Securing the Bomb 2010: Securing All Nuclear Materials in Four Years

Securing the Bomb 2010

Securing All Nuclear Materials in Four Years

MATTHEW BUNN

PROJECT ON MANAGING THE ATOM
BELFER CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS
HARVARD KENNEDY SCHOOL
HARVARD UNIVERSITY

COMMISSIONED BY THE NUCLEAR THREAT INITIATIVE

APRIL 2010

www.nti.org/securingthebomb

Printed in the United States of America

HARVARD Kennedy School
BELFER CENTER
for Science and International Affairs

Project on Managing the Atom
Belfer Center for Science and International Affairs
Harvard Kennedy School
Harvard University
79 JFK Street, Mailbox 134
Cambridge, MA 02138
Fax: (617) 496-0606
Email: atom@harvard.edu
Web: http://www.managingtheatom.org

NTI
Working for a Safer World

Nuclear Threat Initiative
1747 Pennsylvania Avenue NW, 7th Floor
Washington, D.C. 20006
Fax: (202) 296-4811
Email: contact@nti.org
Web: http://www.nti.org

A companion website to this report is available at http://www.nti.org/securingthebomb

TABLE OF CONTENTS

EXECUTIVE SUMMARY

As President Barack Obama has said, the danger that terrorists could get and use a nuclear bomb remains "the most immediate and extreme threat to global security." Incidents around the world make clear that urgent action is needed to improve security for nuclear stockpiles around the world and to keep nuclear weapons and the materials needed to make them out of terrorist hands. That is the purpose of both the global effort to secure all nuclear weapons and weapons-usable nuclear material within four years that President Obama has initiated, and the nuclear security summit he is hosting in Washington on 12-13 April 2010.

Although the Obama administration has made progress toward this goal, much more needs to be done. Today, the world is not yet on track to succeed in achieving effective security for all stockpiles of nuclear weapons and weapons-usable nuclear materials within four years. To meet that objective, the nuclear security summit must be only the first step in a broader campaign to shift the global nuclear security effort onto a faster and broader trajectory.

The Threat of Nuclear Terrorism

Several facts frame the danger:

- Al Qaeda is seeking nuclear weapons and has repeatedly attempted to acquire the materials and expertise needed to make them.
- Numerous studies by the U.S. and other governments have concluded that it is plausible that a sophisticated terrorist group could make a crude nuclear bomb if it got enough of the needed nuclear materials.
- There have been over 18 documented cases of theft or loss of plutonium or highly enriched uranium (HEU), the essential ingredients of nuclear weapons. Peace activists have broken into a Belgian base where U.S. nuclear weapons are reportedly stored; two teams of armed men attacked a site in South Africa where hundreds of kilograms of HEU are stored; and Russian officials have confirmed that terrorist teams have carried out reconnaissance at Russian nuclear weapon storage facilities.
- The immense length of national borders, the huge scale of legitimate traffic, the myriad potential pathways across these borders, and the small size and weak radiation signal of the materials needed to make a nuclear bomb make nuclear smuggling extraordinarily difficult to stop.

No one knows the real likelihood of nuclear terrorism. But the consequences of a terrorist nuclear blast would be so catastrophic that even a small chance is enough to justify urgent action to reduce the risk. The heart of a major city could be reduced to a smoldering radioactive ruin, leaving tens to hundreds of thousands of people dead. Devastating economic consequences would reverberate worldwide. America and the world would be changed forever.

Making plutonium or HEU is well beyond the plausible capabilities of terrorist groups. Hence, if all the world's stockpiles of these materials can be secured from falling into terrorist hands, nuclear terrorism can be prevented. Improved nuclear security is the single point on the terrorist pathway to the bomb where government policies can do the most to reduce the danger. After a nuclear weapon or the material needed to make one has been stolen, every later step on the terrorist pathway is easier for terrorists to take and harder for governments to stop.

Nuclear Security Today

Today, nuclear weapons or the separated plutonium or HEU needed to make them exist in hundreds of buildings and bunkers in dozens of countries. Each country where such stockpiles exist is responsible for securing them, and the specific approaches, procedures, and rules for securing and accounting for nuclear stockpiles vary widely. There are no binding global rules that specify how much security these stockpiles should have.

In many countries, nuclear security today is substantially better than it was in the mid-1990s, as a result of national efforts and international cooperative programs. Security and accounting systems for all but a few dozen of the hundreds of buildings and bunkers in Russia and the Eurasian states have been substantially improved through cooperative efforts. Some 17 countries have eliminated all of the weapons-usable nuclear material on their soil. These successes represent, in a real sense, bombs that will never go off—and demonstrate the progress that can be achieved through cooperation.

But serious risks remain, as evidenced by recent incidents at nuclear sites and ongoing cases of theft or loss of weapons-usable nuclear material. Upgraded security systems will not last forever unless states provide the resources to sustain them and write and enforce rules that require sites and transporters to maintain effective security and accounting systems. Strong security cultures—in which all relevant staff take security seriously, every day—are also an essential component of effective nuclear security.

Based on unclassified information on the quantity and quality of nuclear stockpiles around the world, the security levels in place, and the adversary threats these security systems must protect against, it appears that the highest risks of nuclear theft today are in:

- Pakistan, where a small and heavily guarded nuclear stockpile faces immense threats, both from insiders who may be corrupt or sympathetic to terrorists and from large-scale attacks by outsiders;
- Russia, which has the world's largest nuclear stockpiles in the world's largest number of buildings and bunkers; security measures that have improved dramatically but still include important vulnerabilities (and need to be sustained for the long haul); and substantial threats, particularly from insiders, given the endemic corruption in Russia; and
- HEU-fueled research reactors, which usually (though not always) use only modest stocks of HEU, in forms that would require some chemical processing before they could be used in a bomb, but which often have only the most minimal security measures in place—in some cases little more than a night watchman and a chain-link fence.

While these are the highest-risk categories, the risks elsewhere are very real as well. Transport of nuclear weapons and materials is a particular concern, as it is the part of the nuclear material life-cycle most vulnerable to violent, forcible theft, since it is impossible to protect the material with thick walls and many minutes of delay when it is on the road. Reprocessing plutonium from spent fuel and recycling it as new fuel requires intensive security measures and creates risks that are not present when the plutonium remains in massive, intensely radioactive spent fuel assemblies that would be very difficult to steal. Nuclear security issues exist not only in developing and transition countries but in wealthy countries as well, some of which have no armed guards at nuclear facilities, or only protect these facilities against very modest threats. In the end, virtually every country where these materials exist—including the United States—has more to do to ensure that these stocks are effectively protected against the kinds of threats that terrorists and criminals have shown they can pose. Table ES-1 provides a summary of the state of nuclear security around the world today.

President Obama, building on programs launched by his predecessors, has taken a number of steps to accelerate nuclear security improvements, including launching the four-year nuclear security effort, hosting the nuclear security summit, creating new U.S. government positions to coordinate these programs, and requesting a significant increase in the budget for nuclear security improvement programs in fiscal year (FY) 2011 (though not, unfortunately, in FY 2010). Recent progress includes:

- During FY2009, security and accounting upgrades were completed at 29 additional weapons-usable nuclear material buildings in Russia, bringing the total for such buildings upgraded in Russia and the Eurasian states to 210, only 19 short of the target of 229 buildings to be completed through FY2012.
- Since President Obama launched the four-year nuclear security effort four countries have eliminated all the weapons-usable nuclear material on their soil, with U.S. help. To date, the United States has helped remove all the HEU from more than 47 facilities in countries around the world.
- Discussions about eliminating all HEU in several of the developing or transition non-nuclear-weapon states with the largest HEU stocks are well advanced.
- Cooperation to improve nuclear security is continuing in Pakistan, though the specifics are classified; the United States and Russia have greatly broadened their exchanges of best practices, efforts to strengthen security culture, and cooperation to ensure effective nuclear security will be sustained for the long haul; and detailed dialogue with China on improving nuclear security and accounting is continuing.

The nuclear security summit has elevated the issue of nuclear security to a far higher political level. If the summit succeeds, it will help build a new sense of urgency among the participants about taking action to prevent nuclear terrorism. Products of the summit are expected to include a communiqué from the assembled leaders, a more detailed expert-level work plan, and commitments to nuclear security actions that individual participating countries are likely to make. The success of the summit will be measured by whether it leads to real change in the pace and scope of nuclear security improvements on the ground in the months that follow.

Despite this progress, the world is not yet on track to succeed in achieving effective security for all stockpiles of nuclear weapons and weapons-usable nuclear

Table ES-1: Global Nuclear Security Today

Category	Assessment
Russia	Dramatic progress, though major issues remain. Planned U.S.-sponsored security upgrades for both warhead sites and nuclear material buildings almost complete, though some warhead sites and material buildings not covered. Inadequate Russian investment to ensure sustainability, though signs of improvement. Questions on security culture. Poorly paid and trained conscript guards for nuclear material. Substantial threats from widespread insider corruption and theft, while material accounting and control measures remain weak in some cases. Substantial outsider threats as well, though suppressed by counterinsurgency in Chechnya. Major need for consolidation, as Russia still has the world's largest numbers of nuclear weapons sites and weapons-usable nuclear materials buildings, including the world's largest fleet of HEU-fueled research reactors.
Developing states with nuclear weapons (Pakistan, India, China, North Korea)	Pakistan has a small, heavily guarded nuclear stockpile. Substantial security improvements have been made in recent years, in part with U.S. help, but the specifics of this cooperation are classified. Immense threats in Pakistan from nuclear insiders with extremist sympathies, al Qaeda or Taliban outsider attacks, and a weak state. India also has a small nuclear stockpile, and reports that it requires its stocks to be protected against a range of outsider and insider threats, but has so far rejected nuclear security cooperation with the United States. China has a somewhat larger nuclear stockpile, believed to be protected by substantial guard forces. A broad U.S.-Chinese nuclear security dialogue is underway, and China appears to have modernized security and accounting measures at some sites, but little evidence that China has yet required such measures in its regulations. In North Korea, a very small nuclear stockpile and a garrison state probably limit the risks of nuclear theft.
Developing and transition non-nuclear-weapon states	Important progress in recent years, but some issues remain. U.S.-funded security upgrades completed at nearly all facilities with weapons-usable material in the Eurasian states outside of Russia, and in Eastern Europe. Belarus, Ukraine, Kazakhstan, and South Africa have particularly dangerous nuclear material: upgrades completed in Ukraine (though sustainability is an issue); upgrades nearing completion after a several-year delay in Belarus; South Africa (whose facility suffered a penetration of the outer perimeter by armed men in November 2007) is discussing cooperation on nuclear security. Upgrades completed for nearly all HEU-fueled research reactors that previously did not meet IAEA recommendations, but some upgrades would not be enough to defend against demonstrated terrorist and criminal capabilities.
Developed Countries	Significant progress in recent years, as several countries have strengthened nuclear security rules since 9/11. The United States has ongoing dialogues with key countries on nuclear security, but does not sponsor security upgrades in wealthy countries. Nuclear security requirements in some countries remain insufficient to protect against demonstrated terrorist or criminal threats. Additional efforts needed to consolidate both HEU and separated plutonium in fewer locations.
United States	Substantial progress in recent years, though issues remain. DOE has drastically strengthened its requirements for protecting both nuclear weapons and materials (especially from outsider attack) since 9/11. NRC has also increased its security requirements, though they remain less stringent than DOE requirements, and NRC-regulated research reactors fueled with HEU remain exempt from most NRC security requirements. Major progress in converting NRC-regulated reactors to low-enriched fuel, and in implementing voluntary security upgrades going beyond regulatory requirements at these sites. Recent incidents suggest an ongoing issue with security culture.

materials within four years. To meet that objective, the nuclear security summit and the efforts that follow will have to shift the nuclear security effort onto a faster and broader trajectory.

Next Steps to Secure Nuclear Material in Four Years

The goal of the four-year nuclear security effort that President Obama has called for and that the UN Security Council has endorsed in Resolution 1887 should be to ensure that *all* stocks of nuclear weapons, plutonium, and HEU worldwide are *effectively* and *lastingly* protected.

All means that any nuclear material that could be used to make a nuclear bomb should be included, whether it is in a military or a civilian stockpile. It means the effort must ensure security not just for materials in developing or transition countries such as Russia, Pakistan, or South Africa, but also in wealthy countries such as Belgium and Japan—and the United States.

Effectively is a matter of risk—another way of stating the goal is that at the end of four years, all nuclear stocks should have a low risk of being stolen. That means they have to be reliably protected against the most plausible kinds of adversary capabilities (both outsider and insider) that they might face. In a world with terrorists with global reach, all nuclear weapons and weapons-usable nuclear materials should *at least* be protected against theft by a well-placed insider; a modest group of well-armed and well-trained outsiders, capable of operating as more than one team; or both together, and against a range of tactics such adversaries might use, from frontal assault to deception to covert infiltration. Countries facing more capable adversaries, such as Pakistan, should put even more stringent security measures in place.

Lastingly means that countries have put in place the resources to sustain effective security and accounting measures for the long haul, and the regulations requiring operators to do so.

As with any government program, it will be essential to develop measures and indicators that provide a realistic assessment of the progress being made. Such measures might include, for example, the fraction of the total world number of sites with nuclear weapons or weapons-usable nuclear materials where all of those stocks have been eliminated, and the fraction that have demonstrated that their security systems are performing effectively, and could protect against a broad range of outsider and insider threats.

It would certainly not be possible for U.S.-funded upgrades to be negotiated and implemented for all relevant sites around the world in four years. Instead, the effort must combine U.S.-funded upgrades and material removals (or those funded by other donor states) with security improvements and material removals key countries carry out themselves, once they become convinced of the urgency of action. The administration must develop a clear set of metrics to be used in assessing progress in the four-year nuclear security effort—metrics that assess not just where equipment has been installed but what fraction of the sites where nuclear weapons and weapons-usable nuclear materials exist have effective nuclear security measures in place.

With the right leadership, sufficient resources, a comprehensive, prioritized plan, and a partnership-based approach, it is quite plausible that at the end of the four-year effort, the number of countries where weapons-usable nuclear material exists could be cut in half or more; the number of sites could have been cut by 20-30 percent; and that all the countries where nuclear weapons or weapons-usable nuclear material still exists could put in place effectively enforced rules requiring all of their dangerous nuclear stocks to be protected against a robust set of outsider and insider threats. Such progress would dramatically reduce the danger that nuclear terrorism poses to global security. Nevertheless, it is clear that continued work to improve nuclear security—particularly the important but difficult specifics of accurate control and accounting of nuclear materials being processed in bulk—will still be needed after the end of the four-year nuclear security effort.

Achieving these objectives will require several steps beyond those already being taken.

Build the sense of urgency and commitment worldwide

The fundamental key to the success of the four-year nuclear security effort is to convince political leaders and nuclear managers around the world that nuclear terrorism is a real and urgent threat to *their* countries' security, worthy of a substantial investment of their time and money. If these programs succeed in building that sense of urgency, these officials and managers will take the needed actions to prevent nuclear terrorism; without that sense of urgency, they will not.

The United States and other countries should take several steps to build the needed sense of urgency and commitment, including: (a) *joint threat briefings* at upcoming summits and high-level meetings with key countries, where experts from both the United States and the country concerned would outline the very real possibility that terrorists could get nuclear material and make a nuclear bomb; (b) *intelligence agency discussions,* in which U.S. intelligence agencies would seek to convince their foreign counterparts—who are often their government's main source for assessments of national security threats—that the nuclear terrorism threat is a real one that must be addressed urgently; (c) *an "Armageddon Test,"* in which intelligence agents would attempt to penetrate nuclear smuggling networks and acquire sufficient nuclear material for a bomb, providing a realistic assessment of how difficult it is to do so; (d) *nuclear terrorism exercises* with policymakers from key states, which can sometimes reach officials emotionally in a way that briefings and policy memos cannot; (e) *fast-paced nuclear security reviews,* in which leaders of key states would pick teams of security experts they trust to conduct fast-paced reviews of nuclear security in their countries (with U.S. advice and technical assistance if desired), assessing whether facilities are adequately protected against a set of clearly-defined threats (as the United States did after 9/11, revealing a wide range of vulnerabilities); (f) *realistic testing of nuclear security performance,* in which the United States could help countries conduct realistic tests of their nuclear security systems' ability to defeat realistic insider or outsider threats; and (g) *shared databases of threats and incidents,* including unclassified information on actual security incidents (both at nuclear sites and at non-nuclear guarded facilities) that offer lessons for policymakers and facility managers to consider in deciding on nuclear security levels and particular threats to defend against.

Broaden consolidation and security upgrade efforts

Today, U.S.-funded cooperative nuclear security upgrade efforts are focusing primarily on the former Soviet Union, South Asia, and a few HEU-fueled research reactors elsewhere. (Nuclear security cooperation with China has so far focused on dialogue and exchanges of best practices, not on U.S.-funded upgrades.) U.S.-funded consolidation programs focus primarily on converting HEU-fueled reactors and removing Soviet-supplied HEU and a fraction of U.S.-supplied HEU.

To secure all nuclear stockpiles in four years, both security upgrades and consolidation efforts must be broadened. The United States and other donor countries should plan to carry out security upgrades that are more extensive than those now planned, at more facilities, in more countries. These should include not only installing equipment, but also increasing each country's capacity and commitments to implement effective nuclear security on their own—through training, exchanges of best practices, improvements in regulation and enforcement, sustainability support programs, work on security culture, and more. This effort should include the regional nuclear security "centers of excellence" that President Obama and some European countries have proposed, which could provide central locations for training, demonstrating modern equipment, exchange of best practices, and the like.

Consolidation efforts should be expanded to include reducing the number of sites where nuclear weapons exist (particularly in Russia); limiting the accumulation of stockpiles of separated plutonium, and the number of places where plutonium is processed, stored, and used; and removing HEU from a far broader set of the sites where it now exists, with the goal of eliminating the HEU from the most vulnerable sites during the four-year effort, and eliminating all civil HEU within roughly a decade. The United States and other donor countries should offer additional incentives, structured to the needs of each facility, to convince facilities to agree to convert to fuels that cannot be used in a nuclear bomb, or to shut down, and to give up their HEU or separated plutonium. The United States and other donor states should offer something in the range of $10,000 per kilogram for modest stocks of excess HEU from any country willing to get rid of it and to agree not to make or buy more.

Get the rules and incentives right

Effectively enforced national rules for nuclear security and effective global nuclear security rules are both key elements of the effort to secure nuclear stockpiles around the world. As most nuclear managers only invest in expensive security measures when the government tells them they have to, effective regulation is essential to effective and lasting security. Hence, President Obama and other leaders seeking to improve nuclear security should greatly increase the focus on ensuring that countries around the world put in place and enforce effective nuclear security and accounting regulations, giving all facilities strong incentives to ensure those stockpiles are effectively secured. Regulators in each country must have the authority, independence, expertise, and resources needed to do their jobs effectively—and countries must ensure that operators have the resources needed to follow the rules. These rules should include requirements for realistic testing of the performance of nuclear security systems against intelligent and creative insider and outsider adversaries.

Nuclear security is only as strong as its weakest link. Hence, it is also important to seek effective global nuclear security rules that will help ensure that each country where stockpiles of nuclear weapons and weapons-usable materials exist puts effective national rules and procedures in place. Unfortunately, because of complacency about the threat, concerns over national sovereignty, and differing national approaches, past efforts to negotiate global treaties specifying how secure nuclear weapons or weapons-usable materials should be have not succeeded, and such a treaty-negotiation approach is not likely to succeed in the future. (There is a Convention on Physical Protection and a 2005 amendment to it that provide useful guidelines, but set no specific requirements for how secure weapons-usable nuclear material should be.)

The most promising approach to forging international standards is to make use of UN Security Council Resolution 1540, which already legally requires all countries to provide "appropriate effective" security and accounting for any nuclear stockpiles they may have. The United States should work with other states pursuing improved nuclear security to build a political-level consensus around what essential elements need to be in place for nuclear security systems to be considered "appropriate" and "effective," and then work with other donor states to help (and to pressure) countries around the world to put those essential elements in place. The approach should be based on ensuring that all states provide protection against a plausible set of outsider and insider threats, while leaving flexibility for each country to pursue its own approach to accomplishing that objective. At the same time, the United States should certainly continue to work to get states to ratify the physical protection convention and its 2005 amendment and to strengthen the IAEA's nuclear security guides and recommendations.

Incentives are as important as rules. Given the strong incentives to save money and time by cutting corners on nuclear security, states, agencies, facilities, managers, and staff must be given strong incentives to focus on achieving high nuclear security performance. If the effort to build a sense of urgency around the world about the threat of nuclear terrorism succeeds, the desire to address real threats will provide the most important incentive. President Obama should also make clear to countries around the world that cooperating to ensure effective security for nuclear stockpiles and take other steps to prevent nuclear terrorism is essential to good relations with the United States, just as compliance with arms control and nonproliferation agreements has been for many years. At the same time, the United States should seek to ensure that each country with dangerous nuclear stockpiles establishes financial and other rewards for strong nuclear security performance (comparable, for example, to the bonus payments contractors managing DOE facilities can earn for high performance), and for those who identify nuclear security problems and propose practical solutions. The U.S. government should take the position that only facilities that can demonstrate that they maintain highly effective security will be eligible for U.S. government-funded contracts for cooperative R&D and related efforts, and should seek to convince other governments to do likewise. Ultimately, effective security and accounting for weapons-usable nuclear material should become part of the "price of admission" for doing business in the international nuclear market.

Take a partnership-based approach

To succeed, a global nuclear security improvement effort must be based not just on donor-recipient relationships but on real partnerships, which integrate ideas and resources from countries where upgrades are taking place in ways that also serve their national interests. For countries like India and Pakistan, for example, it is politically untenable to accept U.S. assistance that is portrayed as necessary because they are unable to adequately control their nuclear stockpiles on their own. But joining with the major nuclear states in jointly addressing a global problem may be politically appealing. U.S.-Russian relations are still rocky despite President Obama's efforts to "reset" them, making a real nuclear security partnership with Russia difficult to achieve, but no less essential; shared U.S.-Russian interests in keeping nuclear material out of terrorist hands remain. Such partnerships will have to be based on creative approaches that make it possible to cooperate in upgrading nuclear security without demanding that countries compromise their legitimate nuclear secrets. Specific approaches should be crafted to accommodate each national culture, secrecy system, and set of circumstances. As a central element of this partnership-based approach, the Global Initiative to Combat Nuclear Terrorism should be reinvigorated, with a focus on building the international sense of urgency and commitment to action to reduce the risk of nuclear terrorism, and on meeting the four-year nuclear security objective.

Broaden best practices exchanges and security culture efforts

Opportunities for nuclear security operators to hear about and learn from the best security practices used in other facilities around the world—as offered, for example, by the new World Institute for Nuclear Security—can be powerful motivators for improvement. Targeted efforts to improve nuclear security culture, so that guards are no longer falling asleep on the job or turning off intrusion detectors, are also critical. As Gen. Eugene Habiger, former commander of U.S. strategic nuclear forces and former security "czar" at the U.S. Department of Energy once put it, "good security is 20 percent equipment and 80 percent culture." President Obama and other leaders seeking to improve nuclear security should work with *all* countries where nuclear weapons and weapons-usable nuclear materials exist—as well as countries with major nuclear facilities that might be subject to sabotage—to exchange best practices and strengthen nuclear security culture. The ultimate goal should be to ensure that every facility and transporter handling nuclear weapons and weapons-usable nuclear material participates in programs to exchange best practices, and has a targeted program in place to continually assess and strengthen its nuclear security culture.

Create mechanisms to follow up and to build confidence in progress

Mechanisms to follow up on commitments made and to build confidence that they are being implemented—and that states are maintaining effective nuclear security systems—will be essential if the commitments of the nuclear security summit are to have a real and lasting impact.

First, each participating state should designate one or a small number of key officials to be responsible for implementing their states' efforts, and groups of these officials should meet regularly in the months and years after the summit to review progress and assess next steps. If initial approaches are not working, or particular cooperating countries identify gaps that need to be filled or unexpected problems that need to be solved, these officials should have the authority to modify the cooperative nuclear security efforts.

Second, it is important to build an international understanding of the work to be done. Through intelligence programs such as the Nuclear Materials Information Program, the United States is developing a more comprehensive classified understanding of the state of nuclear security around world. But a common understanding of the state of nuclear security around the world is needed, to provide a baseline against which to judge progress of the four-year nuclear security effort. While many of the specifics of nuclear security arrangements in different countries will inevitably remain shrouded in secrecy, the United States and other countries working to achieve the four-year nuclear security objective should seek to convince countries of the importance of sharing as much information as they can about how many sites with nuclear stockpiles exist in each country, what security measures are in place (at least in general descriptive terms), and the like.

Third, countries should work together to develop means, within the confines of necessary secrecy, to build international confidence that states are taking the steps they have committed to and putting effective nuclear security measures in place. International visits such as those that take place under U.S. nuclear supply agreements, IAEA-led peer reviews, and international cooperation on nuclear security upgrades are all effective mechanisms for expanding transparency to build confidence that effective nuclear security measures are in place, or are being put in place. But additional approaches will be needed for sites that are unlikely to welcome international visitors in the near future—from U.S. and Russian nuclear warhead assembly plants to nuclear sites in Pakistan and Israel. For example, countries might have their adversary teams who test nuclear security systems train together (to increase their understanding of the kinds of tests each participating country conducts)—and then report to each other, at least in general terms, the results of nuclear security tests. The United States, for example, already openly publishes data on what percentage of DOE facilities have received high ratings in DOE security inspections—and uses that percentage as a measure of the effectiveness of ongoing steps to improve security. In the immediate term, until such measures can be agreed, states should do more to provide general descriptions of their nuclear security approaches, photographs of installed equipment, and related data that could be made public and help build confidence that effective nuclear security measures are being taken without providing data that could help terrorists and criminals plan their attacks.

Build a multi-layered defense

Nuclear security systems will never be perfect—and some nuclear material may already have been stolen and never recovered. Hence, a multilayered effort to block the terrorist pathway to the bomb is needed, with nuclear security as the first and most important layer. The United States and other countries seeking to reduce this risk should expand police and intelligence cooperation focused on identifying and countering terrorist groups with nuclear ambitions and seeking to interdict nuclear smuggling. They should work to ensure that countries around the world have criminal laws in place imposing heavy penalties for any participation in efforts to steal or smuggle nuclear material or any assistance to nuclear terrorists—and that states have units of their national police trained and equipped to deal with such cases. They should create new tip lines and reward programs to encourage participants in such conspiracies to blow the whistle. While the likelihood that hostile states would consciously decide to transfer nuclear weapons or the materials needed to make them to terrorists is already low, the United States and its international partners should seek to lower it further, in particular by putting together international packages of carrots and sticks large enough and credible enough to convince North Korea and Iran that it is in their national interests to verifiably abandon their pursuit of nuclear weapons—and by making crystal clear the consequences that any state found to have intentionally transferred such items to terrorists would face.

Provide the needed leadership, planning, and resources

Achieving effective security for all the world's stockpiles of nuclear weapons and weapons-usable nuclear materials poses an extraordinarily difficult challenge. Sustained high-level leadership will be needed to overcome a maze of obstacles posed by complacency about the threat, secrecy, political disputes, sovereignty concerns, and bureaucratic obstacles. Inense engagement from presidents and prime ministers in the months and years following the nuclear security summit will be needed, not just occasional statements of support. Leaders will have to be willing to change outdated rules, overrule officials standing in the way of nuclear security cooperation, invest additional funds in nuclear security, and more.

First, President Obama, building on the structure he has put in place, should give the National Security Council clear direction and authority to take the needed actions to move this agenda forward, and to keep this effort on the front burner at the White House every day. The staff focused on this topic need to wake up every morning thinking "what can we do today to prevent a nuclear terrorist attack?" President Obama should also encourage Russia and other key countries to put similar top-level structures in place, so that it is clear which officials other countries should talk to about nuclear security and nuclear terrorism.

Second, President Obama should direct the NSC staff to further develop a comprehensive, prioritized plan for preventing nuclear terrorism, integrating steps from implementing nuclear security upgrades to expanding intelligence cooperation focused on the nuclear terrorist threat to building the sense of urgency around the world. This plan will have to be continuously modified as circumstances change.

Third, President Obama and the Congress should work together to provide sufficient resources to ensure that steps that could significantly reduce nuclear terrorism risks are not slowed by lack of money. Achieving the four-year nuclear security objective will require doing more, faster, than in the past, which will inevitably require an increase in budgets. Yet nuclear security is eminently affordable: the sums spent on cooperative threat reduction each year are a tiny fraction of the budgets of the Departments of Defense, Energy, and State. As part of providing sufficient resources, the leaders at the 2010 G8 summit should agree to extend the Global Partnership Against the Spread of Weapons and Materials of Mass Destruction for another ten years, with a continuing flow of funds, and target it on helping states around the world provide effective nuclear security and meet their other obligations under UNSCR 1540. In addition, the United States and other countries should expand their efforts to strengthen the IAEA's nuclear security efforts, increasing their budgets and shifting them to the regular budget rather than relying almost exclusively on voluntary contributions.

