.S. Energy Security and Reducing Greenhouse-Gas Emissions: The Role of Nuclear Energy," testimony to the Subcommittee on Energy and Environment, Committee on Science, U.S. House of Representatives, 106th Cong., 2nd Sess., Washington, D.C., July 25, 2000.