Fourth, President Obama should take action to ensure that his administration has the information and analysis it needs to support effective policymaking, including (a) directing U.S. intelligence agencies to place high priority on all aspects of the nuclear terrorism problem, from assessing and penetrating terrorist conspiracies and nuclear smuggling networks to assessing nuclear security measures around the world; and (b) working with Congress to fund non-government institutions to provide independent analysis and suggestions that can help strengthen these programs.

Fifth, President Obama should work to put the United States' own house in order, continuing the effort to convert U.S. HEU-fueled research reactors to use low-enriched uranium (LEU) fuel that cannot be used in a nuclear bomb, going farther in consolidating U.S. stockpiles, and working to strengthen security at U.S. HEU-fueled research reactors (which are exempted from many of the most important U.S. nuclear security rules). Convincing foreign countries to reduce and consolidate nuclear stockpiles, to put stringent nuclear security measures in place, or to convert their research reactors will be far more difficult if the United States is not doing the same at home.

The obstacles to accelerated and expanded progress are real and difficult. But with sustained high-level leadership, a sensible strategy, partnership-based approaches, adequate resources, and good information, they can be overcome. The actions President Obama has already taken open new opportunities. Now is the time to seize them. President Obama still has an enormous opportunity and an obligation, to reduce the danger of nuclear terrorism to a fraction of its current level during his first term in office.

1 INTRODUCTION

The challenges of our time threaten the peace and prosperity of every single nation, and no one nation can meet these challenges alone… [T]he theft of loose nuclear materials could lead to the extermination of any city on Earth.

—President Barack Obama, 10 July 2009

In Prague in April 2009, U.S. President Barack Obama warned that the danger that terrorists could get and use a nuclear bomb remains "the most immediate and extreme threat to global security." From peace activists breaking into a base where U.S. nuclear weapons are reportedly stored in Belgium in early 2010 to armed men assaulting a site with hundreds of kilograms of highly enriched uranium (HEU) in South Africa in 2007 to repeated cases of theft or loss of plutonium or HEU, a drumbeat of events makes clear that urgent action is needed to improve security for nuclear stockpiles around the world and to keep nuclear weapons and the materials needed to make them out of terrorist hands. (See "Incidents Highlight the Global Threat," p. 4.) To respond to this danger, President Obama announced "a new international effort to secure all vulnerable nuclear material around the world within four years."[1] Dating from President Obama's speech, the four-year nuclear security effort would extend to April 2013. In September 2009, the UN Security Council unanimously endorsed this four-year objective in Resolution 1887.[2]

As part of that effort, President Obama is hosting an unprecedented global summit focused entirely on security for nuclear stockpiles, scheduled for 12-13 April 2010, in Washington, D.C.

This report is intended to assess:

- The magnitude of the continuing threat of nuclear theft and terrorism;
- The current global status of security for nuclear weapons and weapons-usable nuclear materials;[3]

[1] The White House, Office of the Press Secretary, "Remarks by President Barack Obama," Prague, Czech Republic, 5 April 2009 http://www.whitehouse.gov/the_press_office/Remarks-By-President-Barack-Obama-In-Prague-As-Delivered/ (accessed 19 February 2010).

[2] United Nations Security Council, "Resolution 1887," S/Res/1887 (New York: United Nations, 24 September 2009), http://daccess-ods.un.org/access.nsf/Get?Open&DS=S/RES/1887%20(2009)&Lang=E&Area=UNDOC (accessed 8 February 2010).

[3] In this report, "weapons-usable materials" refers primarily to HEU and plutonium separated from spent fuel; the phrase as used here is essentially the same as the set of materials the IAEA refers to as "unirradiated direct use nuclear material." Both "reactor-grade" plutonium and HEU enriched to levels well below the 90% usually referred to as "weapon-grade" are weapons-usable. For the most detailed official unclassified statement on the weapons-usability of reactor-grade plutonium, see U.S. Department of Energy, Office of Arms Control and Nonproliferation, Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives, DOE/NN-0007 (Washington, D.C.: DOE, 1997), http://www.osti.gov/bridge/servlets/purl/425259-CXr7Qn/webviewable/425259.pdf (accessed 5 March 2010), pp. 37-39; for a useful discussion in the case of HEU, see Alexander Glaser, "On the Proliferation Potential of Uranium Fuel for Research Reactors at Various Enrichment Levels," *Science and Global Security*, Vol. 14 (2006). The phrase "weapons-usable nuclear material," like the IAEA's phrase, includes not only pure HEU or plutonium but also HEU or plutonium in fabricated reactor fuel that would require some modest chemical processing before it could be used in a nuclear explosive. While it does not include plutonium in intensely radioactive power reactor spent fuel that would be extremely difficult for adversaries to steal and process to recover plutonium for use in nuclear weapons, it does include HEU and plutonium in modestly radioactive materials that do not pose a similar barrier to theft, such as most irradiated research reactor fuel. (For a

- What the goals of this four-year effort should be, and how progress toward them should be judged;
- How much effort has been expended and how much progress has already been made to achieve the goals President Obama and the Security Council outlined; and
- What further steps are needed if the four-year effort is to succeed.

When this report is published, a year of the four years after President Obama's Prague speech will already have gone by, leaving just three years remaining if the original goal is to be met. Identifying the highest-priority risk reduction steps that can be accomplished in that remaining time, and the means to overcome the obstacles to taking those steps, is the central focus of this report. Of course, like many other deadlines, the four-year goal is, in a sense, arbitrary. What is essential is not that nuclear security improvements be accomplished within three years or four years, but that improvements sufficient to keep nuclear materials from being stolen get to the world's stockpiles of nuclear weapons and the materials needed to make them before thieves and terrorists do. The effort to secure the world's nuclear stockpiles is, in that sense, a race—a "race between cooperation and catastrophe," as former Senator Sam Nunn has said.[4]

It is not an accident that President Obama announced the four-year effort to secure nuclear materials worldwide as part of his broad speech on nonproliferation and disarmament, in which he recommitted the United States to seeking "the peace and security of a world without nuclear weapons." Security for nuclear weapons and weapons-usable nuclear materials is the essential foundation for what are often known as the "three pillars" of the Nonproliferation Treaty (NPT)—nonproliferation, disarmament, and peaceful use of nuclear energy.[5] None of those other objectives can realistically be achieved without effective nuclear security. The possibility that states or terrorist groups could rapidly and secretly make a nuclear bomb using stolen nuclear materials poses a fundamental proliferation threat. States with nuclear weapons will not disarm if they believe other states or terrorist groups might suddenly get nuclear weapons by such means. And nuclear power will be unable to gain the support it needs for large-scale growth unless nuclear facilities and nuclear stockpiles are seen to be safe and secure.

discussion of the risks posed by irradiated research reactor fuel, see Matthew Bunn and Anthony Wier, *Securing the Bomb: An Agenda for Action* (Washington, D.C.: Nuclear Threat Initiative and the Project on Managing the Atom, Harvard University, May 2004), pp. 37-39. In addition to plutonium and HEU, the phrase would also include more obscure materials from which a bomb could be made, such as U-233, or certain isotopes of elements such as americium or neptunium. See, for example, David Albright and Lauren Barbour, "Troubles Tomorrow? Separated Neptunium-237 and Americium," in David Albright and Kevin O'Neill, eds., *The Challenges of Fissile Material Control* (Washington, D.C.: Institute for Science and International Security, 1999), pp. 85-96, http://www.isis-online.org/publications/fmct/book/New%20chapter%205.pdf (accessed 5 March 2010). These other materials exist in kilogram quantities in only a few facilities in the world, which are typically highly secure facilities, and therefore do not contribute a major part of the overall risk of nuclear theft and terrorism. As far as is publicly known, actual nuclear weapons have only been fabricated from plutonium, HEU, or both.

[4] See, for example, Sam Nunn, "The Race Between Cooperation and Catastrophe: Reducing the Global Nuclear Threat," speech, National Press Club, 9 March 2005 http://www.nti.org/c_press/speech_nunnpressclub_030905.pdf, (accessed 9 February 2010).

[5] Some governments have referred to nuclear security as a "fourth pillar" of the NPT, but given how essential nuclear security is to the traditional three pillars, it seems more accurate to describe it as a foundation for these three than as a fourth pillar. See Prime Minister Gordon Brown, *The Road to 2010: Addressing the Nuclear Question in the 21st Century* (London: United Kingdom Cabinet Office, July 2009), p. 8.

Nevertheless, this report does not address the full spectrum of steps needed to reduce the dangers of nuclear weapons or limit their spread to additional states.[6] Instead, it is focused only on steps to prevent terrorist acquisition and use of an actual nuclear explosive. It does not cover the broad range of non-nuclear means by which terrorists might be able to cause catastrophic harm.[7] The use of a nuclear bomb would be among the most difficult types of attack for terrorists to accomplish—but the massive, assured, instantaneous, and comprehensive destruction of life and property that would result may make nuclear weapons a priority for terrorists despite the difficulties.

It is important to understand the full history-changing scope of the catastrophe that even a single terrorist nuclear bomb could cause. The heart of a major city could be reduced to a smoldering radioactive ruin, leaving tens or hundreds of thousands of people dead.[8] Terrorists—either those who committed the attack or others—would probably claim they had more bombs already hidden in other cities (whether they did nor not), and the fear that this might be true could lead to panicked evacuations, creating widespread havoc and economic disruption.

Some countries may feel that nuclear terrorism is really only a concern for the countries most likely to be the targets, such as the United States. In reality, however, such an event would cause devastating economic aftershocks worldwide.

---

[6] For compilations of recommended steps for the broader problem of nuclear nonproliferation, see, for example, George Perkovich et al., *Universal Compliance: A Strategy for Nuclear Security* (Washington, D.C.: Carnegie Endowment for International Peace, 2005), http://www.carnegieendowment.org/files/UC2.FINAL3.pdf (accessed 10 December 2009); Weapons of Mass Destruction Commission, Hans Blix, chairman, *Weapons of Terror: Freeing the World of Nuclear, Biological, and Chemical Arms* (Stockholm: Weapons of Mass Destruction Commission, 2006), http://wmdcommission.org/files/Weapons_of_Terror.pdf (accessed 9 February 2009); and International Commission on Nuclear Non-Proliferation and Disarmament, Gareth Evans and Yoriko Kawaguchi, co-chairs, *Eliminating Nuclear Threats: A Practical Agenda for Global Policymakers* (Canberra/Tokyo: International Commission on Nuclear Non-Proliferation and Disarmament, November 2009), http://www.icnnd.org/reference/reports/ent/pdf/ICNND_Report-EliminatingNuclearThreats.pdf.

[7] For an official listing of major terrorist and natural scenarios that could cause catastrophic harm, see U.S. Homeland Security Council, *National Planning Scenarios: Version 20.1 Draft* (Washington, D.C.: U.S. Homeland Security Council, 2005), http://media.washingtonpost.com/wp-srv/nation/nationalsecurity/earlywarning/NationalPlanningScenariosApril2005.pdf (accessed 9 February 2010).

[8] There have been many assessments of the impact of such an attack, though they usually focus narrowly on the death and destruction the explosion itself would cause, rather than the reverberating aftershocks. An earlier report in this series, estimated that if terrorists detonated a 10-kiloton bomb (that is, one with the explosive power of 10,000 tons of TNT, somewhat smaller than the bomb that obliterated Hiroshima) at Grand Central Station in Manhattan on a typical workday, the attack could kill half a million people and cause roughly $1 trillion in direct economic damage. See Matthew Bunn, Anthony Wier, and John Holdren, *Controlling Nuclear Warheads and Materials: A Report Card and Action Plan* (Cambridge, Mass., and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, 2003; available at http://www.nti.org/e_research/cnwm/cnwm.pdf as of 28 March 2008), pp. 15-19. This was a rough estimate based on a relatively crude analysis. A number of more detailed analyses of the effects of a terrorist nuclear weapon in a U.S. city are available, though a surprising number of them either envision a bomb going off in an area with much lower population density than mid-town Manhattan, or envision the bomb being detonated at night (when the populations at the center of most cities are far lower, but easier to get information about from the U.S. census). For a recent official government analysis of such an event in Washington D.C., see, for example, U.S. Homeland Security Council, *National Planning Scenarios: Version 20.1 Draft*. Recent detailed non-government analyses include Charles Meade and Roger C. Molander, *Considering the Effects of a Catastrophic Terrorist Attack* (Washington, D.C.: RAND, 2006; available at http://www.rand.org/pubs/technical_reports/2006/RAND_TR391.pdf as of 28 March 2008) and Ira Helfand, Lachlan Forrow, and Jaya Tiwari, "Nuclear Terrorism," *British Medical Journal* 324 (9 February 2002; available at http://www.bmj.com/cgi/reprint/324/7333/356.pdf as of 28 March 2008).

Incidents Highlight the Global Threat

In early February 2010, a group of peace activists climbed over the perimeter fence at Kleine-Borgel airbase in Belgium, where U.S. nuclear weapons are reportedly stored. The fence was a simple chain-link fence with no intrusion detectors, and the group was not detected. The group walked out onto the runway, where they spent 40 minutes to an hour, expecting to be arrested. They then walked through a gate that had been left open in a double fence surrounding an area of bunkers, placing protest stickers on the wall of one bunker (not, apparently, a nuclear weapon storage bunker). They then proceeded across a large open area, where they were finally stopped by a single guard, whose weapon appeared to be unloaded—some 90 minutes after they entered the base.[1]

Though the area the activists penetrated was not the nuclear weapons storage area, this was a major security breach, revealing substantial weaknesses in the site's ability to detect, assess, and respond to adversary intrusions in a timely way. Remarkably, security at the site was still weak despite a series of warnings of security problems and threats, including: (a) a November 2009 penetration of the site by the same peace group (which only reached the airstrip, not the area with the hardened bunkers); (b) a 2008 report from an Air Force blue-ribbon panel that warned that there were significant security problems at European bases for U.S. nuclear weapons, and that "most sites require significant additional resources to meet [Department of Defense] security requirements";[2] and (c) the 2001 arrest of an al Qaeda operative for planning to bomb the *same* base (and who testified that an insider at the base had sold photos of the facility to al Qaeda).[3]

In November 2007, just over two years earlier, two teams of armed men attacked the Pelindaba nuclear facility in South Africa, where hundreds of kilograms of weapon-grade HEU are located. One of the teams got through a 10,000-volt security fence, disabled intrusion detectors without detection, and proceeded to the emergency control center (where they shot one of the workers on duty in a struggle). They had set off no alarm until the worker at the emergency control center called for help. They left via the same point at the fence by which they arrived, reportedly spending 45 minutes inside the guarded perimeter without ever being engaged by site security forces. The other team engaged the site security forces, but never entered the site perimeter. The attackers' familiarity with how to disable the intrusion detectors and with equipment at the emergency control center strongly suggests they had help from someone with insider knowledge. The attackers have never been identified or captured. The security manager, two guards, and a shift supervisor on duty at the time resigned or were fired. While they never penetrated the inner security for the HEU area, this also represents a major security breach,

[1] For useful discussions of this incident, with links to the peace activists' video taken by the peace activists and to a variety of other relevant sources, see Jeffrey Lewis, "Activists Breach Security at Kleine Brogel," *ArmsControlWonk.com,* 4 February 2010, http://www.armscontrolwonk.com/2614/activists-breach-security-at-kleine-brogel (accessed 5 February 2010), and Hans Kristensen, "U.S. Nuclear Weapons Site in Europe Breached," *FAS Strategic Security Blog,* Federation of American Scientists, 4 February 2010, http://www.fas.org/blog/ssp/2010/02/kleinebrogel.php (accessed 5 February 2010). For confirmation that they did not enter the double-fenced area they entered was not the nuclear weapon storage area, see Jeffrey Lewis, "Yes, It's the Other Area," *ArmsControlWonk.com,* 6 February 2010, http://www.armscontrolwonk.com/2619/yes-its-the-other-area (accessed 6 February 2010).

[2] Major General Polly A. Meyer, chair, *Air Force Blue Ribbon Review of Nuclear Weapons Policies and Procedures* (Washington, D.C.: U.S. Air Force, 8 February 2008), p. 52. This report was first revealed by Hans Kristensen, "USAF Report: 'Most' Nuclear Weapon Sites in Europe Do Not Meet U.S. Security Requirements," *FAS Strategic Security Blog,* Federation of American Scientists, 19 June 2008, http://www.fas.org/blog/ssp/2008/06/usaf-report-%E2%80%9Cmost%E2%80%9D-nuclear-weapon-sites-in-europe-do-not-meet-us-security-requirements.php (accessed 5 February 2010).

[3] See, for example, "Al-Qaeda Suspect Tells of Bomb Plot," *BBC News,* 27 May 2003 http://news.bbc.co.uk/2/hi/europe/2941702.stm (accessed 5 February 2010). The al Qaeda operative in the case was Nizar Trabelsi, who had met repeatedly with Osama bin Laden in Afghanistan. For a summary of Nizar Trabelsi's terrorist activities, see "Nizar Trabelsi," *GlobalJihad.net,* 8 April 2007, http://globaljihad.net/view_page.asp?id=356 (accessed 5 February 2010).

INCIDENTS HIGHLIGHT THE GLOBAL THREAT (CONT)

highlighting substantial weaknesses in the site's detection, assessment, and response arrangements.[4]

A year and a half before that, in February 2006, Russian citizen Oleg Khinsagov was arrested in Georgia (along with three Georgian accomplices) with 79.5 grams of 89% enriched HEU, claiming that he had kilograms more available for sale.[5] There is at least suggestive evidence that this material—and additional HEU seized in Georgia in 2003—was stolen from the large Russian nuclear fuel fabrication plant at Novosibirsk.[6] This 2006 case was only the most recent in a series of incidents: the IAEA has documented 18 cases of actual theft or loss of plutonium or HEU (the materials from which a nuclear bomb could be made), confirmed by the states concerned.[7] Additional thefts are known to have occurred which the relevant states have so far not confirmed to the IAEA.[8] What is not known, of course, is how many thefts may have occurred that were never detected; it is a sobering fact that nearly all of the stolen HEU and plutonium that has been seized over the years had never been missed before it was seized. U.S. intelligence agencies have assessed that "it is likely that undetected smuggling has occurred," and they are "concerned about the total amount of material that could have been diverted over the last 15 years."[9]

All of these events point to a single conclusion: in a variety of countries around the world, security for nuclear weapons and for the materials that would be needed to make them is not adequate to protect against the kinds of threats that terrorists and criminals have shown they can pose.

---

[4] For a description of this event, see Bunn, *Securing the Bomb 2008,* pp. 3-4 (with sources cited therein), and "60 Minutes: Assault on Pelindaba," *CBS News,* 23 November 2008, http://www.cbsnews.com/stories/2008/11/20/60minutes/main4621623.shtml (accessed 6 February 2010).

[5] For an especially useful account of this case, see Michael Bronner, "100 Grams (And Counting): Notes From the Nuclear Underworld" (Cambridge, Mass.: Project on Managing the Atom, Harvard University, June 2008), http://belfercenter.ksg.harvard.edu/files/100-Grams-Final-Color.pdf (accessed 6 February 2010). (The case involved roughly 100 grams of uranium oxide, of which 79.5 grams were uranium.) See also Laurence Scott Sheets, "A Smuggler's Story," *Atlantic Monthly,* April 2008, http://www.theatlantic.com/doc/200804/uranium-smuggling (accessed 6 February 2010), and Elena Sokova, William C. Potter, and Cristina Chuen, "Recent Weapons Grade Uranium Smuggling Case: Nuclear Materials Are Still on the Loose" (Monterey, Calif.: Center for Nonproliferation Studies, Monterey Institute of International Studies, 26 January 2007), http://cns.miis.edu/stories/070126.htm (accessed 6 February 2010). Khinsagov offers a stark jailhouse confession in the film *Countdown to Zero* (Participant Media, January 2010, director Lucy Walker).

[6] The Russian Federal Security Service (FSB) investigation concluded that Khinsagov had traveled to towns near the Novosibirsk facility some years before he was arrested. See Bronner, "100 Grams (And Counting)."

[7] For the International Atomic Energy Agency's list of incidents confirmed by the states concerned, see *IAEA Illicit Trafficking Database: Fact Sheet* (Vienna: IAEA, 2008) http://www.iaea.org/NewsCenter/Features/RadSources/PDF/fact_figures2007.pdf (accessed 6 February 2010). Perhaps the best available summary of what is known and what is not known about nuclear and radiological smuggling is "Illicit Trafficking in Radioactive Materials," in Mark Fitzpatrick, ed., *Nuclear Black Markets: Pakistan, A.Q. Khan, and the Rise of Proliferation Networks: A Net Assessment* (London: International Institute for Strategic Studies, 2007), pp. 119-138. (Lyudmila Zaitseva, principal author.)

[8] See Zaitseva, "Illicit Trafficking in Radioactive Materials."

[9] U.S. National Intelligence Council, *Annual Report to Congress on the Safety and Security of Russian Nuclear Facilities and Military Forces* (Washington, D.C.: Central Intelligence Agency, 2006), http://www.fas.org/irp/nic/russia0406.html (accessed 4 March 2010). Former CIA Director Porter Goss testified to Congress that sufficient material was unaccounted for that he could not provide assurances that enough material for a bomb had not already been stolen. See testimony in Select Committee on Intelligence, *Current and Projected National Security Threats to the United States*, U.S. Senate, 109th Congress, 16 February 2005, http://www.fas.org/irp/congress/2005_hr/shrg109-61.pdf (accessed 31 March 2010). Goss was not saying that the CIA had definite information that enough material for a bomb was missing, only that the accounting uncertainties are large enough that he could not confirm that was not the case. The same is true in the United States; some two tons of U.S. plutonium, for example, enough for hundreds of nuclear bombs, is officially considered "material unaccounted for." See U.S. Department of Energy, *Plutonium: The First 50 Years: United States Plutonium Production, Acquisition, and Utilization from 1944 through 1994* (Washington, D.C.: DOE, 1996), http://www.fas.org/sgp/othergov/doe/pu50y.html (accessed 4 March 2010).

In 2005 then-UN Secretary-General Kofi Annan warned that these global effects would push "tens of millions of people into dire poverty," creating "a second death toll throughout the developing world."[9]

It is also important to emphasize that the nuclear industry itself has a huge interest in preventing nuclear terrorism. A terrorist nuclear bomb, or a major sabotage of a nuclear facility—a "security Chernobyl"—would doom any prospect for gaining the public, government, and utility support needed for large-scale growth of nuclear power, putting tens or hundreds of billions of dollars in future revenue at risk. In some countries, it might even lead to pressures to close major operating facilities.

Unfortunately, as described in the next chapter, al Qaeda has been actively seeking a nuclear bomb for years. Moreover, as already noted, there have been repeated cases of real theft of the materials needed to make a nuclear bomb, and government studies have warned that if a sophisticated terrorist group got enough of these materials, they might well be able to fabricate at least a crude nuclear bomb. The likelihood of terrorists detonating a nuclear bomb may not be high, but the consequences would be so catastrophic—not only for the targeted country but for the entire world—that urgent action is justified to reduce the danger.[10] No one in their right mind would operate a nuclear power plant upwind of a major city if it had a 1% chance each year of a Chernobyl-scale release—the danger would be understood by all to be too great. Yet the international community may well be accepting an even greater risk of nuclear devastation of a major city by terrorists as a result of the way nuclear weapons and materials are managed around the world today.

Terrorists cannot make a nuclear bomb unless they get hold of enough highly enriched uranium (HEU) or plutonium. No material, no bomb. These materials do not occur in nature, and are quite difficult to produce—well beyond the plausible capabilities of terrorist groups. Indeed, making the needed nuclear material has always been the most challenging and costly element of national nuclear weapons programs, having consumed some 90% of the resources devoted to the Manhattan Project. Hence, as President Obama and the UN Security Council recognized, securing nuclear material to prevent it from being stolen is the single most important step that can be taken to reduce the risk of nuclear terrorism. If all the nuclear weapons and all the plutonium and HEU produced by states can be reliably secured and kept out of terrorist hands, terrorists can be prevented from getting nuclear weapons. Nuclear weapons, plutonium, or HEU exist in hundreds of buildings and bunkers in dozens of countries around the world—but not in thousands of buildings in hundreds of countries. Providing effective security for these stockpiles is a big job, and a difficult job, but with the right leadership,

[9] Kofi Annan, "A Global Strategy for Fighting Terrorism: Keynote Address to the Closing Plenary," in *The International Summit on Democracy, Terrorism and Security* (Madrid: Club de Madrid, 2005), http://english.safe-democracy.org/keynotes/a-global-strategy-for-fighting-terrorism.html (accessed 9 February 2010).

[10] A substantial literature now exists on the danger of nuclear terrorism. See in particular the reports in the *Securing the Bomb* series, most recently Matthew Bunn, *Securing the Bomb 2008* (Cambridge, Mass.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, November 2008). These reports are all available (with extensive additional information) at the "Securing the Bomb" section of the Nuclear Threat Initiative's website, http://www.nti.org/securingthebomb. For a seminal, alarming look at the danger, see Graham T. Allison, *Nuclear Terrorism: The Ultimate Preventable Catastrophe* (New York: Times Books/Henry Holt, 2004). For a less alarming analysis, see Michael Levi, *On Nuclear Terrorism* (Cambridge, Mass.: Harvard University Press, 2007).

resources, international cooperation, and planning, it can be done.

Of course, other steps beyond nuclear security should also be taken to block the terrorist pathway to the bomb, providing a multilayered defense in case nuclear security measures do not succeed. (See Figure 1.1.) Cooperative threat reduction programs can help stop the first steps on the terrorist pathway, homeland security measures can help interdict the final steps on the pathway, and intelligence and counter-terrorism measures operate throughout the path. In particular, key steps include identifying and countering terrorist groups with nuclear ambitions, seeking to interdict nuclear smuggling, and further reducing the already low likelihood that states would consciously transfer nuclear weapons or materials to terrorists, and more. But the step on the terrorist pathway that government policies can do the most to stop is the initial theft of a nuclear weapon or nuclear material. The nuclear material needed for a bomb would fit in a suitcase and is difficult to detect; once that material has left the gate of the facility where it was supposed to be, it could be anywhere, and all the later lines of defense are variations on looking for needles in haystacks. The further terrorists get along the pathway to the bomb, the harder they would be to stop; homeland security measures, in this case, are desperate, last-ditch defenses. Hence, this report, like the Security Council resolution and the planned nuclear security summit, will focus primarily on nuclear security measures designed to prevent nuclear weapons or the materials needed to make them from being stolen.[11] This report does not address other important nuclear nonproliferation programs such as efforts to strengthen export controls or to reemploy former weapons scientists in civilian pursuits.

Other Types of Nuclear and Radiological Terrorism

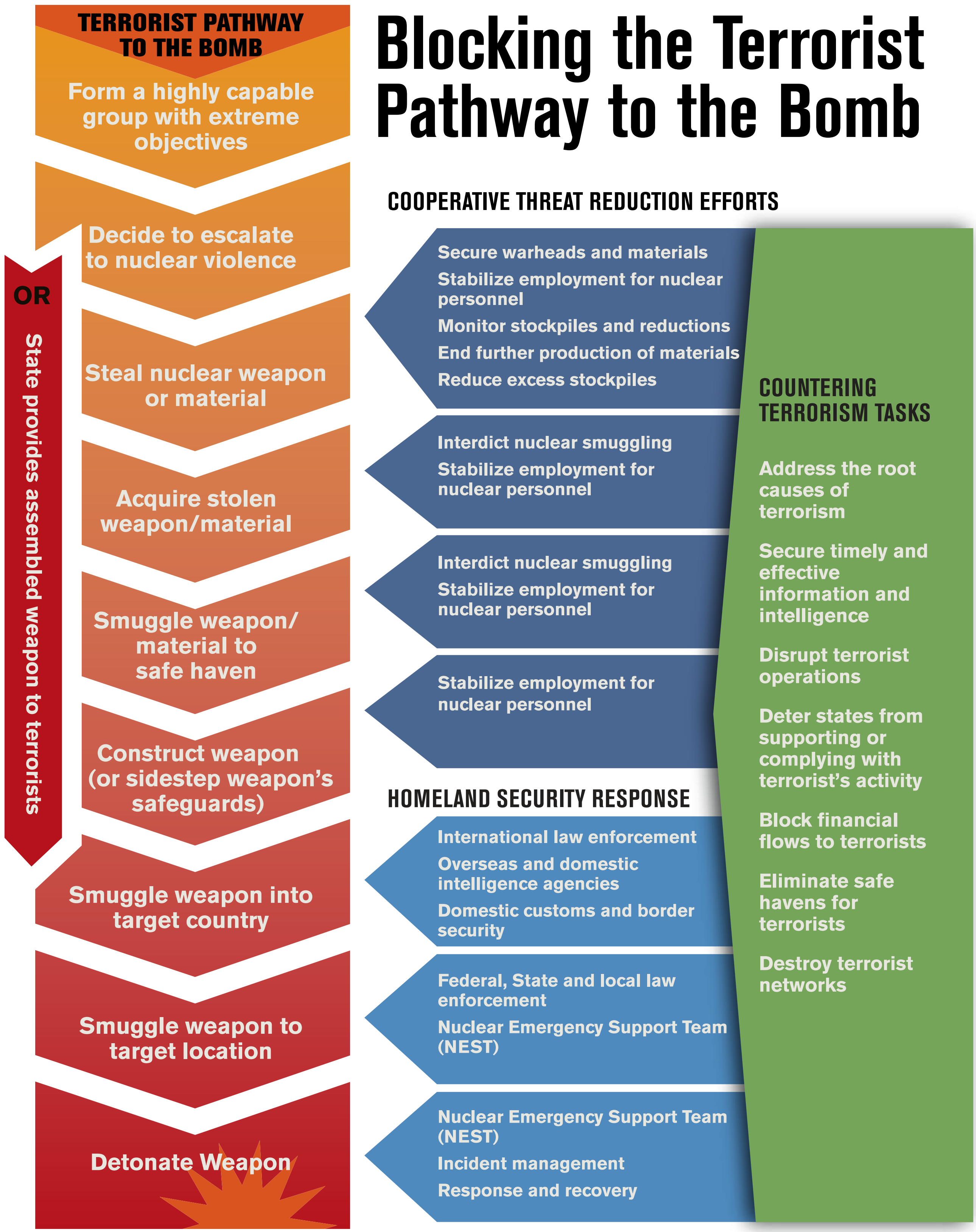
It is important to distinguish terrorist use of an actual nuclear bomb from other terrorist attacks involving nuclear or radiological materials or facilities. Terrorists could use conventional explosives or other means to disperse radioactive material in a so-called "dirty bomb," using, for example, radiological sources in wide use in medicine, industry, and agriculture. Such an attack would be far easier for terrorists to accomplish than would use of an actual nuclear bomb: a far wider range of radioactive materials could be used, available in hospitals, industry, and agriculture, and it is much easier to simply disperse such materials than to set off an explosive nuclear chain reaction. Such a "dirty bomb" attack could potentially cause large-scale panic and disruption, along with tens of billions of dollars in the costs of cleanup and disrupted economic activity—but it would not incinerate the heart of a major city in a flash, as a nuclear bomb could, and in most scenarios, it is likely that few people would die from the radiation. Dirty bombs are sometimes described as "weapons of mass disruption" rather than "weapons of mass destruction."[12] If risk is defined as probability multiplied by consequences, a strong case can be made that terrorist use of an actual nuclear bomb, with its overwhelmingly catastrophic consequences, poses a greater risk, even if it would be much harder for terrorists to accomplish.[13] Successful radiation-

[11] For discussions covering other elements of an overall defense against nuclear terrorism see, for example, Levi, *On Nuclear Terrorism;* Bunn, *Securing the Bomb 2008,* pp. 160-174; and Matthew Bunn, "A Mathematical Model of the Risk of Nuclear Terrorism," *Annals of the American Academy of Political and Social Science,* Vol. 607, No. 1 (September 2006), pp. 103-120.

[12] Michael A. Levi and Henry C. Kelly, "Weapons of Mass Disruption," *Scientific American*, November 2002, pp. 77-81.

[13] *Easier* attacks are not always more *likely.* Probability depends also on how terrorists see the potential

FIGURE 1.1:



Blocking the Terrorist Pathway to the Bomb
TERRORIST PATHWAY TO THE BOMB
Form a highly capable group with extreme objectives
Decide to escalate to nuclear violence
OR
State provides assembled weapon to terrorists
Steal nuclear weapon or material
Acquire stolen weapon/material
Smuggle weapon/ material to safe haven
Construct weapon (or sidestep weapon's safeguards)
Smuggle weapon into target country
Smuggle weapon to target location
Detonate Weapon
COOPERATIVE THREAT REDUCTION EFFORTS
Secure warheads and materials
Stabilize employment for nuclear personnel
Monitor stockpiles and reductions
End further production of materials
Reduce excess stockpiles
Interdict nuclear smuggling
Stabilize employment for nuclear personnel
Interdict nuclear smuggling
Stabilize employment for nuclear personnel
Stabilize employment for nuclear personnel
HOMELAND SECURITY RESPONSE
International law enforcement
Overseas and domestic intelligence agencies
Domestic customs and border security
Federal, State and local law enforcement
Nuclear Emergency Support Team (NEST)
Nuclear Emergency Support Team (NEST)
Incident management
Response and recovery
COUNTERING TERRORISM TASKS
Address the root causes of terrorism
Secure timely and effective information and intelligence
Disrupt terrorist operations
Deter states from supporting or complying with terrorist's activity
Block financial flows to terrorists
Eliminate safe havens for terrorists
Destroy terrorist networks

dispersing sabotage of a major nuclear facility, such as a nuclear power plant or spent fuel pool, is intermediate between a nuclear bomb and a dirty bomb in both the difficulties it poses for terrorists and the consequences it might have. There, too, the evidence suggests the risk is substantial, but less severe than the dangers posed by actual terrorist use of a nuclear bomb.

Though often lumped together under the rubric of "nuclear terrorism," these are very different types of attack, calling for quite different policies to reduce the risks they pose. Because radiological sources exist in thousands of locations all over the world, and because much of the impact of such an attack would arise from the public fear it might provoke, the response to the "dirty bomb" danger should focus not only on improved security for radiological materials, but also on public education and strengthened preparedness that could help reduce the fear and disruption such an attack would cause, reducing terrorists' perception of its likely value. In the case of sabotage, each country operating facilities whose sabotage could pose a major catastrophe—whether nuclear or non-nuclear—should ensure that they have security measures capable of protecting against the most plausible threats, and that appropriate evacuation plans and other procedures to strengthen resilience in the face of attack are in place. Where cost-effective measures are available to change processes and materials so as to lessen the consequences of sabotage (such as switching to less toxic or dispersible chemicals at a chemical plant), they should be implemented. A key difference between sabotage and a nuclear bomb is that sabotage's consequences are concentrated in the immediate area of the facility attacked, while stolen nuclear material could be made into a bomb that might be used anywhere in the world. These other types of nuclear terrorism are addressed elsewhere, and are not discussed further in this report.[14]

Hoaxes and threats are other forms of nuclear-related terrorism that could potentially also have important impacts. If there were a specific and credible threat

consequences of an attack serving their purposes. If the value to them of a potential attack was high, terrorists might be willing to devote substantial resources to overcoming the obstacles to accomplishing it. While some al-Qaeda-linked terrorists, such as Dhiren Barot, have pursued "dirty bomb" concepts, there is significant evidence that the central leadership of al Qaeda has focused on acquiring an actual nuclear explosive, rather than on dirty bombs. Rolf Mowatt-Larssen, who led the CIA's effort to track al Qaeda's nuclear, chemical, and biological efforts after 9/11, remains convinced that despite the greater ease of a radiological attack, a terrorist attack using an actual nuclear bomb may be just as likely, because this is what he observed Osama bin Laden and Ayman al-Zawahiri were focused on achieving. See Rolf Mowatt-Larssen, "Al Qaeda WMD Threat: Hype or Reality?" (Cambridge, Mass.: Belfer Center for Science and International Affairs, Harvard Kennedy School, January 2010), http://belfercenter.ksg.harvard.edu/files/al-qaeda-wmd-threat.pdf (accessed 6 February 2010). In this paper, Mowatt-Larssen provides a detailed chronology of al Qaeda's efforts to acquire nuclear and biological weapons for large-scale strategic attacks.

[14] See, for example, Charles D. Ferguson and William C. Potter, with Amy Sands, Leonard S. Spector, and Fred L. Wehling, *The Four Faces of Nuclear Terrorism*, ed. Amy Sands, Leonard S. Spector, and Fred L. Wehling (Monterey, Cal.: Center for Nonproliferation Studies, Monterey Institute of International Studies, 2004), http://www.nti.org/c_press/analysis_4faces.pdf (accessed 9 February 2010). One conceivable type of nuclear terrorism, not addressed in this report, is the possibility of terrorists somehow figuring out a way to cause an existing nuclear weapon to be launched, or to provoke existing nuclear weapon states to launch a nuclear attack (for example by introducing false alarms into nuclear warning systems). Possibly the earliest public discussion of such possibilities was in Bruce G. Blair and Gary D. Brewer, "The Terrorist Threat to the World's Nuclear Weapons Programs," *Journal of Conflict Resolution* Vol. 31, No. 3, September 1977, pp. 379-403, http://www.cdi.org/blair/terrorist-threat.cfm (accessed 9 February 2010). More recently, see, for example, Gary Ackerman and William C. Potter, "Catastrophic Nuclear Terrorism: A Preventable Peril," in Nick Bostrom and Milan M. Cirkovic, *Global Catastrophic Risks* (Oxford: Oxford University Press, 2008), pp. 402-449.

that a nuclear bomb was hidden in Washington, D.C.—perhaps backed up by a genuine sample of HEU or plutonium and a credible bomb design included in the threat—the federal and local governments would be faced with extraordinarily difficult choices. The terrorists might well provide the threat to the national media as well, potentially provoking widespread fear that it might be real. Better preparations for such events are surely needed. But hoaxes and threats, by their nature, would not have the catastrophic, history-changing impact of a mushroom cloud rising over the ruins of the heart of a major city, and they, too, are not addressed further in this report.

Cooperation, Not Confrontation, is the Answer

Combining fears of nuclear bombs and terrorists in a single terrifying idea, the concept of nuclear terrorism reaches many people's deepest fears, and provokes in some the desire to lash out militarily if necessary to protect against this danger. Indeed, the fear that Saddam Hussein might pass nuclear, chemical, or biological weapons to terrorists was a prominent part of the debate over the U.S.-led invasion of Iraq in 2003.

But the reality is that nuclear terrorism cannot be prevented by force of arms. The world's stockpiles of HEU and plutonium, located in dozens of countries, can only be secured through broad international cooperation, with many countries working together to confront a threat to their common security. Terrorist networks that might be working on nuclear weapons are international, and can only be found and countered with international intelligence and police cooperation. Nuclear smuggling can only be stopped through similar intelligence and police cooperation, combined with customs and border control cooperation and other efforts to track down the material and those who are moving it. There will surely be cases where a Predator strike or some other use of force is an important part of the struggle—but the fundamental elements of the effort to prevent nuclear terrorism involve politically sensitive cooperation across the globe.

A Note on Sources— and the Need for Accountability

No one wants nuclear thieves or saboteurs to know the details of the security measures they will have to defeat. Hence, every country that possesses nuclear weapons, weapons-usable nuclear materials, or major nuclear facilities considers the specifics of its nuclear security arrangements a closely guarded secret.

As a result, no government or international organization has a complete understanding of where all the nuclear weapons and weapons-usable nuclear materials in the world are and the security measures in place at each of those locations. (In recent years, the U.S. government has sought to compile and to analyze as much of this information as it can, and to identify what is still unknown, in an effort known as the Nuclear Materials Information Program, or NMIP.) There is no internationally agreed baseline from which to judge how much progress is being made in improving nuclear security and reducing the risks of nuclear theft. Nor are there any agreed measures of progress from whatever the starting point might be. Safeguards inspectors from the International Atomic Energy Agency (IAEA) inspect to make sure non-nuclear-weapon states have not diverted nuclear material to military programs, but they are not charged with either guarding these stockpiles from theft or assessing how well countries are guarding them: ironically, "safeguards" have little to do with either safety or guarding.[15] The lack of either an agreed baseline or agreed measures of progress from that starting point makes it extraordinarily difficult to set priorities focusing on the highest-risk locations, to gain specific nuclear security commitments, or to hold countries accountable for fulfilling the commitments they make—a fundamental challenge for the four-year effort to achieve effective security for nuclear stockpiles worldwide.

One major recommendation of this report, discussed in the final chapter, is that the United States and other countries working to improve nuclear security should do as much as is possible within the confines of necessary secrecy to reach a common understanding of where nuclear security stands around the world, and should develop measures countries can use to build international confidence that they are providing effective security and meeting whatever nuclear security commitments they have entered into.

Developing an assessment of the state of nuclear security and the risks of nuclear theft from outside any government, relying only on unclassified information, is more difficult still. This report provides a best estimate based on a wide range of unclassified sources, including published national regulations, reports, and statements of policy; conference papers; visits to nuclear facilities; and interviews with nuclear security officials and experts in several countries. In order to allow these officials to be candid, they remain anonymous. Although the picture provided here is global, alert readers will note that the information provided about nuclear security in the United States and Russia is more detailed; that is because, after nearly two decades of nuclear security cooperation, more detailed information is publicly available about nuclear security in these two countries than in others. This report is the latest in a series, building on nearly two decades of research and government service focused on the management of nuclear materials.[16]

Plan of This Report

This report begins with assessments of the current risk of nuclear terrorism and the current global status of nuclear security. This provides, in effect, the beginning point for the four-year effort to secure nuclear stockpiles called for by President Obama and Security Council Resolution 1887. Next, the report lays out a set of objectives for providing effective security for all nuclear materials worldwide, and outline indicators that can be used to judge the level of effort devoted to reducing these dangers, and the degree of progress being made. The next section describes the efforts to upgrade nuclear security and to prevent nuclear terrorism made by the Obama administration and other governments during 2009, and uses some of the indicators developed in the previous chapter to assess those efforts. The final chapter outlines what steps need to be taken if the international community is to succeed in securing all nuclear material worldwide in four years.

[15] As discussed later in this report, however, some states have voluntarily requested IAEA-led reviews of their security arrangements—an effort quite separate from IAEA safeguards—and some are obligated by agreements with suppliers, particularly the United States, to accept supplier review of their security arrangements.

[16] In particular, this report draws heavily on the conclusions and analysis in Matthew Bunn, *Securing the Bomb 2008* (Cambridge, Mass.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, November 2008). That report, previous reports in the "Securing the Bomb" series, and a wide range of other information, including an on-line interactive budget database for all threat U.S.-sponsored threat reduction programs, can be found at http://www.nti.org/securingthebomb.

2 THE CONTINUING DANGER OF NUCLEAR THEFT AND TERRORISM

Complacency about the threat is perhaps the biggest obstacle to forging the urgent, in-depth international cooperation needed to secure nuclear stockpiles and reduce the danger of nuclear terrorism. Many policymakers around the world continue to believe that it would take a Manhattan Project to make a nuclear bomb, that it would be almost impossible for terrorists to get the necessary nuclear material, and that the risk of terrorists getting and using a nuclear bomb is therefore vanishingly small. The experience of finding that Iraq did not have nuclear, chemical, or biological weapons in 2003 has made many justifiably skeptical of other assertions about serious threats from such weapons. Unfortunately, while no one can say precisely what the probability of nuclear terrorism is, the danger is very real. Several unfortunate facts shape the risk the world faces.

Some Terrorists are Seeking Nuclear Weapons

Most terrorist groups are focused on small-scale violence to attain local objectives. For them, the old adage that "terrorists want a lot of people watching, not a lot of people dead" holds true, and nuclear weapons are likely to be irrelevant or counterproductive for their goals.

But a small set of terrorists with global ambitions and nihilistic visions clearly are eager to get and use a nuclear bomb. Osama bin Laden has called the acquisition of nuclear weapons or other weapons of mass destruction a "religious duty."[1]

For years, al Qaeda operatives have repeatedly expressed the desire to inflict a "Hiroshima" on the United States.[2] Al Qaeda operatives have made repeated attempts to buy nuclear material for a nuclear bomb, or to recruit nuclear expertise.

Shortly before the 9/11 attacks, for example, bin Laden and Ayman al-Zawahiri met with two senior Pakistani nuclear scientists to discuss nuclear weapons.[3] Former CIA Director George Tenet reports that the two provided al Qaeda with a rough sketch of a nuclear bomb design, and that U.S. officials were so concerned

[1] Rahimullah Yusufzai, "Interview with Bin Laden: World's Most Wanted Terrorist" (ABC News Online, 2 January 1999), http://cryptome.org/jya/bin-laden-abc.htm (accessed 6 February 2010). For further details on U.S. intelligence on al Qaeda's nuclear efforts, see Rolf Mowatt-Larssen, "Al Qaeda WMD Threat: Hype or Reality?" (Cambridge, Mass.: Belfer Center for Science and International Affairs, Harvard Kennedy School, January 2010), http://belfercenter.ksg.harvard.edu/files/al-qaeda-wmd-threat.pdf (accessed 6 February 2010); George Tenet, *At the Center of the Storm: My Years at the CIA* (New York: HarperCollins, 2007), pp. 259-280; and Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction, *Report to the President* (Washington, D.C.: WMD Commission, 2005), http://www.gpoaccess.gov/wmd/pdf/full_wmd_report.pdf (acessed 6 February 2010), pp. 267-278. While Tenet's credibility has been undermined by the discovery that Iraq had no chemical or biological weapons and no substantial nuclear program remaining in 2003, his descriptions of al Qaeda's efforts to get a nuclear bomb have not been subject to substantial public challenge.

[2] Steve Coll, "What Bin Laden Sees in Hiroshima," *Washington Post*, 6 February 2005.

[3] David Albright and Holly Higgins, "A Bomb for the Ummah," *Bulletin of the Atomic Scientists* 59, no. 2 (March/April 2003), http://thebulletin.metapress.com/content/ru1k226j4ln4585l/ (accessed 9 February 2010)), pp. 49-55. For a somewhat more detailed version, see David Albright and Holly Higgins, "Pakistani Nuclear Scientists: How Much Nuclear Assistance to Al Qaeda?" (Washington, D.C.: Institute for Science and International Security, 2002), http://www.exportcontrols.org/pakscientists.html#back29 (accessed 9 February 2010).

about the activities of the "charity" they had established (whose board of directors also included a range of senior retired military officers, and which reportedly also offered nuclear weapons help to Libya) that President Bush directed him to fly to Pakistan and discuss the matter directly with Pakistani President Pervez Musharraf.[4] Sultan Bashiruddin Mahmoud, the more senior of the two, had long argued that Pakistan's nuclear weapons rightfully belonged to the whole worldwide "ummah," or Muslim community, and had advocated sharing nuclear weapons technology.[5]

After the 9/11 attacks, intelligence agencies from the United States and other countries learned that in the years leading up to the attacks, al Qaeda had a focused nuclear weapons program managed by Abdel Aziz al-Masri (aka Ali Sayyid al-Bakri), an Egyptian explosives expert. The program reported directly to Zawahiri, as did al Qaeda's anthrax efforts, its other major strategic-scale weapons of mass destruction program. This program reportedly got to the point of carrying out tests of conventional explosives for use in a nuclear bomb.[6]

Al Qaeda's nuclear efforts apparently continued after the disruptions the group faced following the overthrow of the Taliban government and the removal of al Qaeda's Afghan sanctuary. In 2002-2003, U.S. intelligence received a "stream of reliable reporting" that the leadership of al Qaeda's cell in Saudi Arabia was negotiating to purchase three objects they believed to be Russian "nuclear devices," and that al Qaeda's central leadership had approved the purchase *if* a Pakistani expert using his equipment confirmed that they were genuine. (The actual nature of these "devices," if they existed, the name of the Pakistani expert, and the type of equipment he was to use to examine the devices have never been learned.)[7] At the same time these discussions were taking place, bin Laden arranged for a radical Saudi cleric to issue a *fatwa* or religious ruling authorizing the use of nuclear weapons against American civilians.[8] The cleric who issued the *fatwa* was the "steady companion" of the al Qaeda operative leading the negotiations over the nuclear devices.[9]

Before al Qaeda, the Japanese terror cult Aum Shinrikyo also made a concerted effort to get nuclear weapons.[10] Chechen terrorists have certainly pursued the possibility of a radioactive "dirty bomb," and there are at least suggestive indications that they also have pursued nuclear weapons—including two incidents of terrorists conducting reconnaissance at secret nuclear weapon storage sites, confirmed by Russian officials. There are at least some indications that Pakistani groups such as Lashkar-e-Taiba may also be interested—a particularly troubling possibility given the deep past connections these groups have

[4] Tenet, *At the Center of the Storm*, pp. 266-268.

[5] Albright and Higgins, "Pakistani Nuclear Scientists: How Much Nuclear Assistance to Al Qaeda?"

[6] Mowatt-Larssen, "Al Qaeda WMD Threat: Hype or Reality?" See also Tenet, *At the Center of the Storm*, p. 275.

[7] Mowatt-Larssen, "Al Qaeda WMD Threat: Hype or Reality?" See also Tenet, *At the Center for the Storm*, pp. 272-276.

[8] For an English translation of this fatwa, see Nasir Bin Hamd al-Fahd, "A Treatise on the Legal Status of Using Weapons of Mass Destruction Against Infidels," May 2003, http://www.carnegieendowment.org/static/npp/fatwa.pdf (accessed 19 January 2010). Al-Fahd was subsequently arrested, served some years in prison, and released; during that time, he publicly renounced some of his previous rulings.

[9] Mowatt-Larssen, "Al Qaeda WMD Threat: Hype or Reality?"

[10] For earlier discussions of the al Qaeda and Aum Shinrikyo efforts, see Matthew Bunn and Anthony Wier, with Joshua Friedman, "The Demand for Black Market Fissile Material," in *Nuclear Threat Initiative Research Library: Securing the Bomb* (Cambridge, Mass.: Project on Managing the Atom, Harvard University, and Nuc

International Statements on the Threat of Nuclear Terrorism

Nuclear terrorism is one of the most serious threats of our time. Even one such attack could inflict mass casualties and create immense suffering and unwanted change in the world forever. This prospect should compel all of us to act to prevent such a catastrophe.

—U.N. Secretary-General Ban-Ki Moon, 13 June 2007, http://www.un.org/News/Press/docs/2007/sgsm11040.doc.htm (accessed 5 March 2010)

Experts estimate that terrorists with 50 kilograms of highly enriched uranium (HEU), an amount that would fit into six one-litre milk cartons, need only smuggle it across borders in order to create an improvised nuclear device that could level a medium-sized city.

—High-Level Panel on Threats, Challenges, and Change, *A More Secure World: Our Shared Responsibility* (New York: United Nations, 2004), p. 16

Nuclear terrorism is still often treated as science fiction. I wish it were. But unfortunately we live in a world of excess hazardous materials and abundant technological know-how, in which some terrorists clearly state their intention to inflict catastrophic casualties. Were such an attack to occur, it would not only cause widespread death and destruction, but would stagger the world economy… [creating] a second death toll throughout the developing world.

—then-UN Secretary-General Kofi Annan, "A Global Strategy for Fighting Terrorism," 10 March 2005, http://english.safe-democracy.org/keynotes/a-global-strategy-for-fighting-terrorism.html (accessed 5 March 2010)

The gravest threat faced by the world is of an extremist group getting hold of nuclear weapons or materials.

—then-Director-General of the International Atomic Energy Agency Mohammed ElBaradei, address to the United Nations General Assembly, 14 September 2009, http://www.iaea.org/NewsCenter/Statements/2009/ebsp2009n011.html (accessed 5 March 2010)

We have firm knowledge, which is based on evidence and facts, of steady interest and tasks assigned to terrorists to acquire in any form what is called nuclear weapons, nuclear components.

—Anatoly Safonov, Special Representative of the Russian President for International Cooperation in the Fight Against Terrorism and Transnational Organized Crime, *Interfax*, 27 September 2007 (translation by Simon Saradzhyan)

There is a risk that security weaknesses could allow terrorists to steal enough material, or even an actual device. The most crucial step in preventing nuclear terrorism is, therefore, to keep terrorists from acquiring access to such materials or devices… Given these risks, both highly enriched uranium and plutonium merit access controls as strict as those prescribed for nuclear weapons.

—Weapons of Mass Destruction Commission, *Weapons of Terror: Freeing the World of Nuclear, Biological, and Chemical Arms* (Stockholm: WMD Commission, 2006), pp. 83-84.

had with Pakistani security services, their ongoing cooperation with al Qaeda, and the example of in-depth cooperation on unconventional weapons provided by al Qaeda's work with Jemaah Islamiyah on anthrax.[11]

With at least two groups going down this path in the last 15 years, and possibly more, there is no reason to expect that others will not do so in the future.

Some Terrorist Groups Might be Able to Make Crude Nuclear Bombs

Repeated assessments by the U.S. government and other governments have concluded that it is plausible that a sophisticated terrorist group could make a crude nuclear explosive—capable of destroying the heart of a major city—if they got enough plutonium or HEU. A "gun-type" bomb made from HEU, in particular, is basically a matter of slamming two pieces of HEU together at high speed. An "implosion-type" bomb—in which precisely arranged explosives crush nuclear material to a much higher density, setting off the chain reaction—would be substantially more difficult for terrorists to accomplish, but is still plausible, particularly if they got knowledgeable help (as they have been actively attempting to do).[12]

One study by the now-defunct congressional Office of Technology Assessment summarized the technical reality: "A small group of people, none of whom have ever had access to the classified literature, could possibly design and build a crude nuclear explosive device... Only modest machine-shop facilities that could be contracted for without arousing suspicion would be required."[13] Indeed, even before the revelations from Afghanistan, U.S. intelligence concluded that "fabrication of at least a 'crude' nuclear device was within al-Qa'ida's capabilities, if it could obtain fissile material."[14]

It is important to understand that making a crude, unsafe, unreliable bomb of uncertain yield that might be carried in the back of a large van is a dramatically simpler task than designing and building a safe, secure, reliable, and efficient weapon deliverable by a ballistic missile, which a state might want to incorporate into its arsenal. Terrorists are highly unlikely to ever be able to make a sophisticated and efficient weapon, a task that requires a substantial nuclear weapons enterprise—but they may well be able to make a crude one. Their task would be easier if they managed to recruit experts with experience in key aspects of a national nuclear weapons program.

Nuclear weapons themselves generally have substantial security measures and

---

lear Threat Initiative, 2005), http://www.nti.org/e_research/cnwm/threat/demand.asp (accessed 6 February 2010), and Sara Daly, John Parachini, and William Rosenau, *Aum Shinrikyo, Al Qaeda, and the Kinshasa Reactor: Implications of Three Case Studies for Combating Nuclear Terrorism* (Santa Monica, Cal.: RAND, 2005), http://www.rand.org/pubs/documented_briefings/2005/RAND_DB458.sum.pdf (accessed 6 February 2010).

[11] Mowatt-Larssen, "Al Qaeda WMD Threat: Hype or Reality?"

[12] For a more detailed unclassified discussion, with relevant references, see Matthew Bunn and Anthony Wier, "Terrorist Nuclear Bomb Construction: How Difficult?" *Annals of the American Academy of Political and Social Science,* Vol. 607, pp. 133-149.

[13] U.S. Congress, Office of Technology Assessment, *Nuclear Proliferation and Safeguards* (Washington, D.C.: OTA, 1977) http://www.princeton.edu/~ota/disk3/1977/7705/7705.PDF (accessed 30 October 2009), p. 140. OTA reached this conclusion long before the internet made a great deal of relevant information much more widely available.

[14] Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction, *Report to the President* (Washington, D.C.: WMD Commission, 2005), http://www.gpoaccess.gov/wmd/index.html (accessed 30 October 2009), p. 276.

would be more difficult to steal than nuclear materials. If terrorists nevertheless managed to steal an assembled nuclear weapon from a state, there is a significant risk that they might figure out how to set it off—though this, too, would in most cases be a difficult challenge for a terrorist group.[15] Many modern U.S. and Russian nuclear weapons are equipped with sophisticated electronic locks, known in the United States as "permissive action links" or PALs, intended to make it difficult to detonate the weapon without inserting an authorized code, which terrorists might find very difficult to bypass. Some weapons, however, are either not equipped with PALs or are equipped with older versions that lack some of the highest-security features (such as "limited try" features that would permanently disable the weapon if the wrong code is inserted too many times or attempts are made to bypass the lock).[16] Many nuclear weapons also have safety features designed to prevent the weapon from detonating unless it had gone through its expected flight to its target—such as intense acceleration followed by unpowered flight for a ballistic missile warhead—and these would also have to be bypassed, if they were present, for terrorists to be able to make use of an assembled nuclear weapon they acquired.

If they could not figure out how to detonate a stolen weapon, terrorists might choose to remove its nuclear material and fashion a new bomb. Some modern, highly efficient designs might not contain enough material for a crude, inefficient terrorist bomb; but multistage thermonuclear weapons, with nuclear material in both the "primary" (the fission bomb that sets off the fusion reaction) and the "secondary" (where the fusion takes place) probably would provide sufficient material. In any case, terrorists in possession of a stolen nuclear weapon would be in a position to make fearsome threats, for no one would know for sure whether they could set it off.

Terrorists Might be Able to Get HEU or Plutonium

Unfortunately, there is also a real risk that terrorists could get the plutonium or HEU needed to make a nuclear bomb. As described in more detail in the next chapter, important weaknesses in nuclear security arrangements still exist in many countries, creating weaknesses that outsider or insider thieves might exploit. And as discussed in the previous chapter, theft of the essential ingredients of nuclear weapons is not a hypothetical worry but an ongoing reality—the IAEA has documented 18 cases of theft or loss or plutonium or HEU, confirmed by the states concerned.

---

15 See Bunn and Wier, "Terrorist Nuclear Bomb Construction: How Difficult?"

16 Bruce Blair, a former U.S. ballistic missile launch officer who has written extensively about U.S. and Russian nuclear command and control, reported that Russian tactical nuclear weapons "built before the early 1980s lack the safety locks known as permissive action links." See testimony in U.S. House of Representatives, National Security Committee, Military Research & Development Subcommittee, *Hearing on Russian Missile Detargeting and Nuclear Doctrine and its Relation to National Missile Defense*, 105th Cong., 1st sess. March 13, 1997. Similarly, by one account, U.S. intelligence has concluded that Russian tactical weapons "often" have external locks "that can be removed, and many have none at all." Bruce W. Nelan, "Present Danger: Russia's Nuclear Forces are Sliding Into Disrepair and Even Moscowis Worried About What Might Happen," *Time Europe,* 7 April 1997. In both the United States and Russia, thousands of nuclear weapons, particularly older varieties, have been dismantled in recent years, and it is likely that most of the dangerous weapons lacking modern safeguards have been destroyed. Less is known about such electronic locks in other nuclear powers, though Pakistan has asserted that it has similar systems in place, and it seems likely that advanced nuclear weapon states such as Britain and France have made use of such technology as well. India, Pakistan, and China are believed to store many or their weapons in partly disassembled form.

Suitcase Nukes Probably Not on the Loose

In late 1997, General Alexander Lebed (retired), who had recently been Russian President Boris Yeltsin's national security advisor, provoked an international furor by asserting in interviews that scores of nuclear weapons similar to suitcases were missing.

It is clear that small nuclear weapons existed—both the United States and the Soviet Union produced nuclear weapons intended to be carried and emplaced by individuals, as well as nuclear artillery shells. But the Russian military vigorously denied that any such weapons were missing. Despite the chaos following the collapse of the Soviet Union, there is no convincing evidence that Lebed's claims were correct, and substantial reason to doubt them: meticulous records were kept of each Russian nuclear weapon, and each weapon was accompanied by a "passport" showing its serial number, where and when it had been made, where it had been sent for deployment and for maintenance, and so on. It is extraordinarily unlikely that nuclear weapons went missing without detection. Lebed himself—well known for his erratic actions and statements—later backed off from the claim that suitcase nukes were missing, and the official Lebed appointed to look into the matter eventually came forward to confirm that his group had accounted for all of the small nuclear weapons in question.

In short, stolen "suitcase nukes" are not likely to be an important part of the overall risk of nuclear terrorism. Still less are terrorist-made nuclear bombs likely to fit in a suitcase: rather, a terrorist nuclear bomb might well weigh over a ton, and be more suitable for delivery in a truck.

HEU-fueled research reactors, for example, sometimes located on university campuses, often have only the most minimal security measures in place. Many have few or no armed guards; very loose arrangements (if any) to screen personnel before granting them access to the reactor and its nuclear material; few means to detect intruders until they are entering the nuclear material areas; and little revenue to pay for more substantial security arrangements. In some cases, the security in place amounts to little more than a night watchman and a chain-link fence.

In countries such as Pakistan, even substantial nuclear security systems are challenged by immense adversary threats, both from nuclear insiders—some with a demonstrated sympathy for Islamic extremists—and from outside attacks that might include scores or hundreds of armed attackers. In Russia, there have been dramatic improvements in security and accounting for nuclear materials since the early 1990s, and the most egregious security weaknesses—gaping holes in fences, lack of any detector to set off an alarm if plutonium or HEU is being removed—have been corrected, with U.S. and other assistance and Russia's own efforts. But significant risks remain, from insider corruption to weak nuclear security regulation. In the end, all countries where these materials exist—including the United States—have more to do, and need to continually reassess their efforts, to ensure that the security and accounting measures they have in place are sufficient to meet the evolving threat. A nuclear security system not focused on continual improvement is likely to see its effectiveness decline over time as complacency sets in.

Nuclear Smuggling Is Extremely Difficult to Interdict

The nuclear material needed for a bomb is small and difficult to detect. Once such material has left the facility where it is supposed to be, it could be anywhere, and finding and recovering it poses an immense challenge. The plutonium re-

Nuclear Terrorism and the Nuclear Energy Revival

Growing energy demand and concerns over climate change and energy security are driving a number of countries to increase their emphasis on nuclear power. Fortunately, the expected growth and spread of nuclear energy need not increase the chance that terrorists could get their hands on the material for a nuclear bomb.

Today, most nuclear power reactors run on low-enriched uranium fuel that cannot be used in a nuclear bomb without further enrichment, which is beyond plausible terrorist capabilities. These reactors produce plutonium in their spent fuel, but that plutonium is one percent by weight in massive, intensely radioactive spent-fuel assemblies that would be extraordinarily difficult for terrorists to steal and to process into material for a bomb. In some countries, the plutonium is removed from the spent fuel (an approach known as "reprocessing") for recycling into new fuel; that process requires extraordinary security measures to ensure against terrorist access to the separated plutonium. Fortunately, economics and counterterrorism point in the same direction in this case: because reprocessing is much more expensive than simply storing spent fuel pending disposal, few countries that do not already reprocess their fuel are interested in starting, and some of the existing plants are running far below capacity or will soon be shut down.

Many more nuclear power reactors in many more countries would mean more potential targets for terrorist sabotage—and more chances that some reactor's security would be weak enough that a terrorist attack would succeed. Sabotage would not cause the kind of massive, instantaneous destruction a nuclear bomb would cause, but in the worst case, successful sabotage might cause a massive radiation release—a "security Chernobyl." Such an event would be a catastrophe for the country where it occurred, and for its downwind neighbors; but unlike readily transported nuclear weapons or materials, it would not pose a threat to countries thousands of kilometers away. It would, however, pose a threat to the global nuclear power industry, for the public reaction to such an event would almost surely doom any prospect for nuclear growth on the scale needed to play a significant role in mitigating the threat of climate change.

quired for an implosion-type nuclear bomb would fit in a soda can. The HEU required for the simplest type of nuclear bomb for terrorists to make, a less efficient "gun-type" bomb that slams two pieces of HEU together at high speed, is smaller than two two-liter bottles.[17] The radiation from plutonium, and particularly from HEU, is weak and difficult to detect, particularly if the adversaries attempting to smuggle it use any significant amount of shielding. The detectors that are being widely deployed throughout the world—or even the more expensive Advanced Spectroscopic Portals (ASPs) that are being considered to replace them—would have little chance of detecting HEU metal if it had significant shielding.[18] (Plutonium's radiation is more penetrating and easier to detect.) To date, only one of the successes in seizing stolen nuclear material reportedly included the material being detected by one of these detectors; the others were the result of police and intelligence efforts, often including participants in the conspiracy or people they were trying to convince to help them or to buy their stolen nuclear material informing the police.[19]

[17] For a more detailed discussion, see Bunn and Wier, "Terrorist Nuclear Weapon Construction: How Difficult?"

[18] See, for example, discussion in Thomas B. Cochran and Matthew G. McKinzie, "Detecting Nuclear Smuggling," *Scientific American*, April, 2008.

[19] For a detailed account of the 2006 nuclear smuggling incident, see Bronner, "110 Grams (and

North Korea, Iran, and the Risk of Nuclear Terrorism

Discussions about the dangers of nuclear terrorism often turn quickly to two states that provoke particular fear in the United States: North Korea and Iran. But the available evidence suggests that these states contribute only a small part of the overall risk of nuclear terrorism.

The current situation in these two countries is very different. North Korea already has enough plutonium for several nuclear weapons, has conducted two nuclear tests, has pulled out of the NPT, and has ejected international inspectors. By contrast, as far as the international community knows, Iran has not yet produced any of its own HEU (though it has a few kilograms of irradiated HEU research reactor fuel supplied by the United States in the Shah's time and less than a kilogram of Chinese-origin HEU in the core of a small research reactor supplied in the early 1990s). While Iran is defying UN Security Council resolutions requiring it to suspend enrichment and continuing to try to shield some activities from IAEA inspectors, it remains a party to the NPT, with international inspectors at its major nuclear sites.

Several scenarios in which these states might contribute to the risk of nuclear terrorism should each be considered separately.

Conscious state decisions to provide nuclear weapons or materials to terrorists. It is very unlikely that either of these states—or other states, for that matter—would consciously decide to transfer nuclear weapons or materials to terrorists. Hostile dictators focused on preserving their regimes are highly unlikely to hand over the greatest power they have ever acquired to groups they cannot control, in ways that might provoke retaliation that would destroy their regimes forever. Only if the survival of the regime seemed to depend on the revenue that might be generated from such a transfer—highly unlikely, given the relatively modest resources of even the wealthiest terrorist groups—or as a last act of vengeance as a regime was collapsing—might the risk of such a transfer increase.[1]

Today, Iran simply does not have enough HEU for a bomb available to transfer. Moreover, while Iran has supported both Hezbollah and Hamas—both of which are terrorist groups as well as social and political movements—there is no evidence it has ever provided chemical weapons to these groups (despite acknowledging that it has possessed such arms).

North Korea has exported ballistic missiles to many countries for cash, and apparently transferred a plutonium production reactor to Syria.[2] But transferring technology to build nuclear weapons to

---

[1] Similarly, despite various warnings, from the Bush administration, the U.S. intelligence community concluded that the probability that Saddam Hussein's Iraq would take the "extreme step" of transferring weapons of mass destruction to terrorist groups was low, unless Hussein concluded that the United States was going to overthrow his regime in any case and that such a transfer represented "his last chance to exact vengeance." (See George Tenet, letter to Senator Bob Graham, 7 October 2002, http://www.globalsecurity.org/wmd/library/news/iraq/2002/iraq-021007-cia01.htm (accessed 27 March 2010). Along the same lines, a comprehensive Defense Department assessment of proliferation threats just before the 9/11 attacks concluded that "the likelihood of a state sponsor providing such a weapon to a terrorist group is believed to be low." See U.S. Department of Defense, *Proliferation: Threat and Response* (Washington, D.C.: DOD, January 2001), p. 61. For an attempt to estimate the fraction of the overall risk of nuclear terrorism contributed by different pathways to the bomb, see Matthew Bunn, "A Mathematical Model of the Risk of Nuclear Terrorism," *Annals of the American Academy of Political and Social Science*, Vol. 607, No. 1 (September 2006), pp. 103-120.

[2] North Korea may also be the state that transferred uranium hexafluoride to Libya, though there are still some controversies about that judgment. For a brief summary, see, for example, Jeffrey Lewis, "A Financial Link in that AQ Khan-North Korea-Libya Daisy Chain?" *ArmsControlWonk.com,* 1 April 2005, http://www.armscontrolwonk.com/index.php?id=509 (accessed 31 March 2010).

North Korea, Iran, and the Risk of Nuclear Terrorism (cont)

states that will almost certainly never use them is a profoundly different act than transferring themto terrorists who are very likely to detonate them. The United States and other governments should be taking steps to reduce this small risk still further—by reiterating that the consequences of such a transfer would be disastrous for the North Korean government, by making the benefits of a path away from hostility and nuclear weapons equally clear, and by working internationally to strengthen controls over materials coming out of North Korea, increasing the risk that such a transfer would be intercepted.[3]

Theft of nuclear weapons or material. Currently, theft of nuclear weapons or material in either North Korea or Iran is also unlikely, so they need not be central priorities for the four-year nuclear security effort. North Korea is a tightly controlled garrison state, and there is currently virtually no risk of a group of terrorists storming its facilities and seizing plutonium. Because North Korea has only enough plutonium for a few nuclear bombs, and this material is considered crucial to the state, it is presumably under controls that would make it very difficult for insiders to steal nuclear material or a nuclear weapon covertly. Virtually nothing is publicly known, however, about the specifics of North Korea's nuclear security arrangements. In Iran, there is no weapons-usable nuclear material to steal except for the few kilograms of irradiated research reactor fuel. (Arrangements should be made to ship that fuel elsewhere—either back to the United States as is being done with other U.S.-origin HEU, or if that is politically impossible, to Russia or France, as is being done with a variety of other HEU research reactor fuel.)

Future scenarios. Two future scenarios merit concern—state collapse, and growing nuclear stockpiles. Collapse of the state—which is far more likely in North Korea than in Iran —could destroy whatever controls are in place and create a serious problem of "loose nukes."[4] At the same time, if North Korea's stockpile grows in the future, the possibility that key military officers might come to believe that they could sell off some of the plutonium without the top North Korean leadership finding out might grow—one of many reasons why it is important to again seek to halt North Korean production of fissile material, and ultimately to roll back North Korea's nuclear weapons program. Similarly, if Iran does ultimately produce HEU and nuclear weapons, that will create a new potential source for nuclear theft—and regional fears and tensions that could increase the chance that other countries in the region might follow the same path. This is yet another reason why pulling together an international package of carrots and sticks large enough and credible enough to convince the Iranian government that it is in its interests to verifiably end its quest for nuclear weapons should remain a high priority.

---

[3] As with stopping other nuclear smuggling, reducing the risk of such North Korean transfers poses an enormous challenge; unless circumstances arise that make it possible to stop and search all ships, aircraft, and ground transports leaving North Korea, it will never be possible to have confidence that North Korea would have not have substantial chances to complete such a shipment. Hence, primary reliance must be placed on further strengthening the already strong disincentives to the North Korean regime considering such a transfer. But North Korea's extreme isolation from the rest of the world makes the prospects of monitoring such shipments at least somewhat better than they would be from most other countries.

[4] Ashton B. Carter, William J. Perry, and John M. Shalikashvili, "A Scary Thought: Loose Nukes in North Korea," *Wall Street Journal*, 6 February 2003, http://belfercenter.ksg.harvard.edu/publication/1243/ (accessed 9 February 2010).

A crude terrorist nuclear bomb would be considerably larger than the plutonium or HEU at its core, perhaps weighing a ton or so. Nevertheless, just as interdicting smuggling of nuclear materials poses immense challenges, it would also be extremely difficult to stop terrorists from smuggling a crude nuclear weapon to its target. A nuclear bomb might be delivered, intact or in ready-to-assemble pieces, by boat or aircraft or truck. The length of national borders, the diversity of means of transport, the vast scale of legitimate traffic across borders, and the ease of shielding the radiation from plutonium or especially from HEU all operate in favor of the terrorists. Building the overall system of legal infrastructure, intelligence, law enforcement, border and customs forces, and radiation detectors needed to find and recover stolen nuclear weapons or materials, or to interdict these as they cross national borders, is an extraordinarily difficult challenge.[20]

Nuclear Thieves Could Strike in Any Country

International terrorists have demonstrated that they have global reach. Everyone recalls the attacks in the United States, in Moscow and Beslan, in London, and in Madrid. But it is important to recall that al Qaeda-linked conspiracies have been uncovered even in countries that have never been the victims of large-scale terrorist attacks, from Canada to Belgium to the Netherlands. Japan has experienced homegrown terrorism with weapons of mass destruction from Aum Shinrikyo—and in the years to come, such groups could arise in other countries.

Al Qaeda bombed the U.S. embassies in Kenya and Tanzania not because they had any special quarrel with Kenya or Tanzania but because they were particularly vulnerable targets that would hurt the United States. Similarly, terrorists will seek nuclear material for a bomb wherever they think the combination of their strength and the security systems' weakness makes it easiest to get. Given the immense difficulty of stopping nuclear smuggling, the terrorists do not have to steal it in the country that is the ultimate target; it could be from a country on the opposite side of the world. No country should believe that because it has never been threatened by extremists it need not provide stringent security for its nuclear material. In a very real sense, vulnerable weapons-usable nuclear material anywhere is a threat to everyone, everywhere.

Nuclear Terrorism: The Good News

The good news is that there is no convincing evidence that any terrorist group has yet gotten a nuclear weapon or the materials and expertise needed to make one. Moreover, making and delivering even a crude nuclear bomb would be among the most technically challenging and complex operations any terrorist group has ever carried out. There would be many chances for the effort to fail. But given a history of terrorist efforts to get a nuclear bomb, and the dire consequences should they ever succeed, there can be no room for complacency. All countries must take action to reduce the risks of nuclear theft and terrorism to the lowest practicable level. This report is intended to offer a roadmap for the needed actions.

Counting)."

[20] For a useful discussion emphasizing the ease with which terrorists might follow different pathways to deliver their weapon, see Allison, *Nuclear Terrorism: The Ultimate Preventable Catastrophe,* pp. 104-120. For a more optimistic view of the potential of these parts of a defensive system, see Levi, *On Nuclear Terrorism*, pp. 49-61, 87-96, 115-121.

3 GLOBAL NUCLEAR SECURITY TODAY

Today, nuclear weapons or the separated plutonium or HEU needed to make them exist in dozens of countries. Worldwide, these stockpiles can be found in hundreds of buildings and bunkers, and scores or hundreds of transports of these stocks from one place to another occur every year.

Each country where such stockpiles exist is responsible for securing them, and the specific approaches, procedures, and rules for securing and accounting for nuclear stockpiles vary widely. There are no binding global rules that specify how much security these stockpiles should have.

Most nuclear stockpiles around the world have generally effective security measures in place. Moreover, national programs and international cooperative efforts—many of them funded by the United States—have led to major security improvements for some of the world's most vulnerable stockpiles over the last 18 years. Other stocks have been eliminated entirely—representing, in a real sense, bombs that will never go off. The world owes the hundreds of men and women who have labored to make these improvements a substantial debt of gratitude.

But other stockpiles of nuclear material still have security measures that would demonstrably not be enough to stop a theft attempt using some of the capabilities and tactics that terrorists or thieves have already demonstrated in non-nuclear incidents. Some countries require that stocks of nuclear weapons or weapons-usable nuclear material be guarded by scores of heavily armed troops, multiple layers of barriers, security cameras, detectors, and alarms; other countries require no armed guards at all (relying on police some distance away) and in some cases few other security measures are in place.

In general, military stockpiles have more stringent security measures than civilian stocks, and wealthy developed countries often devote more resources to security than developing countries transitioning from communism do. But there are important exceptions to both of these rules of thumb—as the Belgian incident described at the outset of this report makes clear, along with incidents such as the U.S. Air Force's inadvertent flight of six nuclear weapons to an air base that did not know it had received them in 2007, which, along with other incidents, led to the firing of both the Secretary and the Chief of Staff of the Air Force.[1]

Nuclear security should not be thought of as some sites being "secured" and others "unsecured," or one site "vulnerable" and another "not vulnerable." Rather, nuclear security is a spectrum of degrees of risk—additional security measures could always be added to any facility, if the threat justified the additional cost and inconvenience. Indeed, even assessing whether one site has more effective security than another can be difficult, as one site may have especially good protection against one type of threat (such as insiders at the facility removing material and smuggling it out the door), while another may have

[1] A detailed account of the inadvertent movement of the six nuclear weapons, along with a review of organizational issues that contributed to this incident, can be found in Defense Science Board, Permanent Task Force on Nuclear Weapons Surety, *Report on the Unauthorized Movement of Nuclear Weapons* (Washington, D.C.: U.S. Department of Defense, February 2008), http://www.fas.org/nuke/guide/usa/doctrine/usaf/Minot_DSB-0208.pdf (accessed 5 March 2010).

superior protection against other types of threats (such as outsiders storming the facility with automatic weapons and explosives). President Obama's reference to securing all "vulnerable" nuclear material around the world was an unfortunate choice of words, both because there is no clear line that delineates which material is vulnerable and because the reaction of many countries was to deny that their nuclear stockpiles are "vulnerable."

There is probably nowhere in the world where substantial stocks of HEU or separated plutonium are entirely "unsecured" in the sense of having no security measures at all (though there was an incident in the United States where government experts visiting a civilian site found a metal plate containing a kilogram of HEU hanging on the inside of the door of a janitor's closet).[2] Indeed, managers of nuclear facilities around the world, in most cases never having had a nuclear theft attempt at their site, are almost all convinced that the security measures they already have in place are fully adequate—even though in some cases they amount to little more than a night watchman and a chain-link fence.

The difficult question of how much nuclear security, of what kinds, is "enough" must be based on an assessment of *risk*—given the quality and quantity of nuclear material (or nuclear weapons) at a site, the security measures in place there, and the kinds of capabilities adversaries in that country may be able to bring to bear to try to steal a nuclear weapon or the nuclear material needed to make one, how does the risk of nuclear theft at one site compare to the risk at others? Additional steps should be taken to improve security wherever the risk of nuclear theft appears to be substantial—and particularly if that risk appears to be higher than the comparable risk at other sites with nuclear weapons or weapons-usable nuclear material.

[2] Interview with National Nuclear Security Administration (NNSA) officials, October 2008.

This risk assessment approach depends crucially on the kinds of capabilities adversaries who might attempt a nuclear theft could plausibly put together in the place where a particular nuclear facility or transport link is located. The reason to be concerned about nuclear theft in Pakistan, for example, is not that they have weak security for their nuclear stockpile—they do not—but rather that their security systems must protect that stockpile against extraordinary threats, from both nuclear insiders with a demonstrated willingness to sell nuclear weapons technologies and outsiders that might include dozens or even hundreds of armed extremists (as occurred in an assault on a Frontier Corps base in January 2009).[3] A nuclear security system that was sufficient to reduce the risk of nuclear theft to a low level for a nuclear facility in Canada might still leave a high risk of nuclear theft if the facility was in Pakistan.

It is also important to understand that nuclear security is a complex system that depends not only on having effective equipment in place, but even more on the actions of people, having guards and staff who take security seriously every day, and who do not prop open security doors for convenience or turn off intrusion detectors out of annoyance over their false alarms. As Gen. Eugene Habiger, former commander of U.S. strategic nuclear forces and former security "czar" at the U.S. Department of Energy once put it, "good security is 20 percent equipment and 80

[3] See, for example, Richard A. Oppel, Jr. and Pir Zubair Shah, "46 Die in Taliban Attack on Pakistan Troops," *New York Times*, 11 January 2009, http://www.nytimes.com/2009/01/12/world/asia/12pstan.html (accessed 5 March 2010). The authors quote Frontier Corps officials as estimating that there were some 600 attackers, armed with machine guns and rocket-propelled grenades.

percent culture."[4] In this sense, nuclear security is an ever-evolving *process,* one that depends on how security is implemented day-to-day, for years at a time, including when no inspectors or observers are present. As with safety, each facility should set excellence in nuclear security as its goal, and strive to create a culture of continual improvement—for an organization that is not always on the lookout for ways to improve, and problems to be fixed, is an organization whose security performance is likely to decline over time as complacency sets in and unidentified problems mount.[5]

Global Distribution of Nuclear Stockpiles

Today, some 38 states either possess nuclear weapons or have HEU or plutonium separated from spent fuel on their soil.[6] Of these, nine possess nuclear weapons.[7] Beyond those nine, roughly 18 states have enough plutonium or HEU on their soil to require the highest international standards of security, while eleven have only one to a few kilograms.[8] See Table 3.1-Table 3.3. The tables also include information on some key commitments and transparency measures related to nuclear security, including which countries:

- Are recipients of U.S.-origin nuclear material (which means they are obligated to accept U.S. visits to review their physical protection arrangements for that material);
- Have asked for and received an IAEA-led International Physical Protection Advisory Service (IPPAS) mission to review their physical protection arrangements;
- Have cooperated with the United States on upgrading nuclear security (providing another window of transparency into how physical protection is being implemented);
- Have ratified the Convention on Physical Protection;
- Have ratified the 2005 amendment to the physical protection convention.

As can be seen, most of these countries have ratified the Convention on Physical Protection and participate in at least one of the different types of international physical protection transparency. Most, however, have not ratified the 2005 amendment.

Many of these countries have only a single facility, such as a research reactor, where HEU or separated plutonium are located. Others may have dozens, or, in the Russian case, hundreds of locations where nuclear weapons or weapons-usable fissile materials are stored or processed.

---

[4] Interview by author, April 2003.

[5] For a very useful guide to best practices in improving nuclear security culture—with a tool for organizations to assess their own performance in this area—see World Institute for Nuclear Security, *Nuclear Security Culture: A WINS Best Practice Guide for Your Organization,* Rev. 1.4 (Vienna: WINS, September 2009).

[6] See sources for the tables.

[7] In order of the estimated number of nuclear weapons in each country, these are Russia, the United States, France, China, the United Kingdom, Israel, Pakistan, India, and North Korea. In addition, U.S. nuclear weapons are reportedly located at one base each in Belgium, Germany, the Netherlands, and Turkey, and two bases in Italy. See Robert S. Norris and Hans M. Kristensen, "Nuclear Notebook: Worldwide Deployments of Nuclear Weapons, 2009," *Bulletin of the Atomic Scientists,* November/December 2009, http://thebulletin.metapress.com/content/xm38g50653435657/fulltext.pdf (accessed 27 March 2010).

[8] It is worth nothing that NNSA's programs to remove nuclear material are now moving rapidly enough that several countries had to either be moved to a lower category or removed from these tables entirely because of removal of material in between the first and the final drafts of this report.

Table 3.1: Countries With ≥2 Tons of Weapons-Usable Nuclear Material: Stocks Physically Located in Each Country as of the end of 2003, in Metric Tons

Country	U.S. Supplied	IPPAS	U.S. Funded Security Cooperation	Party to CPPNM	Party to CPPNM Amendment
Russia	No	No	Yes	Yes	Yes
United States	Yes	No	Yes	Yes	No
U.K.	Yes [b]	No	No	Yes	No
France	Yes [b]	No	No	Yes	No
China	No	No	Yes [c]	Yes	Yes
Germany	Yes	No	No	Yes	No
Japan	Yes	No	No	Yes	No
Belgium	Yes	No	No	Yes	No
India	No	No	No	Yes	Yes
Kazakhstan [a]	No	Yes	Yes	Yes	No

Sources for tables: International Panel on Fissile Materials, *Global Fissile Materials Report 2009: A Path to Nuclear Disarmament* (Princeton, N.J.: IPFM, October 2009); David Albright and Kimberly Kramer, *Global Stocks of Nuclear Explosive Materials* (Washington, D.C.: Institute for Science and International Security, July 2005); data on countries where all or most HEU has been removed provided by NNSA, January and March 2010; data on countries that have hosted International Physical Protection Advisory Service (IPPAS) missions provided by the International Atomic Energy Agency (IAEA), February 2010; IAEA, *Convention on the Physical Protection of Nuclear Material* (Vienna, IAEA, 24 September 2009), http://www.iaea.org/Publications/Documents/Conventions/cppnm_status.pdf (accessed 10 February 2010); IAEA, *Amendment to the Convention on the Physical Protection of Nuclear Material* (Vienna, IAEA, updated 8 February 2010), http://www.iaea.org/Publications/Documents/Conventions/cppnm_amend_status.pdf (accessed 10 February 2010).

[a] Kazakhstan has some 10 tons of irradiated fuel from the now-closed BN-350 fast reactor, which was primarily in the range of 22-27% enrichment before irradiation; a publicly unknown quantity of this material is still HEU, though its enrichment has been reduced by fission of U-235 during irradiation. The BN-350 spent fuel also contains some 3 tons of high-grade plutonium, though this is less than 1 percent by weight of the spent fuel.
[b] The United Kingdom and France have substantial stocks of material they produced themselves, but also some U.S.-origin material.
[c] China and the United States have been engaged in a broad dialogue on best practices for security and accounting for nuclear materials, but this has involved U.S.-funded upgrades at only one site in China; for the rest, China is expected to undertake improvements with its own resources. U.S. officials have not visited the sensitive facilities where most of China's HEU and plutonium, and all of China's nuclear weapons, are stored.

Fissile materials are used for both military and civilian purposes. The military stockpiles are larger, but are generally heavily guarded, while the smaller civilian stockpiles often have more modest security measures in place.[9]

Over 95% of the world's HEU was produced for military use, either for nuclear weapons or for naval fuel, though the civilian HEU, largely in the fuel cycle for nuclear research reactors, also poses substantial risks, discussed in more detail below. Russia and the United States possess well over 90% of the global HEU stock, though most of the other countries in the tables also have civil HEU on their soil. The world HEU stockpile is declining as Russia and to a lesser extent the United States blend down excess HEU no longer needed for military purposes to LEU, at a rate far greater than the small continuing production of HEU in Pakistan and possibly in India.

World stockpiles contain some 500 tons of plutonium outside of spent fuel, roughly half in military stockpiles (including stocks declared excess to military needs) and half in civilian stockpiles (which are increasing steadily, as more plutonium is reprocessed from spent fuel than is fabricated into new fuel every year).[10] The world stockpiles of military plutonium are growing only very slowly, as only Pakistan, India, North Korea, and possibly Israel are continuing to produce plutonium for weapons.

Where, among these dozens of countries and hundreds of sites, is the risk of nuclear theft the highest? What places

[9] For a recent overview of world fissile material stockpiles, see International Panel on Fissile Materials, *Global Fissile Materials Report 2009: A Path to Nuclear Disarmament* (Princeton, N.J.: IPFM, October 2009), http://www.fissilematerials.org/ipfm/site_down/gfmr09.pdf (accessed 31 January 2010), pp. 8-23.

[10] Throughout this report, "tons" refers to metric tons. A metric ton is 1000 kilograms, or approximately 2200 pounds.

Table 3.2: Other Countries With Cat. I Quantities of Weapons-Usable Material[a]

Country	U.S. Supplied	IPPAS	U.S. Funded Security Cooperation	Party to CPPNM	Party to CPPNM Amendment
Belarus	No	Yes	Yes	Yes	No
Canada	Yes	No	No	Yes	No
Czech Republic	No	Yes	Yes	Yes	No
Hungary	No	Yes	Yes	Yes	Yes
Israel	Yes	No	No	Yes	No
Italy[b]	Yes	No	No	Yes	No
Mexico	Yes	Yes	Yes	Yes	No
Netherlands[b]	Yes	Yes	No	Yes	No
North Korea	No	No	No	No	No
Pakistan	No	No	Yes	Yes	No
Poland	No	Yes	Yes	Yes	Yes
Serbia	No	Yes	Yes	Yes	No
South Africa	Yes	No	No	Yes	No
Switzerland[c]	Yes	Yes	No	Yes	Yes
Ukraine	No	Yes	Yes	Yes	Yes
Uzbekistan	No	Yes	Yes	Yes	No
Vietnam	No	No	Yes	No	No

[a] "Category I" quantity is 5 kilograms of U-235 in HEU, or 2 kilograms of plutonium or U-233.
[b] Italy and the Netherlands possess substantial stocks of separated civilian plutonium, but much of it is physically located in other countries. The Netherlands also has significant civil HEU.
[c] Switzerland has no civil HEU, and has consumed most of its former stock of civilian plutonium, but still (as of early 2010) has a modest stock of civilian plutonium.

should be the top priorities for the four-year effort to secure nuclear weapons and materials around the world? That central question is very difficult to answer, particularly as most countries keep the specifics of their nuclear security practices secret. Overall, the risk of nuclear theft from any particular facility or transport operation depends on the quantity and quality of the material available to be stolen (that is, how difficult would it be to make the available material into a nuclear bomb), the security measures in place (that is, what kind of insider and outsider thieves could the security measures protect against, with what probability), and the threats those security measures face (that is, the probability of different levels of insider or outsider capabilities being brought to bear in a theft attempt). Based on the limited unclassified information available, it appears that the highest risks of nuclear theft today are in:

- Pakistan, where a small and heavily guarded nuclear stockpile faces immense threats from Islamic extremists;
- Russia, which has the world's largest nuclear stockpiles in the world's largest number of buildings and bunkers, and security measures that have improved dramatically but still include important vulnerabilities; and
- HEU at research reactors, which usually (though not always) use only modest stocks of HEU, in forms that the would require some chemical processing before they could be used in a bomb, but which often have only the most minimal security measures in place.

While these are the highest-risk categories, the risks elsewhere are very real as well. Transport of nuclear weapons and materials is a particular concern, as it is the part of the nuclear material life-cycle most vulnerable to violent, forcible theft, since it is impossible to protect the mate-

Table 3.3: Other Countries With Kilogram-Range Quantities of Weapons-Usable Material as of early 2010

Country	U.S. Supplied	IPPAS	U.S. Funded Security Cooperation	Party to CPPNM	Party to CPPNM Amendment
Argentina	Yes	No	No	Yes	No
Australia	Yes	No	No	Yes	Yes
Austria	Yes	No	No	Yes	Yes
Chile	Yes	Yes	Yes	Yes	Yes
Ghana	No	Yes	No	Yes	No
Indonesia[a]	Yes	Yes	Yes	Yes	No
Iran	No[b]	Yes	No	No	No
Jamaica	Yes	No	Yes	Yes	No
Nigeria	No	No	No	Yes	Yes
Norway	Yes	Yes	No	Yes	Yes
Syria	No	No	No	No	No

[a] Indonesia no longer uses HEU for either research reactor fuel or isotope production targets, but used HEU for medical isotope production for roughly a decade, and still has HEU remaining from that program.
[b] Iran has several kilograms of U.S.-origin HEU, but because the United States and Iran do not have diplomatic relations, the United States does not conduct visits to confirm that this material has adequate physical protection, as it does in other countries with U.S.-origin nuclear material.

rial with thick walls and many minutes of delay when it is on the road, and since transports of both weapons and materials are remarkably frequent. In the end, virtually every country where these materials exist—including the United States—has more to do to ensure that these stocks are effectively protected against the kinds of threats that terrorists and criminals have shown they can pose.

Pakistan

Pakistan's modest nuclear stockpile arouses global concern because Pakistan is also the world headquarters of al Qaeda; its stockpile faces a greater threat from Islamic extremists seeking nuclear weapons than any other nuclear stockpile on earth. Despite extensive security measures, there is a very real possibility that sympathetic insiders might carry out or assist in a nuclear theft, or that a sophisticated outsider attack (possibly with insider help) could overwhelm the defenses. Over the longer term, there is at least a possibility of Islamic extremists seizing power, or of a collapse of the Pakistani state making nuclear weapons vulnerable—though present evidence suggests both of these scenarios remain unlikely.

Pakistan is believed to have an arsenal of some 70-90 nuclear weapons, stored at several sites.[11] It also has HEU and plutonium production and processing facilities (including weapons-component fabrication facilities) and a small research reactor where a small amount of U.S.-origin HEU is located, all of which must be protected against nuclear theft. Pakistan's nuclear stockpile is growing, as it continues to produce HEU, it announced the startup of a plutonium production reactor at Khushab in 1998, and it has two more plutonium production reactors under construction.[12]

Extensive Security Measures

In the last decade, Pakistan has taken major steps to improve security and command and control for its nuclear

[11] See Robert Norris and Hans Kristensen, "Nuclear Notebook: Pakistani Nuclear Forces, 2009," *Bulletin of the Atomic Scientists,* Vol. 63, No. 3 (September/October 2009http://thebulletin.metapress.com/content/f828323447768858/fulltext.pdf (accessed 3 February 2010),), pp. 82-89.

[12] Norris and Kristensen, "Nuclear Notebook: Pakistani Nuclear Forces, 2009."

stockpiles.[13] While Islamabad maintains a veil of secrecy over the specifics of its nuclear security arrangements, its stockpiles are thought to be under heavy guard, protected by a 1,000-man armed security force overseen by a two-star general, which is part of the larger 8-10,000-person Strategic Plans Division that manages Pakistan's nuclear weapons.[14] Personnel participating in the nuclear program are subject to extensive screening, in a program reported to be comparable to the U.S. Personnel Reliability Program.[15] Pakistani nuclear weapons are believed to be stored in disassembled form, with the components stored in separate buildings, so that thefts from more than one building would be required to get the complete set of components for a nuclear weapon.[16] Pakistani officials also report that locks to prevent unauthorized use are incorporated into Pakistani weapons, though it is not known how these would be incorporated in weapons that are stored in disassembled form, or how difficult the Pakistani lock designs would be to bypass.[17] In a crisis in which Pakistan sought to disperse its nuclear weapons to ensure their survival and prepare for their possible use, the controls that help prevent unauthorized use in peacetime might be seriously weakened.[18] The United States has cooperated with Pakistan to further strengthen nuclear security, as Pakistan has acknowledged, and Obama administration officials have sought to broaden and deepen this effort, but specifics concerning what steps have been implemented, are still underway, or are still being discussed remain classified.[19]

While Pakistani generals share the U.S. concern over extremist threats to their nuclear stockpiles, their first concern is protecting these stocks from Indian strikes—or American seizure. The latter fear is stoked by repeated U.S. press speculation about planning for such possibilities.[20] Hence, Pakistan has not

---

[13] For an unclassified overview of Pakistan's nuclear security arrangements, see International Institute for Strategic Studies, *Nuclear Black Markets: Pakistan, A.Q. Khan and the Rise of Proliferation Networks: A Net Assessment* (London: IISS, 2007), pp. 112-118. For a recent Pakistani view, see Feroz Khan, "Nuclear Security in Pakistan: Separating Myths and Reality," *Arms Control Today*, http://www.armscontrol.org/act/2009_07-08/khan#41 (accessed 28 January 2010). (Khan is a retired Pakistani brigadier general, who served as director for arms control and disarmament affairs in Pakistan's Strategic Plans Division.) Along similar lines, see Kenneth N. Luongo and Brig. Gen. (Ret.) Naeem Salik, "Building Confidence in Pakistan's Nuclear Security," *Arms Control Today*, December 2007, http://www.armscontrol.org/act/2007_12/Luongo.asp (accessed 28 January 2010); for a more alarming view, see Rolf Mowatt-Larssen, "Nuclear Security in Pakistan: Reducing the Risks of Nuclear Terrorism," *Arms Control Today*, July/August 2009, http://www.armscontrol.org/act/2009_07-08/Mowatt-Larssen (accessed 28 January 2010). See also Shaun Gregory, *The Security of Nuclear Weapons in Pakistan*, Pakistan Security Research Unit (PSRU) Brief Number 22, 18 November 18 2007, http://spaces.brad.ac.uk:8080/download/attachments/748/Brief_22finalised.pdf (accessed 28 January 2010).

[14] IISS, *Nuclear Black Markets*, p. 112.

[15] See, for example, Khan, "Nuclear Security in Pakistan."

[16] See, for example, David Albright, "Securing Pakistan's Nuclear Infrastructure," in Lee Feinstein et al., *A New Equation: U.S. Policy toward India and Pakistan after September 11* (Washington, D.C.: Carnegie Endowment for International Peace, 2002), http://www.carnegieendowment.org/files/wp27.pdf (accessed 31 January 2010).

[17] See, for example, Hamid Mir, interview with former Pakistan Atomic Energy Commission Chairman Samar Mubarakmand, *Geo-TV*, 5 March 2004, http://www.pakdef.info/forum/showthread.php?t=9214 (accessed 31 January 2010).

[18] For a useful discussion making the case that this is an inherent feature of Pakistan's nuclear posture, see Vipin Narang, "Posturing for Peace? Pakistan's Nuclear Postures and South Asian Stability," *International Security*, Vol. 34, No. 3 (Winter 2009/2010), pp. 65-73.

[19] For one unclassified account of these topics, see David Sanger, "Obama's Worst Pakistan Nightmare," *New York Times Magazine*, 8 January 2009, http://www.nytimes.com/2009/01/11/magazine/11pakistan-t.html (accessed 13 February 2010).

[20] See, for example, Seymour Hersh, "Watching the Warheads," *The New Yorker*, 5

permitted U.S. experts to visit its nuclear sites, or even disclosed where they are. Though the U.S. and Pakistani governments describe themselves as allies, anti-American feeling and suspicion of U.S. motives is widespread in Pakistan, particularly on nuclear issues (as the United States long opposed Pakistan's nuclear weapons program, and is still suspected of trying to undermine it). These suspicions can sometimes undermine cooperation in sensitive nuclear areas, and are only inflamed by detailed public discussions in the United States of possible actions to improve Pakistani nuclear security.

Extraordinary Insider and Outsider Threats

While Pakistani security measures are extensive, they must provide protection against extraordinary threats, from both insider infiltration and outsider attack. In the global black-market network led by Pakistan's A.Q. Khan, insiders within Pakistan's program demonstrated both a willingness to sell nuclear weapons technology around the globe and an ability to remove major items from Pakistan's nuclear material production facilities and ship them abroad. As discussed earlier, other senior Pakistani nuclear scientists led a "charity" that reportedly offered to help al Qaeda (and Libya) with nuclear weapons.[21] Pakistan also suffers pervasive and deeply ingrained corruption, which can create opportunities for insider recruitment.[22] Insiders among the elite group guarding then-Pakistani President Pervez Musharraf cooperated with al Qaeda in two assassination attempts that came within a hair's breadth of succeeding. If the military personnel guarding the President cannot be trusted, how much confidence can the world have in the military personnel guarding the nuclear weapons?

Sophisticated outsider attacks involving scores or even hundreds of armed extremists are also a serious possibility. A January 2009 attack on a base for the paramilitary Frontier Corps in the Mohmand district near the Afghan border, for example, reportedly involved hundreds of attackers armed with machine guns and rocket-propelled grenades.[23]

There have been terrorist attacks targeting nuclear facilities in Pakistan, including attacks on or near the Sargodha air base and the Wah cantonment, both sites where nuclear weapons are believed to be stored or handled.[24] These attacks, however, were typically simple car bombings that

November 2001, http://www.newyorker.com/archive/2001/11/05/011105fa_FACT (accessed 13 February 2010), or Christina Lamb, "Elite U.S. Ready to Combat Pakistani Nuclear Hijacks," *The Times* (London), 17 January 2010 http://www.timesonline.co.uk/tol/news/world/asia/article6991056.ece (accessed 13 February 2010). Note that while the latter article also provoked Pakistani concern, the specific scenario described was U.S. special forces responding to extremist theft of a nuclear weapon, presumably with the knowledge and cooperation of the Pakistani military, rather than U.S. seizure of Pakistan's nuclear weapons against Pakistan's will.

[21] Tenet, *At the Center of the Storm*, p. 262-68; Mowatt-Larssen, "Al Qaeda WMD Threat: Hype or Reality?," and Albright, "A Bomb for the Ummah."

[22] Russia, Pakistan, Ukraine, and Belarus are the only countries with substantial amounts of weapons-usable nuclear materials in the worst 50 of 180 countries ranked for perceptions of corruption by Transparency International. See Transparency International, *Corruption Perceptions Index 2009* (Berlin: Transparency International, 17 November 2009), http://www.transparency.org/policy_research/surveys_indices/cpi/2009 (accessed 13 March 2010).

[23] Richard A. Oppel, Jr., and Pir Zubair Shah, "46 Die in Taliban Attack on Pakistani Troops," *New York Times*, 11 January 2009, http://www.nytimes.com/2009/01/12/world/asia/12pstan.html?_r=1&hp (accessed 29 January 2010).

[24] Shaun Gregory, "The Terrorist Threat to Pakistan's Nuclear Weapons," *CTC Sentinel*, Vol 2, No. 7 (July 2009), http:// www.ctc.usma.edu/sentinel/CTCSentinel-Vol2Iss7.pdf (accessed 29 January 2010).

never breached the perimeter security of the facilities, having little to do with the tactics that would be needed to steal a nuclear weapon or nuclear material. Indeed, these attacks may have the effect of *reducing* the risk of nuclear theft, as mass murder of military and nuclear personnel (or their children, in the case of one attack) presumably will make it more difficult for the extremists to recruit military and nuclear personnel to their cause.

The 2009 attack on Pakistani Army headquarters was more worrisome (though it also may have had the effect of making military personnel less likely to support the extremists). The attackers, wearing Pakistani army uniforms, penetrated the site and seized dozens of hostages, apparently with detailed knowledge of the layout of the site. A Pakistani elite unit defeated the attackers and rescued most of the hostages, after several hours.[25] With the right tactics and enough firepower, a similar attack—a terrorist assault on a heavily guarded facility, involving sophisticated planning, the use of deception (including, by some accounts, not just the uniforms but forged identifications), attackers willing and eager to sacrifice their lives, and probably insider knowledge of the security arrangements—would pose a serious threat to a nuclear weapons or nuclear materials site.

Ultimately, no nuclear security system can protect against an unlimited threat. Hence, reducing the risk of nuclear theft in Pakistan must include both steps to further improve nuclear security measures and steps to reduce extremists' ability to challenge the Pakistani state, to recruit nuclear insiders, and to mount large outsider attacks. Fortunately, the Pakistani government, with support from the United States and other countries, is moving on both fronts, seeking to wage both a military/intelligence battle and a "hearts and minds" campaign against violent extremists in Pakistan (though as of early 2010, the Pakistani military was declining to take on those elements of the Taliban located in North Waziristan). The extremists' ability to mount attacks throughout the country, and to acquire inside information on security arrangements at sites they are considering attacking, remain troubling, however.

Finally, it is important to understand the limits of the policy tool of improving nuclear security. The more extreme scenarios in Pakistan would not be addressed by any plausible nuclear security system. If the Pakistani state collapsed, or Taliban-linked jihadists seized power, or hundreds of well-armed and well-trained jihadists attacked a nuclear site all at once, or senior generals decided to provide nuclear assistance to jihadis, better nuclear security systems would not solve the problem. However large or small these risks may be, other policy tools will be needed to address them.

Russia

Russia has the world's largest stockpiles of nuclear weapons, plutonium, and HEU, located in the world's largest number of buildings and bunkers. Having recovered from the chaos following the collapse of the Soviet Union, Russia now has substantial security and accounting measures in place for its nuclear weapons and materials, but significant weaknesses remain in some areas, and its security measures face substantial threats from both insiders and outsiders.

Dramatically Improved Nuclear Security

When the Soviet Union collapsed in 1991, many important elements of nuclear security—which had been based on a closed

[25] Jane Perlez, "Pakistani Police Had Warned Army About a Raid," *New York Times*, 11 October 2009, http://www.nytimes.com/2009/10/12/world/asia/12pstan.html (accessed 29 January 2010).

society, closed borders, close surveillance of all nuclear-related personnel by the KGB, and nuclear workers who got the best of everything Soviet society had to offer—collapsed along with it. Since then, through Russia's own efforts and cooperation with the United States and other countries, nuclear security in Russia has improved dramatically. The nuclear security initiative launched by U.S. President George W. Bush and Russian President Vladimir Putin at Bratislava in 2005 was completed at the end of 2008, with extensive security upgrades in place for all but a modest number of nuclear weapon sites and buildings with weapons-usable nuclear material. Cooperative upgrades are continuing at buildings where cooperation was agreed after the initial Bratislava list was prepared, and other cooperation to strengthen sustainability, regulations, inspections, training, material accounting and control procedures, security culture, and more is ongoing. (See "Progress in Nuclear Security Upgrades in Russia and the Eurasian States," p. 35.)

Throughout the Russian nuclear complex, the most egregious weaknesses of the past—gaping holes in security fences, lack of any detector at all to set off an alarm if someone were carrying out bomb material in a briefcase—appear to have been fixed, making nuclear thefts far more difficult to accomplish. At the same time, the Russian economy improved dramatically over the past decade (though it has taken a substantial hit from the current world economic crisis), and that, combined with an overall revival of both the civilian and military sides of Russia's nuclear establishment, has largely eliminated the 1990s-era desperation that created unique incentives and opportunities for nuclear theft. No longer are there guards leaving their posts to forage in the forest for food, as occurred in the late 1990s. And strengthened central control and the renewed strength of the FSB, the successor to the KGB, undoubtedly also contribute to deterring attempts at nuclear theft. Overall, the risk of nuclear theft in Russia has been reduced to a fraction of what it was a decade ago.[26] Nevertheless, there remain strong grounds for concern, discussed below.

Insider Threats

All of the known cases of theft of weapons-usable nuclear material where the circumstances of theft are known were perpetrated by insiders, or with the assistance of insiders. Thefts by employees are widespread at non-nuclear facilities in Russia; in 2006, authorities stopped an ongoing insider conspiracy that had stolen hundreds of items from the Hermitage, one of Russia's leading (and most secure) museums.[27] In the case of nuclear weapons and materials, the temptations for such insider theft may be high: in one case revealed in 2003, a Russian businessman was offering $750,000 for stolen weapon-grade plutonium for sale to a foreign client.[28]

---

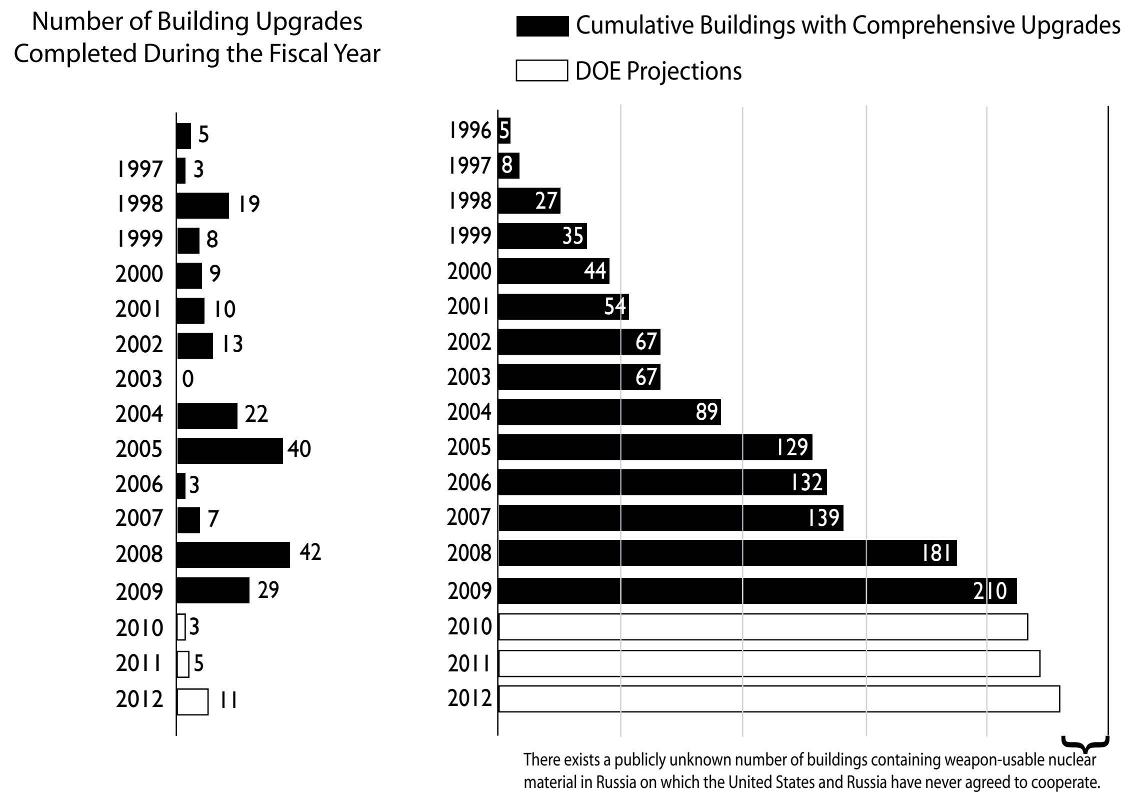
[26] For more in-depth information and references, see Matthew Bunn, "The Threat in Russia and the Newly Independent States," in *Nuclear Threat Initiative Research Library: Securing the Bomb* (Cambridge, Mass., and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, 2006), http://www.nti.org/e_research/cnwm/threat/russia.asp (accessed 9 February 2010).

[27] Alex Rodriguez, "The Inside Job at Russia's Hermitage," *Chicago Tribune*, 20 August 2006; Geraldine Norman, "Mystery of Missing Treasures," *The Daily Telegraph (London)* 5 December 2006; and Galina Stolyarova, "State Has No Plan to Guard Works of Art," *Moscow Times*, 15 August 2006.

[28] For a summary of multiple Russian sources on this case, see "Plutonium Con Artists Sentenced in Russian Closed City of Sarov," *NIS Export Control Observer*, (November 2003), http://cns.miis.edu/pubs/nisexcon/pdfs/ob_0311e.pdf (accessed 9 February 2010). See also "Russia: Criminals Indicted for Selling Mercury as Weapons-Grade Plutonium," trans. U.S. Department of Commerce, *Izvestiya*, 11 October 2003; "Russian Court Sentences Men for Weapons-Grade Plutonium Scam," trans. BBC Monitoring Service, *RIA Novosti*, 14 October 2003.

Progress in Nuclear Security Upgrades in Russia and the Eurasian States

FIGURE 3.1: FSU BUILDINGS WITH SECURITY UPGRADES



Since the 1990s, U.S., Russian, and Eurasian experts have worked closely together to upgrade nuclear material protection, control, and accounting (MPC&A) systems throughout Russia and the Eurasian countries. The Bratislava nuclear security initiative, launched by Presidents Bush and Putin in 2005 and completed at the end of 2008, accelerated and expanded this cooperative effort. As shown in Figure 3.1, by the end of fiscal year (FY) 2009, MPC&A upgrades had been completed for 210 of the roughly 250 buildings in the former Soviet Union where plutonium or HEU exist. Similarly, U.S. and Russian experts have completed security upgrades at all of the warhead sites where the United States and Russia agreed to cooperation, including all but a very few of the warhead storage sites in Russia and most of the temporary warhead handling areas, a total of 97 of the estimated 110-130 nuclear warhead sites in Russia.

The United States and Russia have cooperated on a broad range of other elements of a comprehensive nuclear security system as well, establishing facilities for training personnel and maintaining equipment; drafting new regulations and procedures; training and equipping guard forces; consolidating nuclear material at fewer locations; creating programs to strengthen security culture; instituting computerized national and site-level accounting systems for nuclear weapons and materials; and exchanging "best practices" in areas ranging from countering insider threats to budget planning for nuclear security.

These efforts have dramatically reduced the risk of nuclear theft in Russia, with major benefits for the security of the United States, Russia, and the world. They have also established patterns of cooperation and transparency that have offered both sides much greater insight into how the other manages its nuclear stockpiles—an intangible but substantial security benefit in itself.

Corruption and insider theft are endemic in Russia, and have included military personnel selling off conventional weapons; one Russian official estimated in 2008 that a third of Russia's military spending is lost to corruption.[29] Russian President Dmitri Medvedev has identified corruption as one of the biggest threats to Russia's national security.[30] In the nuclear sector, former Minister of Atomic Energy Evgeniy Adamov's conviction for stealing millions of dollars from the HEU Purchase Agreement is only the tip of the iceberg. In 2003, the chief of security for one of Russia's largest HEU and plutonium facilities warned that guards there were often corrupt, becoming "the most dangerous internal adversaries."[31] In May 2008, an MVD colonel was reportedly arrested for soliciting thousands of dollars in bribes to overlook violations of security rules in the closed nuclear city of Snezhinsk.[32]

Protective measures to prevent insider theft at nuclear facilities have improved dramatically in recent years, but significant weaknesses remain. In general, material control and accounting measures have not progressed as rapidly as physical protection improvements have. Many facilities continue to use easily-faked wax or lead seals. Facilities with hundreds or thousands of containers of nuclear material have paper records of how much material is in those containers, but in some cases have still not actually measured each container to see if any of that material is missing. Rules for material accounting do not yet require the statistical analyses necessary to detect a slow, bit-by-bit theft. The most important insider issues relate to bulk processing facilities (which have been the source of almost all of the known thefts of HEU or plutonium), where insiders might be able to steal small amounts of material at a time without detection.

Outsider Threats

Nuclear facilities in Russia also face serious outsider threats, though as a result

---

29 Steven Eke, "Russian Military 'Deeply Corrupt'," *BBC News*, 3 July 2008, http://news.bbc.co.uk/2/hi/7488133.stm (accessed 29 January 2010). The estimate was from Aleksander Kvashin, leader of the military affairs commission of Russia's Public Chamber. Estimates from Russian ministries are much lower, but still substantial. Russia's chief military prosecutor estimated in early 2010 that losses to the government from military corruption and theft had doubled in 2009 compared to 2008 (when Kvashin made his estimate), putting the losses identified in confirmed cases in the range of $100 million. See "Russia Army Corruption 'Cost $100M in 2009'," *BBC News*, 26 January 2010.

30 See Janet McBride and Michael Stott, "Poverty and Corruption Threaten Russia: Medvedev," *Reuters*, 25 June 2008. In 2009, Transparency International's index of corruption perceptions rated Russia as one of the most corrupt countries on earth (tied with Ukraine and Zimbabwe, among others for 146th place out of 180 countries ranked, with first place being least corrupt). Transparency International, *Transparency International Corruption Perceptions Index 2009* (Berlin: Transparency International, 17 November 2009) http://www.transparency.org/content/download/47852/763508/CPI+2009_Presskit_complete_en.pdf (accessed 29 January 2009). For an overview of security issues posed by corruption in Russia and other states of the former Soviet Union, see Robert Legvold, "Corruption, the Criminalized State, and Post-Soviet Transitions," in Robert I. Rotberg, ed., *Corruption, Global Security, and World Order* (Washington, D.C.: Brookings, 2009), pp. 194-238.

31 Igor Goloskokov, "Refomirovanie Voisk MVD Po Okhrane Yadernikh Obektov Rossii (Reforming MVD Troops to Guard Russian Nuclear Facilities)," trans. Foreign Broadcast Information Service, *Yaderny Kontrol* 9, no. 4 (Winter 2003), http://www.pircenter.org/data/publications/yk4-2003.pdf (accessed 31 January 2010).

32 "An Employee of the Department of Classified Facilities of the MVD Was Arrested in Snezhinsk: What Incriminates the 'Silovic'," *www.ura.ru*, 29 May 2008 [translated by Jane Vayman]. Personnel who have recently retired and have limited incomes, or are about to lose their jobs but still have access to nuclear material or knowledge of nuclear security systems, may pose particularly important insider risks—including retired 12th GUMO or Strategic Rocket Forces personnel, or the thousands of employees in the process of losing their jobs as Russia's last plutonium production reactors and their associated reprocessing plants shut down.

of Russia's suppression of the Chechen insurgency, it may now be unlikely that a nuclear site could be assaulted by a force as substantial as the 32-person team, armed with rocket-propelled grenades, machine guns, and explosives, that seized the school in Beslan in 2004.[33] Russia is the only country in the world where senior officials have confirmed that terrorist teams have carried out reconnaissance at nuclear weapon storage sites (whose locations are secret).[34] Similarly, in late 2005, Russian Interior Minister Rashid Nurgaliev, in charge of the MVD troops guarding nuclear facilities, confirmed that in recent years "international terrorists have planned attacks against nuclear and power industry installations" intended to "seize nuclear materials and use them to build weapons of mass destruction for their own political ends."[35] In 2007, Anatoly Safonov, then-President Putin's special representative for the fight against terrorism and deputy foreign minister, said: "We know for sure, with evidence and facts in hand, about this steady interest and a goal pursued by terrorists to obtain what is called nuclear weapons and nuclear components in any form."[36]

Transports of nuclear weapons and materials are the point in the nuclear material life-cycle that is most vulnerable to violent outsider attack, since it is impossible to provide a transport with the layers of barriers and detectors that are available at a fixed site. In Russia, dozens of nuclear weapon transports and scores of weapons-usable nuclear material transports take place every year, often over remote routes including the Trans-Siberian rail line. U.S. programs have helped Russia purchase secure railcars and trucks, acquire armored "supercontainers" for shipping nuclear warheads, strengthen regulations, improve tactical approaches for defending warhead transports, and take other measures to improve transport security, but questions remain about the potential risk of armed theft from a transport.

It appears, however, that Russia's war in Chechnya has significantly reduced Chechen rebels' ability to organize and mount large, sophisticated attacks, reducing the outsider threat to Russia's nuclear facilities.[37]

[33] It is worth noting that the Beslan attackers acquired some of their weapons stockpile in an even larger and more sophisticated June 2004 raid on Russian Interior Ministry buildings and arms depots in the neighboring province of Ingushetia. That raid reportedly involved at least 200 attackers and left some 80 people dead. In that incident, the attackers, dressed in uniforms of the Russian Federal Security Service, Army intelligence, and other special police squads, overwhelmed local forces, who did not receive reinforcements from federal security service troops for several hours. Were a nuclear site to be attacked by a similar force, with reinforcements similarly late to arrive, the attack might well succeed. Mark Deich, "The Ingushetia Knot," *Moskovskii Komsomolets*, 6 August 2004; Boris Yamshanov, "Bribes Reeking of Explosives," *Rossiiskaya Gazeta*, 16 September 2004.

[34] These incidents apparently occurred in the months prior to the 9/11 attacks, when al Qaeda was also eagerly pursuing connections with senior Pakistani nuclear scientists in the Pakistani Ummah Tamir-e-Nau (UTN) network. Two incidents during 2001 were confirmed by Major-General Igor Valynkin, then serving as the commander of the force that guards Russia's nuclear warheads. The Russian state newspaper reported two more such incidents focused on nuclear warhead transport trains. See, for example, "Russia: Terror Groups Scoped Nuke Site," *Associated Press*, 25 October 2001; Pavel Koryashkin, "Russian Nuclear Ammunition Depots Well Protected—Official," *ITAR-TASS*, 25 October 2001. For the train incidents, see Vladimir Bogdanov, "Propusk K Beogolovkam Nashli U Terrorista (a Pass to Warheads Found on a Terrorist)," *Rossiiskaya Gazeta*, 1 November 2002.

[35] "Internal Troops to Make Russian State Facilities Less Vulnerable to Terrorists."

[36] Quoted in "Russian Foreign Ministry Aware of Terrorists Attempts to Obtain Nuclear Weapons—Diplomat," *Interfax*, 27 September 2007.

[37] See, for example, Brian D. Taylor, "Putin's 'Historic Mission': State-Building and the Power Ministries in the North Caucasus," *Problems of Post-Communism*, Vol. 54, No. 6, November/December 2007, pp. 3-16.

Sustainability

A central question is how well Russia will sustain and upgrade over time the improved nuclear security and accounting measures that have been put in place. In contrast to the 1990s, the Russian government now has the resources to pay for effective nuclear security itself, but Russia has not made nuclear security spending a priority. At present, nuclear facilities are generally responsible for paying for their own security measures. Large facilities generating substantial amounts of revenue (either from the commercial market or from Russian defense programs) can afford to sustain effective security, but smaller research facilities have been facing considerable difficulties finding the funds to maintain expensive equipment, testing, and training programs.[38] Three out of four civilian nuclear facilities visited by investigators from the U.S. Government Accountability Office in 2006 (all of which were research facilities with little commercial revenue) expressed concern that they might not be able to afford to maintain the upgraded security systems at their sites when U.S. assistance phased out.[39] U.S. and Russian experts are developing and implementing sustainability plans for each major site, but whether the Russian government and managers of these sites will devote the attention and resources required to maintain effective security for the long haul remains an open question.

The U.S. Congress has directed that the U.S. government's goal should be a nuclear security system entirely sustained by Russia's own resources by the beginning of 2013.[40] This deadline has been useful in convincing Russian officials and site managers that U.S. assistance will not continue forever, and that they have to plan seriously for sustaining effective security themselves. As the deadline nears, however, Congress should consider offering some flexibility, to help convince Russian site managers that U.S. experts will not be departing entirely so soon that it is no longer worth the effort to push potentially controversial cooperative projects through the Russian bureaucratic system. In any case, even after the 2013 deadline, it will certainly make sense to continue a modest level of funding to support exchanges of nuclear security and accounting best practices, joint research and development of improved security and accounting technologies, and other steps that will allow Russia and the United States continued confidence-building insight into how each country is managing nuclear security.

Consolidation

States can achieve more effective nuclear security at lower cost if they have fewer places with nuclear weapons or weapons-usable nuclear material to protect. Russia reduced the number of nuclear weapon sites substantially in the late 1980s and early 1990s, as nuclear weapons were removed from Eastern Europe, the non-Russian states of the former Soviet Union, and some parts of Russia (such as the Caucasus). But Russia is still believed to have 110-130 nuclear weapon sites.[41]

---

[38] Interviews with experts from Russian nuclear research centers, July 2008 and March 2009.

[39] U.S. Congress, Government Accountability Office, *Nuclear Nonproliferation: Progress Made in Improving Security at Russian Nuclear Sites, but the Long-Term Sustainability of U.S.-Funded Security Upgrades Is Uncertain*, GAO-07-404 (Washington, D.C.: GAO, 2007), http://www.gao.gov/new.items/d07404.pdf (accessed 9 February 2010), p. 27.

[40] See, for example, discussion in U.S. Congress, General Accounting Office, *Nuclear Nonproliferation: Progress Made in Improving Security at Russian Nuclear Sites, but the Long-Term Sustainability of U.S.-Funded Security Upgrades Is Uncertain*, GAO-07-404 (Washington, D.C.: GAO, 2007), http://www.gao.gov/new.items/d07404.pdf (accessed 9 February 2010); U.S. Department of Energy, *2006 Strategic Plan: Office of International Material Protection and Cooperation, National Nuclear Security Administration* (Washington, D.C.: DOE, 2006).

[41] See discussion in Bunn, *Securing the Bomb 2008*, pp. 93-94. This figure includes both permanent

Similarly, despite some consolidation of weapons-usable nuclear materials, Russia is still thought to have some 250 buildings where such materials exist, a far larger infrastructure of such buildings than exists in any other country.[42] Russia should make consolidating these stockpiles to a much smaller and easier-to-protect number of sites a high priority, as it has not been so far.[43]

In particular, Russia has over 60 operating HEU-fueled research reactors and critical assemblies, far more than any other country.[44] (The nuclear theft dangers posed by HEU-fueled research reactors are discussed in more detail below.) Many of these facilities are little-used, yet Russia has shown little inclination to convert them to low-enriched uranium (LEU) that cannot be used in a nuclear weapon, or to shut them down. In the Bratislava nuclear security initiative of 2005, Russian officials insisted that the reference to converting such reactors refer only to reactors in "third countries," eliminating any commitment to move toward conversion in Russia or the United States. Despite more than a decade of effort and the blending down of some 12 tons of HEU, the U.S.-sponsored Material Consolidation and Conversion (MCC) program has led to complete removal of the HEU from only one site, the Krylov Shipbuilding Research Institute. Negotiation of an agreement on consolidating nuclear materials has been stalled for years. Russia has agreed to permit six of its facilities to accept U.S. funding to perform feasibility studies concerning whether they could convert to LEU, but there is as yet no commitment that these or other facilities will actually be converted.[45]

Regulation

Russia's nuclear security and accounting rules and their enforcement have improved substantially since the collapse of the Soviet Union.[46] This is a crucial

---

storage sites and temporary locations such as rail transfer points or loading areas at military bases where nuclear weapons may be located for hours at a time.

[42] NNSA plans to complete upgrades on 229 buildings with HEU or separated plutonium, of which 15 are in other Eurasian states. See U.S. Department of Energy, *Department of Energy FY 2011 Congressional Budget Request: National Nuclear Security Administration,* Volume 1, DOE/CF-0047 (Washington, D.C.: February 2010), http://www.nnsa.energy.gov/about/documents/FY_2011_CONG_NNSA_Merged.pdf (accessed 19 February 2010), p. 372.

[43] For discussions of the importance of consolidation of nuclear weapon sites, see Gunnar Arbman and Charles Thornton, *Russia's Tactical Nuclear Weapons: Part II: Technical Issues and Policy Recommendations*, vol. FOI-R-1588-SE (Stockholm: Swedish Defense Research Agency, 2005), http://www.foi.se/upload/pdf/FOI-RussiasTacticalNuclearWeapons.pdf (accessed 30 January 2010), and Harold P. Smith, Jr., "Consolidating Threat Reduction," *Arms Control Today* 33, no. 9 (November 2003) http://www.armscontrol.org/act/2003_11/Smith.asp (accessed 30 January 2010). For a discussion of consolidating weapons-usable nuclear material in Russia, see Pavel Podvig, *Consolidating Fissile Materials in Russia's Nuclear Complex,* Research Report No. 7 (Princeton, N.J.: International Panel on Fissile Materials, May 2009), http://www.fissilematerials.org/ipfm/site_down/rr07.pdf (accessed 30 January 2010).

[44] Ole Reistad and Styrkaar Hustveit, "HEU Fuel Cycle Inventories and Progress on Global Minimization," *Nonproliferation Review* 15, no. 2 (July 2008), and the on-line supplement, Ole Reistad and Styrkaar Hustveit, "Appendix II: Operational, Shut Down, and Converted HEU-Fueled Research Reactors," http://cns.miis.edu/pubs/npr/vol15/152_reistad_appendix2.pdf (accessed 30 January 2010).

[45] Interviews with NNSA officials, December 2009 and January 2010.

[46] In particular, in July 2007, after years of delay, the Russian government finally issued an updated overall physical protection regulation (though that rule is very general, and depends for its effectiveness on specifics laid down in agency-level rules, some of which are still being updated). See "Procedures for the Physical Protection of Nuclear Material, Nuclear Facilities, and Nuclear Material Storage Points," Decree No. 456 (Moscow: Government of the Russian Federation, 19 July 2007). Similarly, a modified version of the basic rules of material control and accounting, known by its Russian acronym as OPUK, was issued in 2005; a substantially modified version of that set of basic

element of sustainability, as nuclear managers typically will not invest scarce resources in security unless the government tells them they have to do so.

But Russia's nuclear security rules still have important weaknesses, its regulatory agencies have limited resources for inspection and enforcement, and the regulators in many cases have less power than Rosatom, the state corporation that manages much of Russia's nuclear complex, or the other agencies handling nuclear materials that they are supposed to regulate, making it difficult in some cases for them to enforce fines and shutdowns when facilities violate nuclear security and accounting rules. Russia's nuclear regulatory agency, once an independent body reporting directly to the Russian President, was folded in years ago to be one small part of a much broader agency regulating virtually all aspects of safety in Russia—and in 2008, that broader agency was turned into one small part of the Ministry of Natural Resources, creating multiple levels of administration that nuclear regulators must go through before a dangerous issue can be raised to the highest levels of the Russian government.[47] (Virtually every other country operating major nuclear facilities has an independent, stand-alone nuclear regulatory agency, as Russia had in the past.) Key nuclear security requirements are spread between several layers of national, agency-level, and site-level rules, and are sometimes vague or confusing, making it difficult in some cases for working-level personnel to know how to follow the rules. It remains unclear whether the nuclear regulators have the expertise and resources to provide in-depth evaluation of the capability of each site to provide effective protection against designated insider and outsider threats. The nuclear regulators have no authority to regulate the MVD forces that provide most of the guards for nuclear sites; instead, the MVD regulates itself. Regulation of nuclear material control and accounting is also evolving; among other issues, statistical analyses of accounting results to determine if material is being removed in small amounts over time are not yet required. Given the modest salaries of inspectors and the high costs a site might face to fix a violation inspectors uncovered, the possibility of corruption is also a potential problem—as in the case of the MVD officer arrested for soliciting bribes to overlook violations of nuclear security rules, mentioned earlier.

NNSA experts, working with Russian experts, have laid out a structure of hundreds of key elements they believe an appropriate nuclear security and accounting system should have, and are working to put those elements in place.[48] NNSA has also helped Russia develop a regulatory library to help staff understand and implement multiple layers of regulatory requirements. But Russian agreement to implement and enforce such a structure of rules remains far from certain. There is still a long way to go to build a structure of effective rules, effectively enforced—without which sustainable nuclear security is unlikely to be achieved.

---

rules is in development. Interview with Russian regulatory official, March 2009.

[47] This sub-agency is known as the Federal Service for Ecological, Technological, and Nuclear Supervision (known in Russia as Rostekhnadzor). A separate unit within the Ministry of Defense (MoD), substantially smaller than Rostekhnadzor, regulates safety and security for MoD nuclear weapons and materials and those facilities at Rosatom manufacturing nuclear weapons components and other secret items.

[48] See, for example, Greg E. Davis et al., "Creating a Comprehensive, Efficient and Sustainable Nuclear Regulatory Structure: A Process Report from the U.S. Department of Energy's Material Protection, Control and Accounting Program," in *Proceedings of the 47th Annual Meeting of the Institute for Nuclear Materials Management, Nashville, Tenn., 16-20 July 2006* (Northbrook, Ill.: INMM, 2006).. Also interviews with NNSA officials, July 2006 and June 2007.

Security Culture

As noted in the first chapter, building strong security cultures—strengthening the habit, among all security-relevant personnel, of taking security seriously and taking the actions needed to ensure high security—is critical to achieving effective nuclear security. In Russia, both Russian and American experts have reported a systemic problem of inadequate security culture—intrusion detectors turned off when the guards get annoyed by their false alarms, security doors left open, senior managers allowed to bypass security systems, effective procedures for operating the new security and accounting systems either not written or not followed, and the like.[49] In 2003 the security chief at Seversk, one of Russia's largest plutonium and HEU processing facilities, reported that guards at his site routinely patrolled with no ammunition in their guns and had little understanding of the importance of what they were guarding.[50]

NNSA has launched an impressive effort to work with Russia to strengthen security culture—expanded after the presidential endorsement of the effort in the Bratislava nuclear security initiative in 2005. Moreover, the transformation in culture that inevitably arises from dealing with material that is now stored in a vault with a huge steel door which no one can access alone, arrived at through layers of fences, bars, and detectors, should not be underestimated. But whether ongoing efforts to strengthen security culture will succeed on the scale required remains an open question. Unfortunately, changing any deeply ingrained aspect of organizational culture, including security culture, is very difficult.[51] It will not happen unless key Russian officials and site managers become convinced of the urgency of the threat and the need to make nuclear security a top priority of their organizations.

Guard Forces

Nuclear weapon sites in Russia are guarded by a well-trained, professional military force, the 12th Main Directorate of the Ministry of Defense (known as the 12th GUMO, its Russian acronym). At most weapons-usable nuclear material sites, by contrast, the main response forces are from the MVD, some of whom are poorly paid and poorly trained conscripts. A transition is underway toward increased use of professional, better paid guards, such as Rosatom's "Atomguard" force, but that transition is proceeding slowly, and at most sites, the main armed response to an outsider attack would come from the MVD.[52] In 2003, the chief of security at Seversk reported that the Ministry of Inte-

[49] Indeed, on one visit to a facility whose security had been upgraded with U.S. assistance, the U.S. General Accounting Office found that the gate to the central storage facility for the site's nuclear material was left wide open and unattended. At another site, guards did not respond when visitors entering the site set off the metal detectors, and the portal monitors to detect removal of nuclear material were not working. See U.S. Congress, General Accounting Office, *Nuclear Nonproliferation: Security of Russia's Nuclear Material Improving; Further Enhancements Needed*, GAO-01-312 (Washington, D.C.: GAO, 2001), http://www.gao.gov/new.items/d01312.pdf (accessed 31 January 2010), pp. 12-13. For a useful discussion of the security culture problem generally, see Igor Khripunov and James Holmes, eds., *Nuclear Security Culture: The Case of Russia* (Athens, Georgia: Center for International Trade and Security, The University of Georgia, 2004), http://www.nti.org/c_press/analysis_cits_111804.pdf (accessed 31 January 2010).

[50] Goloskokov, "Reforming MVD Troops to Guard Russian Nuclear Facilities."

[51] A classic text on organizational culture (though one much critiqued in some circles as too focused on managers' role in culture) is Edgar H. Schein, *Organizational Culture and Leadership*, Third ed. (San Francisco, CA: Jossey-Bass, 2004). See also John P. Kotter, *Leading Change*, First ed. (Boston, MA: Harvard Business School Press, 1996).

[52] A transition is underway toward greater use of the volunteer "Atomgard" force controlled by Rosatom, but so far Atomgard largely handles tasks internal to the sites, such as access control, and not the job of fighting off external adversaries. As one resident of Sarov put it to the author, "they are mostly old

Progress in Consolidating Nuclear Stockpiles

In recent years, national programs and international cooperation have led to major progress in consolidating nuclear weapons and materials to fewer locations—though much remains to be done.

In the United States in particular, a substantial consolidation program is under way in the Department of Energy (DOE) complex, focused on eliminating weapons-usable nuclear material entirely from as many sites and buildings as possible, driven in part by the immense costs of meeting post-9/11 security requirements for such materials. Moreover, international cooperative efforts have contributed to consolidation in many countries. By NNSA's accounting, by the end of 2009, the GTRI program and its predecessors had:

- Contributed to converting or verified the shutdown of 67 HEU-fueled research reactors worldwide;[1]
- Helped remove all HEU from 47 facilities, so that these locations no longer have any weapons-usable nuclear material to steal (see Figure 3.2);[2]
- Shipped some 2,508 kilograms of HEU from potentially vulnerable facilities back to the United States or Russia for secure storage and disposition.[3]

Most remarkably, perhaps, by the end of January 2010, 19 countries had eliminated all the weapons-usable nuclear material on their soil.[4] (See Table 3.4.) As long as they do not reintroduce such material, none of these countries will ever again have to worry about having potential ingredients of nuclear weapons on their soil.

[1] A more accurate figure would be 64, since three of these 67 were only partly converted and therefore still use HEU in parts of their reactor cores. A much larger number of HEU-fueled reactors has shut down over the years than NNSA tracks; NNSA counts only those that were on their list to attempt to convert which then shut down. For a more complete list, see Reistad and Hustveit, "Appendix 2: Operational, Shut Down, and Converted HEU-fueled Reactors."

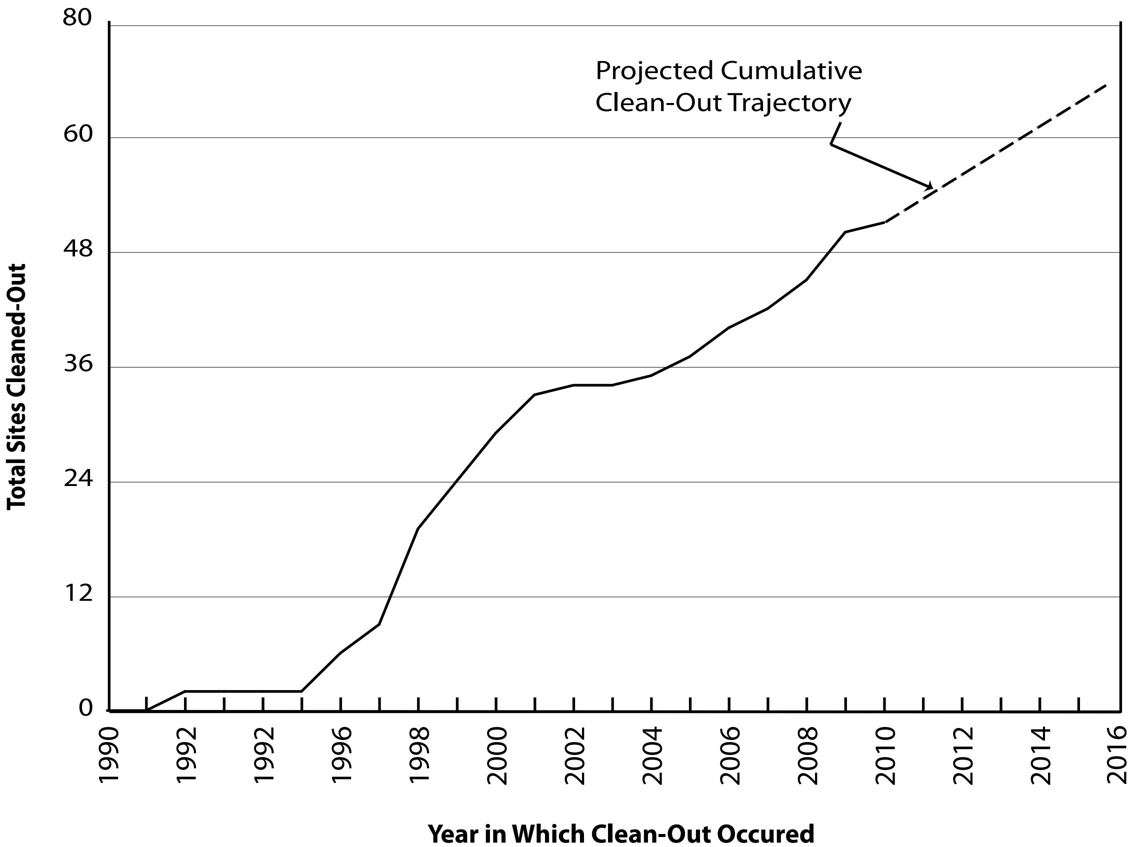
[2] Data provided by NNSA, January 2010. Note that the renewal of the U.S. take-back offer in 1996 started the effort on a steep upward trajectory, which was renewed, after a period of slow progress, by the establishment of the GTRI program in 2004, which broadened the nuclear material removal effort and brought increased focus and resources to it. Here, too, the true number of sites with all weapons-usable nuclear material removed is larger, since NNSA's figure does not include the many facilities within the United States from which all HEU has been removed; the Krylov Shipbuilding Institute in Russia, which eliminated all its HEU with help from the Material Consolidation and Conversion effort that is part of INMPC; the many buildings in Russia where all nuclear material has been eliminated, in part with help from INMPC; the two HEU-fueled research reactors in Iraq from which the United Nations Special Commission (UNSCOM) removed all the HEU after the 1991 Gulf War; the Ulba fuel fabrication facility at Ust-Kamenogorsk in Kazakhstan, from which Project Sapphire removed all HEU in 1994; the HEU-fueled research reactor in Georgia from which Operation Auburn Endeavor (otherwise known as Project Olympus) removed all HEU in 1998; or other facilities that eliminated their weapons-usable nuclear material without U.S. involvement, such as by converting to use LEU materials as their fuel and shipping their HEU to La Hague for reprocessing.

[3] Data provided by NNSA, January 2010. NNSA's figures do not include the tens of kilograms of research reactor HEU fuel removed from Iraq by United Nations teams after the 1991 war; the nearly 600 kilograms of HEU removed in Project Sapphire in 1994; or the few kilograms removed from Georgia in Operation Auburn Endeavor in 1998. Nor do they include the 12 tons of HEU in Russia that the INMPC program has paid to have converted to low-enriched uranium, or the large stocks of HEU that have been removed from research reactors or other sites in the United States.

[4] Data provided by NNSA, January 2010. Taiwan is counted here as a country, since it currently has its own government separate from that of the rest of China. Iraq and Georgia, where nuclear material was removed by other programs, are added here to have a more complete accounting. Spain, which is included here, possesses significant stocks of plutonium separated from spent fuel, but as far as is publicly known these are located in foreign countries, not in Spain itself.

Progress in Consolidating Nuclear Stockpiles (cont)

Figure 3.2: Sites With All HEU Removed Over Time



Since it was established, the GTRI program has succeeded in sharply accelerating the consolidation efforts it is focusing on, speeding up reactor conversions and HEU removals several-fold compared to the years just before GTRI was created. And in 2009, GTRI announced it was adding an addition 71 more research reactors to the list of facilities it hopes to help countries convert to less dangerous fuels or shut down. While there are still some operating HEU-fueled research reactors that GTRI does not believe it will be able to reach, this nonetheless represented a major step to close a gap in U.S. efforts, which previously had no plans for a substantial fraction of the world's operating HEU-fueled research reactors.[5]

There is still a need, however, for a broader approach to consolidating nuclear weapons and weapons-usable nuclear materials in fewer locations. First, there are tons of civilian HEU that GTRI does not plan to address—representing primarily U.S.-supplied HEU in developed countries. While these stocks may in many cases pose lower risks than those in some other countries, that is not the same as saying they pose no risks—and as noted earlier, recent incidents make clear that the assumption that developed countries always maintain effective security for nuclear stockpiles is not universally correct.

[5] For a critique of GTRI's focus on addressing only a fraction of the world's research reactor HEU, see Bunn, *Securing the Bomb 2008,* pp. 44-57, 105-108.

Progress in Consolidating Nuclear Stockpiles (cont)

Table 3.4: Countries That Have Eliminated All Their Weapons-Usable Nuclear Material

Country	Year
Iraq	1992
Colombia	1996
Spain	1997
Denmark	1998
Georgia	1998
Philippines	1999
Thailand	1999
Slovenia	1999
Brazil	1999
Sweden	2002
Greece	2005
South Korea	2007
Latvia	2008
Bulgaria	2008
Portugal	2008
Romania	2009
Libya	2009
Taiwan	2009
Turkey	2010

Over the long term, consideration should even be given to the costs and benefits of converting naval reactors to LEU as well. Second, except for some small unwanted stocks that GTRI plans to address, there is no plan to consolidate civilian plutonium. Despite the long-standing debates between different countries over whether reprocessing and recycling plutonium from spent fuel or direct disposal of spent fuel is the best approach to the back end of the nuclear fuel cycle, it should be possible over time to reach agreement on limiting the number of sites where plutonium separated from fission products is processed, stored, and used; maintaining stringent standards of security at those sites; and restraining the huge buildup of stockpiles of civilian separated plutonium (which are now as large or larger than all the world's stockpiles of weapons plutonium combined), separating plutonium even in countries choosing a reprocessing fuel cycle only when the plutonium is needed for production of fuel. Finally, there should also be renewed efforts focused on consolidating nuclear weapons themselves to fewer locations—particularly in Russia (which has by far the world's largest number of nuclear weapon sites) and the United States (which is the only country that deploys nuclear weapons in other countries).

rior troops guarding the facility routinely failed to protect the facility from outside attack in tests; routinely failed to prevent insiders from removing material in tests; often patrolled with no ammunition in their guns; and were frequently corrupt.[53]

ladies, and they are not frightening." Personal communication, June 2006.

[53] Goloskokov, "Reforming MVD Troops to Guard Russian Nuclear Facilities."

The combination of low pay, boring work, and posting at remote nuclear sites contributes to low morale among these troops: brutal hazing and suicides are distressingly common.[54] NNSA has been providing equipment and training to nuclear guard forces, helping to finance

[54] "Analysis: Hazing in Russian Guard Units Threatens Nuclear Cities Security," *Foreign Broadcast Information Service*, 9 June 2005.

dedicated training facilities for nuclear guards, and has been discussing assistance with a personnel reliability program to screen new recruits and conscripts.[55] But over time, to achieve highly effective protection for these nuclear material sites Russia will need to move to a well-trained professional guard force, as it has long had for nuclear weapon sites.

In short, as a CIA report summed it up in 2006: "Russia's nuclear security has been slowly improving over the last several years, but we remain concerned about vulnerabilities to an insider who attempts unauthorized actions as well as to potential terrorist attacks."[56]

HEU-Fueled Research Reactors

HEU-fueled research reactors typically have comparatively modest stockpiles of material, often in forms that would require some chemical processing to be used in a bomb. But they have some of the world's weakest security measures for those stocks. (Ironically, the security measures at Pelindaba, which were challenged by the November 2007 intrusion described in the first chapter, are much more substantial than the security measures at many other HEU-fueled research reactors around the world.) And it is important to remember that much of the irradiated fuel from research reactors is still HEU, and is not radioactive enough to pose any significant deterrent to theft by suicidal terrorists.[57]

Over 130 research reactors around the world still use HEU as their fuel, or as targets for producing medical isotopes.[58] In addition, several plutonium or tritium production reactors, one nuclear power reactor, 15 reactors for nuclear-powered

[55] Information provided by NNSA, October 2008.

[56] U.S. National Intelligence Council, *Annual Report to Congress on the Safety and Security of Russian Nuclear Facilities and Military Forces* (Washington, D.C.: NIC, April 2006), http://www.fas.org/irp/nic/russia0406.pdf (accessed 1 February 2010). Although this is intended to be an annual report, no subsequent report has yet been released.

[57] For a discussion of the proliferation threat posed by irradiated HEU fuel, see Matthew Bunn and Anthony Wier, *Securing the Bomb: An Agenda for Action* (Cambridge, Mass., and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, 2004), http://www.nti.org/e_research/analysis_cnwmupdate_052404.pdf (accessed 9 February 2010), pp. 36-37. For studies of the fact that a radiation level from irradiated fuel of 100 rad/hr at one meter is grossly insufficient to prevent theft by determined terrorists, see J.J. Koelling and E.W. Barts, *Special Nuclear Material Self-Protection Criteria Investigation: Phases I and II*, vol. LA-9213-MS, NUREG/CR-2492 (Washington, D.C.: U.S. Nuclear Regulatory Commission, 1982), http://www.sciencemadness.org/lanl1_a/lib-www/la-pubs/00307470.pdf (accessed 9 February 2010); C.W. Coates et al., "Radiation Effects on Personnel Performance Capability and a Summary of Dose Levels for Spent Research Reactor Fuels," in *Proceedings of the 47th Annual Meeting of the Institute for Nuclear Materials Management, Nashville, Tenn., 16-20 July* (Northbrook, Ill.: INMM, 2006).

[58] For data on world HEU-fueled research reactors, see See Ole Reistad and Styrkaar Hustveit, "Appendix II: Operational, Shut Down, and Converted HEU-Fueled Research Reactors," http://cns.miis.edu/pubs/npr/vol15/152_reistad_appendix2.pdf (accessed 13 February 2010), online supplement to Ole Reistad and Styrkaar Hustveit, "HEU Fuel Cycle Inventories and Progress on Global Minimization," *Nonproliferation Review*, Vol. 15, No. 2 (July 2008). Reistad and Hustveit list 133 research reactors operating with HEU as of the end of 2007. Since that time, 12 of these reactors have either shut down or converted to LEU. NNSA, however, has also identified 14 research reactors operating with HEU that were not on previous lists, bringing the total to 135. (These are on the listing of additional reactors added to GTRI's scope presented at the "31st Annual Meeting on Reduced Enrichment for Research and Test Reactors," Beijing, 1-5 November 2009.) Similarly, NNSA previously tracked a total of 207 HEU-fueled reactors, of which 15 were icebreaker reactors rather than research reactors, and 65 have been converted or shut down, leaving 127, but the new list includes 14 more research reactors, bringing the total to 141. The variations in numbers arise from differences in counting rules (e.g., whether reactors that have not operated in years but might be operated in the future are counted as operational or shut-down, whether only HEU-fueled reactors are counted or whether the small number of plutonium-fueled research reactors are included as well, and the like) and by identification of additional reactors not included in earlier lists.

icebreakers, and scores of reactors for naval ships and submarines also use HEU fuel. The world's research reactors use some 800 kilograms of HEU fuel or target material every year. Many tons of HEU exist at these research reactors, or in the research reactor fuel cycle.[59] Often—though not always—this material is in forms that would require some chemical processing to use in a bomb. But any group that could pull off the difficult job of making a nuclear bomb from HEU metal would have a good chance of mastering the simpler job of getting HEU metal out of research reactor fuel.

Many of these reactors do not have enough nuclear material to make a bomb on-site—in many cases, it would require thefts from two or three facilities to get enough material for a bomb. But some reactors have large stocks of high-quality material. Critical assemblies and pulse reactors are types of particular concern, as they frequently have tens or hundreds of kilograms of high-quality HEU, which is so lightly irradiated that it is effectively little different from fresh, unused HEU. The hundreds of kilograms of HEU for critical assemblies that used to be located at Technical Area 18 (TA-18) at the Los Alamos National Laboratory, at a difficult-to-defend site in a valley, provoked such security concern that the site was closed and the material shipped to the Device Assembly Facility (DAF) in Nevada, one of the most secure facilities in the DOE complex.[60]

Most of the world's HEU-fueled research reactors are in Russia (which has by far the world's largest fleet of them) and the United States. But such reactors exist in many other countries as well—indeed, nearly all of the countries with weapons-usable nuclear material on their soil listed in Tables 3.1-3.3 has at least one research reactor using HEU. Indeed, many countries are on the list only because of one or a few HEU-fueled research reactors.

The most significant stocks of HEU at research reactor sites in developing or transition countries outside of Russia are located in Belarus, Kazakhstan, South Africa, and Ukraine. Research reactors in developed countries including Belgium, Canada, Germany, Japan, and the United States, among others, also have substantial stocks.

Many research reactors have remarkably modest security arrangements. One recent review of research reactors that had received U.S.-sponsored security upgrades identified research reactors that were wholly dependent on off-site response forces to respond to a theft attempt, but had never exercised the capabilities of those forces; a reactor that conducted no search of vehicles leaving the site for potential nuclear contraband; a reactor for which the national regulatory agency had not established any nuclear security requirements; and a reactor where no background checks were performed before allowing access to nuclear material.[61] (Since only five reactors were reviewed, without any attempt to choose reactors likely to have weak security, this list of issues is particularly worrisome.) Many research reactors have no armed guards on site, and rely on local police who are some minutes away, though in tests in several countries, adversary actions sometimes unfold so rapidly that such off-site

[59] IPFM, *Global Fissile Material Report 2009,* pp.14-15.

[60] National Nuclear Security Administration, "Sensitive Nuclear Material Out of Los Alamos TA-18 Facility" (Washington, D.C.: NNSA, 2 November 2005), http://nnsa.energy.gov/news/1177.htm (accessed 31 March 2010).

[61] U.S. Congress, Government Accountability Office, *Nuclear Nonproliferation: National Nuclear Security Administration Has Improved the Security of Reactors in its Global Research Reactor Program, but Action is Needed to Address Remaining Concerns,* GAO-09-949 (Washington, D.C.: GAO, September 2009), http://www.gao.gov/new.items/d09949.pdf (accessed 30 October 2009).

forces might not be able to respond in time. In the United States, research reactors are exempted from almost all Nuclear Regulatory Commission physical protection regulations, and are not required to have armed guards, perimeter fences with intrusion detectors, or extensive barriers to slow adversaries' ability to get to the nuclear material; more fundamentally, they are not required to be able to defend against any specified level of threat.[62]

Nevertheless, security for many HEU-fueled research reactors is much better today than it was two decades ago. Research reactors in Russia and other former Eurasian states have had security upgrades financed by the United States and other donor countries. The United States has also financed security upgrades for over a dozen other HEU-fueled research reactors, in many cases following IAEA-led peer reviews that recommended major security improvements.[63] Within the United States, the GTRI program is helping reactor operators to voluntarily upgrade security to a level well beyond that required for research reactors by NRC regulations; GTRI had completed upgrades at seven U.S. reactors by the end of 2009 (though several of those were LEU-fueled facilities, upgraded primarily to protect against sabotage). These upgrades in the United States and around the world represent very important improvements, but in many cases the fact remains that the sites would not be effectively protected either against attack by well-trained, well-armed outsiders or theft through a well-thought-out conspiracy of well-placed insiders—and these facilities have few resources to be able to sustain more substantial improvements, including the cost of paying round-the-clock armed guards.[64] Ultimately, the only way to reduce the risk of nuclear theft at these facilities to zero is to ensure that there is no weapons-usable material left there to steal—and the GTRI effort has been focusing on doing precisely that, converting research reactors to use LEU fuel and targets, and removing HEU from sites around the world.

Nuclear Stockpiles in Other Contexts

While Pakistan, Russia, and HEU-fueled research reactors appear to pose the world's highest risks of nuclear theft, the risks are significant in many other contexts as well. Ultimately, essentially every country where weapons-usable nuclear material exists—including the United States—has more to do to ensure that these stocks are effectively protected against ever-evolving adversary threats. A brief review of nuclear security in a number of other countries and contexts is provided below.

China has a relatively modest stockpile of nuclear weapons and weapons-usable nuclear materials, which is thought to be under reasonably heavy guard. NNSA

[62] See U.S. Nuclear Regulatory Commission, "Part 73-Physical Protection of Plants and Materials," in *Title 10, Code of Federal Regulations* (Washington, D.C.: U.S. Government Printing Office, 2009), http://www.nrc.gov/reading-rm/doc-collections/cfr/part073/full-text.html (accessed 13 March 2010).

[63] For a list, see Bunn, *Securing the Bomb 2008*, pp. 97-98. Some of these facilities have since converted to LEU, and some of those have had all their HEU removed.

[64] For a discussion of the major difference between upgrading sites to ensure that they roughly follow the very general IAEA physical protection recommendations and upgrading them to the point where they are effectively protected against plausible threats of nuclear theft, see Bunn, *Securing the Bomb 2008*, pp. 96-102. Under U.S. law, the United States carries out visits in countries that have received U.S. nuclear materials and technologies to ensure that the U.S.-origin materials have adequate physical protection, but these visits are only designed to confirm that these facilities follow IAEA physical protection recommendations, not to confirm that they have security measures effective enough to defeat the outsider and insider threats that adversaries might be able to bring to bear in the country where the reactor operates.

has been conducting a broad nuclear security dialogue with China for years, though it is not paying for installation of nuclear security and accounting upgrades, expecting China to implement such upgrades itself. There are indications that China has installed modern security and accounting systems at least at some sites.[65] The U.S.-Chinese dialogue does not explicitly include the organizations that manage China's military stockpiles—by far the largest quantities of HEU and plutonium in China—but experts from those organizations sometimes take part.[66] China reportedly requires sites to provide protection against threats that include both outsider and insider adversaries, but does not require realistic testing of facilities' ability to defeat intelligent adversaries, and it is not clear how widely nuclear security systems have been modernized.[67] Chinese experts have expressed concern that improved protections against insider theft may be needed, given China's shift toward a more market-oriented (and more corrupt) society.[68]

India has a small but growing nuclear stockpile, as its reactors continue to produce more weapons plutonium. Very little information is publicly available about the specifics of India's nuclear security arrangements, though Indian officials report that Indian facilities are required to protect nuclear weapons, HEU, or plutonium against a spectrum of insider and outsider threats; the specifics of the threat to India's nuclear facilities are reviewed frequently.[69] Despite the recent U.S.-Indian nuclear agreement, however, India has so far refused nuclear security cooperation with the United States, though it has hosted regional nuclear security workshops for the IAEA, and plans to participate in the nuclear security summit.[70]

Israel, like India, has a small nuclear weapon stockpile in a state that has remained outside of the nuclear Nonproliferation Treaty (NPT). Israel, which does not even acknowledge the existence of its nuclear weapons, has kept essentially all information about its nuclear security ar-

[65] Yun Zhou, "Security Implications of China's Nuclear Energy Expansion," *Nonproliferation Review,* forthcoming. For earlier accounts of MPC&A in China, see, for example, Hui Zhang, "Evaluating China's MPC&A System," in *Proceedings of the 44th Annual Meeting of the Institute for Nuclear Materials Management*, Phoenix, Ariz., 13-17 July 2003 (Northbrook, Ill.: INMM, 2003), http://belfercenter.ksg.harvard.edu/publication/3201/ (accessed 16 February 2010) and the summary of the sparse publicly available literature in Nathan Busch, "China's Fissile Material Protection, Control, and Accounting: The Case for Renewed Collaboration," *Nonproliferation Review* 9, no. 3 (Fall-Winter 2002); http://cns.miis.edu/npr/pdfs/93busch.pdf (accessed 16 February 2010).

[66] U.S.-Chinese nuclear security cooperation was cut off years ago over allegations of Chinese spying, and China has been unwilling, to date, to allow the organizations managing its military stocks to reengage with U.S. experts. Interviews with NNSA officials, December 2009 and January 2010.

[67] Discussions with Chinese nuclear regulators, March 2010. It appears that the Chinese approach may have developed further in recent years. In the past, it does not appear that sites were required to perform vulnerability assessments against design basis threats specified by the government. See Tang Dan, "Physical Protection System and Vulnerability Analysis Program in China: Presentation to the Managing the Atom Seminar" (23 March 2004). In an interview in October 2006, a Chinese physical protection regulator confirmed that at that time most sites had not performed a systematic vulnerability assessment.

[68] See Tang Dan et al., "Physical Protection System and Vulnerability Analysis Program in China," in *EU-High Level Scientific International Conference on Physical Protection* (Salzburg, Austria: Austrian Military Periodical, 2002). It is notable that the authors begin with a review of recent changes in Chinese society, with the conclusion that these changes increase the criminal threat and decrease the ability to rely solely on the loyalty of insider personnel.

[69] See presentations to International Atomic Energy Agency, "IAEA Regional Training Course on Security for Nuclear Installations," Mumbai, India, 11-20 May 2003.

[70] See, for example, Chidanand Rajghatta, "India-Pak Sideshow Coming Up at Obama Nuclear Meet," *Times of India*, 5 March 2010.

rangements secret. Given the long Israeli experience with terrorism, it seems very likely that Israel has extensive security measures in place for all its nuclear activities.

Most of the sites with weapons-usable nuclear material outside the United States and Russia are in developed countries. Some of these sites have substantial stockpiles, ranging from tens of tons of separated civilian plutonium at well-guarded facilities in Britain and France to hundreds of kilograms of HEU at some less well-protected facilities in several countries. Nuclear security in advanced developed countries should not be taken for granted. The recent incidents at the Belgian air base and with the U.S. Air Force inadvertently flying six nuclear weapons across the country to an airbase that was unaware it had received them—which, combined with other incidents, led to the firing of both the Secretary of the Air Force and the Air Force Chief of Staff—make that clear.

The United States does not finance nuclear security improvements in developed countries, though the United States often seeks, however, through discussions, to convince such states to take steps to strengthen nuclear security themselves, and under U.S. law, the United States conducts occasional visits to confirm that U.S.-origin nuclear material in these countries is protected in accordance with IAEA recommendations. Extensive U.S.-Japanese discussions, for example, helped encourage Japan to strengthen its physical protection rules, though the security measures required in Japan are still modest.[71]

Nevertheless, the general assumption that all nuclear material in wealthy countries is effectively secured is not correct. Many HEU-fueled research reactors in wealthy countries have minimal security measures in place (particularly in the United States, as discussed below). At one research reactor in a developed country, for example, the facility had retained a significant quantity of separated plutonium on-site even though there had not been funds to do any experiments with it for years. The cost of meeting that country's security rules for a Category I facility (the highest level of security, required for this amount of plutonium) was apparently so low that it was not worth the trouble to move this plutonium into another building on the same site which already contained large quantities of plutonium.[72]

France and the United Kingdom have small nuclear weapons stockpiles, huge stockpiles of civilian plutonium (amounting to 84 tons and 109 tons respectively as of their most recent declaration), HEU-fueled research reactors, and, in France's case, a major HEU fuel fabrication facility.[73] Both countries require their nuclear facilities and transports to be protected against a range of both outsider and insider threats. Nevertheless, as in other countries, nuclear security concerns some-

[71] Prior to the 9/11 attacks, Japan did not have armed guards at nuclear facilities, relying instead on armed response units some distance away. Since 9/11, lightly armed members of the national police force have been stationed at nuclear facilities, but they are not required by regulation and may be withdrawn at any time. A senior Japanese regulator estimates that the total cost to all licensees combined of meeting the new physical protection rules was in the range of $50 million. Interview with Japanese nuclear regulator, November 2006.

[72] Visit by the author.

[73] International Atomic Energy Agency, "Communication Received from France Concerning its Policies Regarding the Management of Plutonium," INFCIRC/549/Add.5/13 (Vienna: IAEA, 15 September 2009), http://www.iaea.org/Publications/Documents/Infcircs/2009/infcirc549a5-13.pdf (accessed 19 February 2010), and IAEA, "Communication Received from the United Kingdom of Great Britain and Northern Ireland Concerning its Policies Regarding the Management of Plutonium," INFCIRC/549/Add.8/12 (Vienna: IAEA, 15 September 2009) http://www.iaea.org/Publications/Documents/Infcircs/2009/infcirc549a8-12.pdf (accessed 19 February 2010).

Progress and Delays in Reducing Nuclear Material Stockpiles

Whether a particular building has more or less effective security and accounting measures in place is far more important to the risk of nuclear theft than whether the building has 100 tons or 1 ton of nuclear material in it. Hence, nuclear security programs should not be judged primarily by the sheer quantity of nuclear material they address.

Nevertheless, ultimately the huge stocks of weapons-usable material built up over decades of Cold War and the large stocks that have built up in the civilian sector should be drastically reduced—by transforming them into forms that can no longer be readily used in weapons.

For HEU, this is technically straightforward, as HEU can be mixed with natural, depleted, or slightly enriched uranium to produce low-enriched uranium (LEU) that cannot support an explosive nuclear chain reaction, and cannot be made weapons-usable without expensive and technologically demanding re-enrichment. Excess plutonium poses a more difficult problem, as nearly all combinations of plutonium isotopes are potentially weapons-usable; plutonium, too, can be mixed with uranium, but chemically separating the two to recover weapons-usable plutonium is far less challenging than uranium enrichment. The most plausible approaches to disposition of excess plutonium are using it as fuel in nuclear reactors—for example, as plutonium-uranium mixed oxide (MOX) fuel in existing light-water reactors—or immobilizing it with high-level wastes for permanent disposal.[1]

The United States and Russia have made significant progress in reducing stockpiles of excess HEU. Under the U.S.-Russian HEU Purchase Agreement, Russia is blending some 30 metric tons of HEU every year to LEU for commercial use in the United States and elsewhere. (It is a remarkable fact that nearly 10% of U.S. electricity is fueled by dismantled Russian nuclear bombs.) By early 2010, 382 metric tons of HEU had been destroyed; the agreed plan is to destroy 500 tons of HEU in this way by the time the deal ends in 2013.[2] Similarly, by the end of fiscal year 2009, the United States had blended 127 tons of its excess HEU to LEU (or shipped it for downblending), and was planning to continue doing so at a rate of some 3 tons per year.[3] Both countries, however, have very large stocks of HEU that is still being reserved for military purposes.

Less progress has been made in disposition of excess plutonium. After many years of delays and cost overruns, a MOX fuel fabrication plant for U.S. excess plutonium is under construction at the Savannah River Site, but disposition has not yet begun. DOE has reported that a protocol has been completed modifying the 2000 U.S.-Russian Plutonium Management and Disposition Agreement, which called for disposition of 34 tons of excess weapons plutonium on each side. The protocol would commit the United States, pending the availability of appropriated funds, to provide $400 million to support disposition of Russian excess plutonium in fast-neutron reactors, including the existing BN-600 reactor and the BN-800 reactor that is still under construction. In Russia, too, disposition at any significant scale is still years away.

Ultimately, the United States and Russia should go much farther, agreeing to reduce their total stock

[1] For discussions, see Matthew Bunn and Anatoli Diakov, "Disposition of Excess Highly Enriched Uranium," and "Disposition of Excess Plutonium," in *Global Fissile Materials Report 2007* (Princeton, NJ: International Panel on Fissile Materials, October 2007), pp. 24-42. These are briefly updated in "Disposition of Plutonium and Highly Enriched Uranium," in *Global Fissile Materials Report 2009* (Princeton, NJ: International Panel on Fissile Materials, October 200), pp. 77-86.

[2] See USEC (formerly the U.S. Enrichment Corporation), "Megatons to Megawatts" (Bethesda, Md.: USEC, 2010), http://www.usec.com/megatonstomegawatts.htm (accessed 31 March 2010).

[3] U.S. Department of Energy, *FY2011 Congressional Budget Request: National Nuclear Security Administration,* DOE/CF-0047 (Washington, D.C.: DOE, February 2010) p. 395.

Progress and Delays in Reducing Nuclear Material Stockpiles (cont)

piles of nuclear weapons to very low levels, and to destroy all stocks of HEU and plutonium beyond the minimum needed to support these agreed levels and a small allotment for naval fuel.

In addition to reducing existing stocks, it is important not to accumulate new stocks of these weapons-usable materials. None of the five Nonproliferation Treaty (NPT) nuclear-weapon states are currently producing plutonium or HEU for weapons. With help from NNSA, Russia has shut down two of its three remaining plutonium production reactors—which continued to operate because they provided heat and power to tens of thousands of people in Siberia—and the last of these reactors is expected to close in 2010. This represents a major step forward, ending a substantial accumulation of plutonium every year, major bulk-processing plutonium at the reprocessing plants serving these reactors, and a major use of HEU fuel as "spike" fuel in these reactors' cores.[4]

Unfortunately, however, negotiation of a fissile cutoff agreement that would permanently end production of HEU and plutonium for nuclear weapons has been stymied for years. Pakistan and India, which are still producing plutonium and HEU for weapons, have been resisting such an agreement, and Israel is no more enthusiastic. (North Korea, which says that it will resume plutonium production and that its uranium enrichment program is progressing, is not taking part in the discussions.)

Meanwhile, immense stockpiles of separated plutonium continue to build up in the civilian sector, as plutonium reprocessing outpaces the use of this material as fuel. For the first time in the nuclear age, if current central estimates of military stockpiles of plutonium are correct, there is as much or more plutonium separated from spent fuel in the world's civil stockpiles than there is in all the world's military stockpiles combined—enough for tens of thousands of nuclear weapons.[5] Currently, there are no major international efforts to end the accumulation of these large stocks of civilian plutonium.

It is also important to seek to ensure that new states do not begin producing plutonium or HEU, creating new potential sources for nuclear theft. This includes addressing the nuclear programs of North Korea and Iran, and limiting the spread of enrichment and reprocessing facilities—the key technologies that make it possible to produce weapons-usable nuclear material. A variety of international approaches to the nuclear fuel cycle have been proposed to reduce states' incentives to make the major investments required to build their own nationally controlled enrichment or reprocessing facilities, ranging from multinationally controlled facilities that many states could participate in, to "banks" of enriched uranium that could increase states' confidence that fuel would be available even if there was an interruption of their normal supplies. The IAEA Board of Governors has approved an arrangement in which the IAEA can draw on a bank of enriched uranium on Russian soil, and a separate IAEA-controlled bank proposed by the Nuclear Threat Initiative is expected to be established soon.[6]

---

[4] At the same time, however, the closure of these reactors and their associated reprocessing plants will leave thousands of qualified nuclear experts without work, raising other potential issues.

[5] The most recent declarations of civilian plutonium stockpiles participating in the Plutonium Management Guidelines (as of the end of 2008), combined with unclassified estimates of the civilian stockpiles owned by nonparticipating countries such as India, suggest that current world stocks of civilian plutonium separated from spent fuel amount to roughly 257 tons; central estimates of current military stockpiles, including the portion of those stockpiles declared excess, are slightly lower, though the difference is within the range of uncertainty. For current declarations, see the series of documents in the Information Circular 549 (INFCIRC/549) series; for unclassified estimates of military stockpiles, see IPFM, *Global Fissile Materials Report 2009,* p. 16.

[6] For an overview of such approaches, see, for example, U.S. Committee on Internationalization of the Nuclear Fuel Cycle, National Academy of Sciences and National Research Council, and Russian Committee on Internationalization of the Nuclear Fuel Cycle, Russian Academy of Sciences, *Internationalization of the Nuclear Fuel Cycle: Goals, Strategies, and Challenges* (Washington, D.C.: National Academy Press, 2008)

times arise. U.S. visitors to a major HEU processing facility in France in 2006 found a wide range of security weaknesses.[74] Security for the frequent transports of civilian plutonium in France has reportedly been substantially improved in recent years, after earlier criticisms and incidents of anti-nuclear activists seizing control of plutonium trucks.[75] Similar issues have been raised in the Britain over the years.

The United States may have the most stringent nuclear security rules in the world and almost certainly spends more on securing its nuclear stockpiles than any other country. Annual safeguards and security spending at DOE alone is now in the range of $1.5 billion per year;[76] the private sector and the Department of Defense spend hundreds of millions more each year. All facilities with nuclear weapons or weapons-usable nuclear material except a small number of HEU-fueled research reactors are required to be able to defeat a specified DBT;[77] both armed guards and modern safeguards and security technologies are used to protect these sites (and to protect transports). Regular performance tests probing facilities' ability to fend off mock attackers are required, and routinely contribute to revealing important deficiencies that require correction.[78] While details are classified, the DBT now in place for nuclear weapons and weapons-usable nuclear material at DOE is reported to be comparable in magnitude to the 19 attackers in four independent, well-coordinated groups that struck on 9/11.[79]

---

[74] Interviews with participants in a visit to the CERCA HEU fuel fabrication facility.

[75] Interview with DOE official, November 2009. For a description of the frequency of civilian plutonium transports, including in France see David Albright, *Shipments of Weapons-Usable Plutonium in the Commercial Nuclear Industry* (Washington, D.C.: Institute for Science and International Security, 2007), http://isis-online.org/uploads/isis-reports/documents/plutonium_shipments.pdf (accessed 9 February 2010). For a troubling earlier analysis of security for plutonium transports in France, see Ronald E. Timm, *Security Assessment Report for Plutonium Transport in France* (Paris: Greenpeace International, 2005), www.greenpeace.fr/stop-plutonium/en/TimmReportV5.pdf (accessed 9 February 2010).

[76] U.S. Department of Energy, *FY 2009 Congressional Budget Request: Other Defense Activities*, vol. 2, DOE/CF-025 (Washington, D.C.: DOE, 2008), http://www.cfo.doe.gov/budget/09budget/Content/Volumes/Volume2.pdf (accessed 9 February 2010), p. 414.

[77] As discussed below, HEU-fueled research reactors regulated by the Nuclear Regulatory Commission are exempted from this requirement.

[78] For discussions of the results of some of these tests from a non-government watchdog organization, see, for example, {Project on Government Oversight, 2005, POGOconsolidation05; Project on Government Oversight, 2006, Y12security06; Project on Government Oversight, 2001 #1068} The U.S. approach to such testing is by no means perfect, and has been criticized both by those receiving the tests (who often argue, among other things, that they assume an unrealistic level of insider knowledge of security vulnerabilities) and for presenting an unrealistically positive impression (in part because the tests are done with a substantial period of advance notice, and hence are not necessary reflective of day-to-day security performance in response to a surprise attack). Prior to 9/11, for example, the NRC allowed reactors to beef up their security forces for the day of the test, and then not to maintain those heightened defenses after the test; nevertheless, in a large fraction of the tests, the defenders failed to protect the reactor. See U.S. Congress, General Accounting Office, N*uclear Regulatory Commission: Oversight of Security at Commercial Nuclear Power Plants Needs to Be Strengthened*, GAO-03-752 (Washington, D.C.: GAO, Sepatember 2003), http://www.gao.gov/new.items/d03752.pdf (accessed 31 March 2010). There have also been allegations of cheating on such tests over the years—for example by giving the defenders advance knowledge of the tactics the attackers would use, or by disabling the test gear so that it was unable to detect when a defender received a simulated fatal gunshot, making the defenders essentially invulnerable. See, for example, U.S. Department of Energy, Inspector General, *Protective Force Performance Test Improprieties,* DOE/IG-0636 (Washington, D.C.: DOE, January 2004), http://www.ig.energy.gov/documents/CalendarYear2004/ig-0636.pdf (accessed 9 February 2010).

[79] For a useful discussion of the several steps in the evolution of DOE's DBT since 9/11, see Project on Government Oversight, *U.S. Nuclear Weapons Complex: Y-12 and Oak Ridge National Laboratory at High Risk* (Washington, D.C.: POGO, 2006), http://www.pogo.org/pogo-files/reports/nuclear-security-

Nevertheless, as the Air Force incidents described above make clear, significant controversies continue to arise about the adequacy of nuclear security—and especially security culture—in the United States. Realistic testing of the performance of nuclear security systems against well-equipped and well-trained adversaries have repeatedly revealed serious vulnerabilities in physical protection and accounting systems for nuclear material in the U.S. nuclear complex.[80] Controversy continues to swirl, for example, over the adequacy and danger of security measures at Lawrence Livermore National Laboratory, where simulated attackers easily overcame the defenses in a 2008 red team exercise, and at the Los Alamos National Laboratory, where repeated lapses in securing classified information and a failure to correct problems with security culture led to the firing of NNSA Administrator Linton Brooks in early 2007.[81] A number of the major security initiatives DOE is now undertaking—particularly the consolidation of nuclear materials into fewer, more secure locations—have been slowed by opponents who question their cost and value.[82] While these events indicate that there is more work to do on nuclear security even in the U.S. nuclear weapons complex, they also are clear signs of taking security seriously—requiring facilities to be able to defend against very substantial threats, requiring realistic tests of security performance, and holding both senior officials and lower-level staff accountable for security performance.

HEU at NRC-regulated research reactors is exempt from most of the security requirements that the same material would require if it was located anywhere other than a research reactor. Lightly irradiated HEU is exempt from nearly all of the NRC's security requirements. Fortunately, these reactors generally never have more than a couple of kilograms of unirradiated HEU on-site at any given time, though they may have tens of kilograms of irradiated material on-site, and much of this irradiated material is still very highly enriched, and may not be radioactive enough to prevent theft by determined terrorists.[83] Tons of HEU metal—the easiest material in the world for terrorists to use to make a nuclear bomb—exists at two NRC-licensed facilities that are required to defend against a far smaller and less capable DBT than would be required at DOE sites handling the same material.[84]

safety/Y-12/nss-y12-20061016.html (accessed 9 February 2010).

[80] For a blistering critique of security in the U.S. nuclear weapons complex, published shortly after the 9/11 attacks, see Project on Government Oversight, *U.S. Nuclear Weapons Complex: Security at Risk* (Washington, D.C.: POGO, 2001), http://www.pogo.org/pogo-files/reports/nuclear-security-safety/security-at-risk/ (accessed 9 February 2010). For a recent summary of progress made in improving security since then and problems still remaining, including both official views and those of critics, see Committee on Energy and Commerce, Subcommittee on Oversight and Investigations, *A Review of Security Initiatives at DOE Nuclear Facilities*, U.S. Congress, House of Representatives, 109th Congress, 1st Session, 18 March 2005), http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=109_house_hearings&docid=f:99905.pdf (accessed 9 February 2010). For a brutal earlier 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 U.S. Department of Energy* (Washington D.C.: PFIAB, 1999), http://www.fas.org/sgp/library/pfiab (accessed 9 February 2010).

[81] Steven Mufson, "After Breaches, Head of U.S. Nuclear Program is Ousted," *Washington Post*, 5 January 2007.

[82] See *A Review of Security Initiatives at DOE Nuclear Facilities*.

[83] Matthew Bunn and Anthony Wier, *Securing the Bomb: An Agenda for Action* (Cambridge, Mass., and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, 2004), http://www.nti.org/e_research/analysis_cnwmupdate_052404.pdf (accessed 9 February 2010), pp. 36-37.

[84] The two sites are Nuclear Fuel Services, in Erwin, Tennessee and the Nuclear Productions Division of BWXT Technologies, in Lynchburg, Virginia. See, for example, the brief mention of this point in Proj-

Table 3.5: Global Nuclear Security Today

Category	Assessment
Russia	Dramatic progress, though major issues remain. Planned U.S.-sponsored security upgrades for both warhead sites and nuclear material buildings almost complete, though some warhead sites and material buildings not covered. Inadequate Russian investment to ensure sustainability, though signs of improvement. Questions on security culture. Poorly paid and trained conscript guards for nuclear material. Substantial threats from widespread insider corruption and theft, while material accounting and control measures remain weak in some cases. Substantial outsider threats as well, though suppressed by counterinsurgency in Chechnya. Major need for consolidation, as Russia still has the world's largest numbers of nuclear weapons sites and weapons-usable nuclear materials buildings, including the world's largest fleet of HEU-fueled research reactors.
Developing states with nuclear weapons (Pakistan, India, China, North Korea)	Pakistan has a small, heavily guarded nuclear stockpile. Substantial security improvements have been made in recent years, in part with U.S. help, but the specifics of this cooperation are classified. Immense threats in Pakistan from nuclear insiders with extremist sympathies, al Qaeda or Taliban outsider attacks, and a weak state. India also has a small nuclear stockpile, and reports that it requires its stocks to be protected against a range of outsider and insider threats, but has so far rejected nuclear security cooperation with the United States. China has a somewhat larger nuclear stockpile, believed to be protected by substantial guard forces. A broad U.S.-Chinese nuclear security dialogue is underway, and China appears to have modernized security and accounting measures at some sites, but little evidence that China has yet required such measures in its regulations. In North Korea, a very small nuclear stockpile and a garrison state probably limit the risks of nuclear theft.
Developing and transition non-nuclear-weapon states	Important progress in recent years, but some issues remain. U.S.-funded security upgrades completed at nearly all facilities with weapons-usable material in the Eurasian states outside of Russia, and in Eastern Europe. Belarus, Ukraine, Kazakhstan, and South Africa have particularly dangerous nuclear material: upgrades completed in Ukraine (though sustainability is an issue); upgrades nearing completion after a several-year delay in Belarus; South Africa (whose facility suffered a penetration of the outer perimeter by armed men in November 2007) is discussing cooperation on nuclear security. Upgrades completed for nearly all HEU-fueled research reactors that previously did not meet IAEA recommendations, but some upgrades would not be enough to defend against demonstrated terrorist and criminal capabilities.
Developed Countries	Significant progress in recent years, as several countries have strengthened nuclear security rules since 9/11. The United States has ongoing dialogues with key countries on nuclear security, but does not sponsor security upgrades in wealthy countries. Nuclear security requirements in some countries remain insufficient to protect against demonstrated terrorist or criminal threats. Additional efforts needed to consolidate both HEU and separated plutonium in fewer locations.
United States	Substantial progress in recent years, though issues remain. DOE has drastically strengthened its requirements for protecting both nuclear weapons and materials (especially from outsider attack) since 9/11. NRC has also increased its security requirements, though they remain less stringent than DOE requirements, and NRC-regulated research reactors fueled with HEU remain exempted from most NRC security requirements. Major progress in converting NRC-regulated reactors to low-enriched fuel, and in implementing voluntary security upgrades going beyond regulatory requirements at these sites. Recent incidents suggest an ongoing issue with security culture.

The NRC has ruled that reactors using plutonium in MOX fuel can be exempted from a substantial fraction of the security requirements that are required at other sites with weapons-usable nuclear material, arguing that there is "no rational reason" why a reactor with potential nuclear bomb material on-site should have any more security than any other reactor.[85]

The international nuclear security policy framework

Today, there are many different initiatives, agreements, resolutions, and the like that seek to improve nuclear security and reduce the risk of nuclear terrorism. Unfortunately, however, the overall policy framework remains weak—none of these policy elements, or even all of them in combination, has yet succeeded in ensuring effective security is put in place and maintained for all stockpiles of nuclear weapons and the materials needed to make them worldwide. **T**able 3.6 provides a summary of the current international policy framework for nuclear security.[86]

Each state with nuclear weapons or weapons-usable nuclear materials bears the responsibility for protecting them. Thus national-level rules, regulations, and procedures are the core of the international policy framework for nuclear security.

But while the responsibility is national, the implications are international—thus posing the fundamental paradox of nuclear security. Every state has an enormous interest in ensuring that all states with nuclear weapons or weapons-usable nuclear materials implements their nuclear responsibilities effectively. Facing terrorists with global reach, nuclear security is only as good as its weakest link. Hence, effective (and effectively implemented) global standards for nuclear security are essential. The goal must be to ensure that *all* nuclear weapons and stocks of weapons-usable nuclear materials around the world are effectively protected against the kinds of outsider and insider threats that thieves and terrorists have shown they can pose. Unfortunately, there is not yet any international agreement that can meet this goal. Informal, voluntary approaches may turn out in many cases to be more effective than seeking to negotiate binding nuclear security agreements.

The IAEA's recommendations on physical protection are the closest thing to a global nuclear security standard that exists today. While these are purely advisory, most states follow them, and indeed, the United States and a number of other supplier states require them to do so as a condition of bilateral nuclear supply agreements. These recommendations have contributed to substantial improvements in nuclear security around the world since they were first promulgated in 1972. Nevertheless, these recommendations, while more specific than many of the other documents described below, are quite vague. The discussion process, in which essentially any participating state can object to a particular recommendation, tends to result in least-common-denominator outcomes. For example, for

ect on Government Oversight, *U.S. Nuclear Weapons Complex: Homeland Security Opportunities*.

[85] U.S. Nuclear Regulatory Commission, *In the Matter of Duke Energy Corporation (Catawba Nuclear Station, Units 1 and 2)*, CLI-04-29 (Washington, D.C.: NRC, 2004), http://www.nrc.gov/reading-rm/doc-collections/commission/orders/2004/2004-29cli.pdf (accessed 9 February 2010); U.S. Nuclear Regulatory Commission, *NRC Authorizes Use of Mixed Oxide Fuel Assemblies at Catawba Nuclear Power Plant* (Washington, D.C.: NRC, 2005), http://www.nrc.gov/reading-rm/doc-collections/news/2005/05-043.html (accessed 9 February 2010).

[86] Adapted from Kenneth N. Luongo, "Building a Next Generation Nuclear Security Framework," presentation, Managing the Atom seminar, Harvard University, 9 February 2010, http://belfercenter.ksg.harvard.edu/files/Building-a-Next-Generation-Nuclear-Material-Security-Framework_1.pdf (accessed 19 February 2010).

Table 3.6: Elements of the International Nuclear Security Framework

Category	Summary
National Regulations and Procedures	States are responsible for securing their own nuclear stockpiles; requirements and approaches vary widely.
IAEA Recommendations, Guides, and Assistance	IAEA recommendations and guides are the closest thing that exists to international standards for nuclear security, but remain very generally worded. IAEA-led peer reviews and assistance are effective but have occurred at only a small fraction of sites with plutonium or HEU.
Physical Protection Convention and Amendment	Original convention covered only physical protection during international transport, and criminalization of nuclear theft; amendment covers domestic physical protection and sabotage, but with very general requirements. Amendment has not yet entered into force (as of early 2010).
Nuclear Terrorism Convention	Criminalizes nuclear terrorism-related crimes, and requires states to make "every effort" to provide "appropriate" nuclear security.
UNSCR 1373, 1540, and 1887	1373 legally obligates all states to take action against terrorist groups. 1540 legally requires all states to criminalize any effort to help terrorist groups get nuclear, chemical, or biological weapons and requires all states with such weapons or related materials to provide "appropriate effective" security for them, along with "appropriate effective" export and border controls. 1887 calls on – but does not require – states to take a broad range of nonproliferation actions, including securing all nuclear stockpiles within four years.
Threat Reduction Cooperation	Various programs sponsored by the United States and several other countries have helped improve nuclear security, consolidate and reduce nuclear stockpiles, strengthen interdiction of nuclear smuggling, and more.
G8 Global Partnership	Ten-year, $20 billion threat-reduction effort launched by the G8 in 2002, now has many contributors beyond the G8, though $20 billion target has never been reached; principal early focus on chemical weapons demilitarization and sub dismantlement; 2008 summit agreed to broaden effort to global focus; may be extended at 2010 summit.
Global Initiative to Combat Nuclear Terrorism	Ad-hoc cooperative initiative launched by the United States and Russia in 2006, now has 76 partners. Organizes workshops, exercises, provides forum for discussions, requests for assistance.
World Institute for Nuclear Security	Established 2008, voluntary forum for nuclear security operators to exchange best practices. Organizes workshops, discussions, drafts best practice guides.
Proliferation Security Initiative	Ad-hoc cooperation initiative launched in 2003, now some 90 members, focuses on interdicting illicit shipments of nuclear, chemical, biological, or missile technologies.
Police and intelligence cooperation	Ad-hoc cooperation on particular cases related to nuclear theft, smuggling, and terrorism, not yet structured into more formal mechanisms.

"Category I" nuclear material—the type and quantity requiring the highest levels of nuclear security—the recommendations specify that there should be a fence with intrusion detectors around the area where such material is handled, but say nothing about how difficult to bypass the intrusion detectors should be; they specify that when not in use, material should be in a vault or locked room, but say nothing about how difficult this room should be to penetrate.[87] It is not necessary for a Category I site to have *any* armed guards to comply with the IAEA recommendations (and some countries still do not have armed guards at nuclear facilities), though if a state does not have armed guards, it is recommended that it take other measures to compensate. The recommendations do not specify any set of insider or outsider threats against which all Category I material should be protected. It is, in short, quite possible for a site to comply with the IAEA recommendations and still have nuclear security arrangements in place that are inadequate to protect against the evolving threat.

International discussions of a new revision of the IAEA recommendations—the first since the 9/11 attacks—are now well advanced, and officials expect the revision to be completed during 2010. While the draft text of the new revision has not been made public, it is expected to be significantly more specific than the previous recommendations. The new version reportedly emphasizes performance testing, including a call for "force-on-force" exercises—in which a group pretending to be outsider adversaries attempt to break into the site—for Category I facilities. It is also said to contain new recommendations for protection against insider threats, stand-off attacks, and cyber attacks. One important change is that it reportedly cautions against downgrading the level of protection for lightly irradiated nuclear fuel, which can no longer be considered "self-protecting" against theft in an age of potentially suicidal adversaries. It will still not call on states to post armed guards, however, or to provide protection against any defined set of insider or outsider threats, continuing to leave that to the discretion of each state.[88] The new revision, in short, will be a very important step, but will still not include all of the elements necessary to ensure that a physical protection system would be effective against the insider and outsider threats that exist in the state where the facility or transport operation is located.

The legally binding instruments that exist today are far less specific than the IAEA recommendations. The Convention on the Physical Protection of Nuclear Materials has no requirements for nuclear security within individual countries—its

[87] International Atomic Energy Agency, *The Physical Protection of Nuclear Material and Nuclear Facilities*, INFCIRC/225/Rev.4 (Corrected) (Vienna: IAEA, 1999), http://www.iaea.or.at/Publications/Documents/Infcircs/1999/infcirc225r4c/rev4_content.html (accessed 13 March 2010). INFCIRC/225/Rev. 4 recommends that Category I nuclear material be used and stored in an "inner area" within a "protected area." The document recommends that the protected area have a fence around it with intrusion detectors, and that unescorted access to the protected area and the inner area be limited to the minimum necessary number of people, and limited to people whose trustworthiness has been determined (though it says nothing about how rigorous this screening process should be). It recommends that people within the inner area where the nuclear material is should be under constant surveillance, such as by the use of two-person rule. While the document recommends that all persons and packages leaving an inner area should be subject to search, it makes no specific recommendation for having portal monitors that would detect nuclear material at all exits from such a facility. As a result, a number of facilities with HEU or plutonium around the world do not yet have portal monitors that would set off an alarm if someone were carrying out plutonium or HEU, relying on other types of search instead.

[88] Interviews with IAEA officials, November 2009, and with NNSA officials, January 2010, and data provided by NNSA, March 2010.

nuclear security provisions only apply to material in international transport. (Other provisions establish international jurisdiction for crimes related to nuclear theft.) An amendment to the convention was agreed to in 2005, extending the convention's terms to cover materials in domestic use, storage, and transport, and to cover sabotage of nuclear facilities as well as nuclear theft. But, while containing some useful principles, the amended convention includes no particular standards for how secure nuclear material should be; it says that countries should set national rules for nuclear security, but it says nothing about what those rules should say.[89] As of early 2010—almost 12 years after the United States proposed that the convention be amended in 1998—the amendment had still not attracted enough parties to enter into force.[90] (One goal of the nuclear security summit will certainly be to convince additional countries—including the United States—to ratify the amendment.) For a listing of which of the countries with nuclear weapons or weapons-usable nuclear material are parties to the convention and its amendment, see Table 3.1-Table 3.3.

Similarly, the Convention on the Suppression of Acts of Nuclear Terrorism, also agreed to in 2005, requires parties to "make every effort to adopt appropriate measures to ensure the physical protection of radioactive materials," but says nothing about what measures would be appropriate, beyond mentioning that states should develop them "taking into account" relevant IAEA recommendations.[91] The nuclear terrorism convention entered into force in July 2007, but the number of parties to the convention remains modest.

UN Security Council Resolution (UNSCR) 1373, passed unanimously in the aftermath of the 9/11 attacks, legally requires all states to take a broad range of actions to counter terrorism, but does not include specific requirements for nuclear security. UNSCR 1540, passed unanimously in 2004, is focused specifically on keeping nuclear, chemical, and biological weapons out of the hands of non-state actors. It legally requires *all* states to provide "appropriate effective" security and accounting for any stockpiles of nuclear weapons or related materials they may have—but to date, no one has defined what essential elements must be in place for nuclear security and accounting systems to comply with this requirement.[92]

---

[89] International Atomic Energy Agency, *Nuclear Security - Measures to Protect against Nuclear Terrorism: Amendment to the Convention on the Physical Protection of Nuclear Material*, GOV/INF/2005/10-GC(49)/INF/6 (Vienna: IAEA, 2005), http://www.iaea.org/About/Policy/GC/GC49/Documents/gc49inf-6.pdf (accessed 13 March 2010).

[90] See International Atomic Energy Agency, *Amendment to the Convention on the Physical Protection of Nuclear Material* (Vienna, IAEA, updated 8 February 2010), http://www.iaea.org/Publications/Documents/Conventions/cppnm_amend_status.pdf (accessed 10 February 2010). As of early 2010, there were only 34 parties to the amendment; under the treaty's terms, the amendment will not enter into force even for the countries that have ratified it until two-thirds of the parties, amounting to over 90 countries, have ratified it. It will likely be years before that occurs. The U.S. Senate gave its advice and consent to ratification on 25 September 2008, but as of early 2010, the United States had not yet deposited its instruments of ratification, as the U.S. Congress had not yet passed implementing legislation conforming U.S. criminal laws relating to nuclear smuggling and terrorism to the requirements of the amendment.

[91] *International Convention for the Suppression of Acts of Nuclear Terrorism* (New York: United Nations, 2005), http://www.un.org/ga/search/view_doc.asp?symbol=A/Res/59/290 (accessed 31 March 2010).

[92] The text of UNSCR 1540, along with many related documents, can be found at United Nations, "1540 Committee" (New York: UN, no date), http://www.un.org/sc/1540/ (accessed 27 February 2010). For a proposed definition of essential elements for both nuclear security and nuclear accounting, see Matthew Bunn, "'Appropriate Effective' Nuclear Security and Accounting—What is It?" presentation to the Joint Global Initiative/UNSCR 1540

UNSCR 1540 also requires states to put in place appropriate effective export controls and border controls, and to put in place domestic legislation criminalizing any attempt to assist non-state actors with nuclear, chemical, or biological weapons. The Security Council has established a small committee to oversee implementation of UNSCR 1540, which assesses state's reporting on the steps they have taken to implement the resolution, compiles databases of relevant national legislation, and seeks to match states requiring assistance in implementing the resolution with donor states. A comprehensive review of the implementation of UNSCR 1540 is currently underway, and its conclusions are expected to be published in 2010.

UNSCR 1887, passed unanimously in September 2009, is not legally binding, but goes further, urging all states to take a broad range of measures to strengthen global nonproliferation efforts, including securing all nuclear material worldwide within four years and establishing a fund to help states implement UNSCR 1540.[93]

To date, it does not appear that fora such as the Global Initiative to Combat Nuclear Terrorism, the IAEA Office of Nuclear Security, the UN committee established to oversee implementation of UNSCR 1540, or the G8 Nuclear Safety and Security Group (which discusses implementation of the Global Partnership Against the Spread of Weapons and Materials of Mass Destruction) have been used to try to develop agreed global standards for nuclear security. In short, the world is still a long way from having effective global nuclear security standards in place.

Threat reduction cooperation represents another important element of the international nuclear security framework. U.S.-sponsored threat reduction programs arose in the 1990s in response to the collapse of the Soviet Union, but in recent years have expanded to help states around the world improve controls over nuclear, chemical, biological, radiological, and missile weapons, materials, and expertise—as the very names of programs such as the Global Threat Reduction Initiative make clear. As discussed earlier in this chapter, these programs have dramatically improved nuclear security at many sites around the world, and removed the weapons-usable nuclear material entirely from many others. The global risk of nuclear theft today is surely far lower than it would have been had these programs never existed.

In 2002, at the G8 summit in Kananaskis, Canada, the other members of the G8 pledged $10 billion over 10 years to match a projected U.S. threat reduction investment of $10 billion over that period, in an initiative known as the Global Partnership Against the Spread of Weapons and Materials of Mass Destruction. Since 2002, many other donor countries beyond the G8 have contributed funds as well, though the total has never reached the originally pledged $20 billion from all parties. The Global Partnership has funneled billions of dollars into chemical weapons demilitarization and submarine dismantlement—the two focus areas Russia preferred—but the non-U.S. funds devoted to nuclear security have been a very small fraction of U.S. investments in that area.[94] At the 2008 G8 summit, the partners agreed in principle to extend the

Workshop on "'Appropriate Effective' Material Accounting and Physical Protection," Nashville, Tenn., 18 July 2008, http://belfercenter.ksg.harvard.edu/publication/18452/ (accessed 27 February 2010).

[93] United Nations Security Council, "Resolution 1887," S/Res/1887 (New York: United Nations, 24 September 2009), http://daccess-ods.un.org/access.nsf/Get?Open&DS=S/RES/1887%20(2009)&Lang=E&Area=UNDOC (accessed 8 February 2010).

[94] Global Partnership Working Group, *Annex A: GPWG Annual Report 2009, Consolidated Report Data* (L'Aquila, Italy: GPWG, July 2009), http://www.partnershipforglobalsecurity.org/PDFFrameset.

focus of the Global Partnership beyond Russia and the Eurasian states to address proliferation risks around the globe, but few projects beyond the original focus countries of Russia and Ukraine have yet been implemented. The 2010 G8/G20 summit, again in Canada, may agree to extend the partnership for another 10 years and give it a more explicit global focus.

Some states have also chosen to channel threat reduction funds through the IAEA's Office of Nuclear Security and its Nuclear Security Fund. The IAEA provides international peer reviews of physical protection and other nuclear security arrangements when states request them, and can help states develop comprehensive nuclear and radiological security plans, covering everything from protection of radiological sources to improved detection of nuclear and radiological materials covering international borders. When reviews indicate that significant nuclear security investments are needed, the IAEA can work with donor states to arrange help in financing those investments, and, on a limited basis, can provide equipment and other assistance itself as well.[95]

The Global Initiative to Combat Nuclear Terrorism, launched by the United States and Russia in 2006, is a voluntary group of states—numbering some 75 countries as of early 2010—that organizes workshops to discuss best practices in particular areas relevant to preventing nuclear terrorism (such as law enforcement measures to stop nuclear smuggling); carries out exercises and simulations to help states plan national and international responses to potential emergencies related to nuclear or radiological terrorism; and also helps, in some cases, to match states seeking assistance to donor states willing to provide it.[96] The Global Initiative (GI) brought countries together at the level of undersecretaries of state or deputy foreign ministers, with teams representing a range of relevant agencies, to discuss the danger of nuclear terrorism and measures to prevent and respond to it, which has surely had some effect on international perceptions of the threat. The GI does not appear, however, to have included a major focus on briefings and exercises designed to build states' sense of urgency about the nuclear terrorism threat, efforts to build international intelligence cooperation focused on nuclear terrorism, or discussions of the levels of security that should be provided for all nuclear weapons and weapons-usable nuclear materials, even in the safest countries.

The Proliferation Security Initiative (PSI), launched in 2003, is another voluntary grouping of states, numbering some 90 participants as of early 2010, which focuses on interdicting illicit shipments of nuclear, chemical, biological, or missile weapons, materials, and technologies. It relies on existing international legal authorities, and therefore does not provide a legal option for stopping a ship or aircraft in international waters or airspace if the country where the vehicle is registered does not provide permission. While not directly related to securing nuclear stockpiles, it potentially has a role to play in making nuclear smuggling more difficult.[97] President Obama has proposed transforming both the GI and the PSI into

asp?PDF=g8gp_annex_a.pdf (accessed 19 February 2010)

[95] International Atomic Energy Agency, *Nuclear Security Report 2009*, GOV/2009/53-GC(53)/16 (Vienna: IAEA, 21 August 2009), http://www.iaea.org/About/Policy/GC/GC53/GC53Documents/English/gc53-16_en.pdf (accessed 19 February 2010).

[96] U.S. Department of State, "The Global Initiative To Combat Nuclear Terrorism," (Washington, D.C.: U.S. Department of State, 2009), http://www.state.gov/t/isn/c18406.htm (accessed 19 February 2009).

[97] U.S. Department of State, "Proliferation Security Initiative," (Washington, D.C.: U.S. Department of State, no date), http://www.state.gov/t/isn/c10390.htm (accessed 19 February 2010).

permanent international institutions with staff of their own.[98]

The World Institute for Nuclear Security (WINS) is a new, voluntary organization where nuclear operators can exchange ideas and best practices related to improving nuclear security. WINS was launched in September 2008, headquartered in Vienna.[99] WINS was developed through a partnership between the Nuclear Threat Initiative (NTI) and the Institute for Nuclear Materials Management (INMM), with support from NNSA, and has been gaining endorsements and support from institutions ranging from the IAEA to nuclear firms and agencies in Britain, Norway, France, Japan, the United States, and elsewhere. As of early 2010, WINS had organized two major best practice workshops, the first on steps to improve nuclear security culture and the second on measures to protect against the most plausible threats to nuclear facilities, and expected to prepare over a dozen best practice guides for use by nuclear operators over the next two years.

The international nuclear security framework also includes a range of cooperation that is often secret, between police and intelligence agencies in different countries, working to track down terrorist cells pursuing nuclear or radiological terrorism, or black-market networks smuggling nuclear materials and technology. The demise of the network led by Pakistan's A.Q. Khan, for example, involved in-depth cooperation among a number of countries, especially U.S. and British intelligence.[100] Currently, however, there is far less international police and intelligence cooperation than is needed to address the threat.[101]

The nuclear security summit and the four-year effort to secure nuclear material worldwide are also key elements of the international nuclear security framework, though how much they will accomplish—and whether they will launch new elements of this global framework, such as an effective approach to global standards for nuclear security—is not yet clear.

In short, the global nuclear security framework includes many different elements, each of which is contributing significantly to reducing the risk of nuclear terrorism, or has the potential to do so in the future. Indeed, there are so many different instruments and initiatives that many countries (some of whom may have only one or two officials dealing with this policy area) have trouble keeping track of them all. To date, however, there is no over-arching structure into which these initiatives could be placed, and the combination of all these initiatives has not yet proven sufficient to ensure that all global nuclear stockpiles are effectively secured. Many of the tiles of the nuclear security mosaic are in place, but the picture is only beginning to emerge.

[98] The White House, Office of the Press Secretary, "Remarks by President Barack Obama," Prague, Czech Republic, 5 April 2009 http://www.whitehouse.gov/the_press_office/Remarks-By-President-Barack-Obama-In-Prague-As-Delivered/ (accessed 19 February 2010).

[99] Information on WINS is available at its website, http://www.wins.org (accessed 17 February 2010). See also Roger Howsley, "The World Institute for Nuclear Security: Filling a Gap in the Global Nuclear Security Regime," *Innovations: Technology, Governance, Globalization*, Fall 2009, Vol. 4, No. 4, pp. 203–208.

[100] See, for example, Douglas Frantz and Catherine Collins, *The Nuclear Jihadist* (New York: Twelve, 2007).

[101] Interviews with Rolf Mowatt-Larssen, who formerly led several such cooperative efforts for the U.S. government, and attempted to initiate others, throughout 2009.

4 GOALS FOR NUCLEAR SECURITY AT THE END OF FOUR YEARS

What should the international community hope to have achieved by April of 2013, at the end of the four-year effort to secure all vulnerable nuclear stockpiles around the world? The plain language of the statements from President Obama and the UN Security Council, combined with the needs of global security, suggests that the objective should be that *all* stocks of nuclear weapons, plutonium, and HEU worldwide are *effectively* and *lastingly* protected.

All means that any nuclear material that could be used to make a nuclear bomb should be included, whether it is in a military or a civilian stockpile. It means the effort must ensure security not just for materials in developing or transition countries such as Russia, Pakistan, or South Africa, but also in wealthy countries such as Belgium and Japan—and the United States.

Effectively is a matter of risk—another way of stating the goal is that at the end of four years, we want all nuclear stocks to have a low risk of being stolen. That means they have to be reliably protected against the kinds of adversary capabilities (both outsider and insider) that they are most likely to face. Hence, how much security is enough will vary from country to country, depending on the spectrum of plausible adversary capabilities in each country: a security system that was perfectly adequate in Canada would likely still be considered "vulnerable" or "high risk" in Pakistan. (In some cases, adversary capabilities may be higher in different regions of individual countries as well, Chechnya and neighboring regions of Russia being an obvious example.)

But in a world with terrorists with global reach, even in the safest countries, nuclear weapons, HEU, or plutonium must *at least* be protected against one well-placed insider, a modest group of well-armed and well-trained outsiders (capable of operating in two coordinated teams), or both together; in countries such as Pakistan, such stocks must be protected against more capable threats. Any nuclear weapons or weapons-usable nuclear material *not* well-protected against such minimum threats should be considered a priority to be addressed. The world should not be satisfied just because a facility follows the IAEA's current physical protection recommendations (INFCIRC/225 Rev. 4), as these, while valuable, are vague enough that it is possible to comply with them fully and still not have effective protection against the kinds of capabilities and tactics that terrorists and criminals have used in past attacks and thefts.[1] Following the IAEA recommendations, in short, is necessary but not sufficient for a site to be considered a low risk for nuclear theft. States are now discussing a fifth revision of these recommendations, which is expected to offer significantly more specific guidance—but it still will not specify any sort of baseline set of threats against which the essential ingredients of nuclear bombs must be protected.[2]

Achieving "effective" protection or "low" risk could be achieved by improving protection or by a combination of improving protection and reducing the likely adver-

[1] See discussion in Chapter 3.

[2] Interviews with IAEA officials, November 2009, with National Nuclear Security Administration (NNSA) officials, January 2010, and data provided by NNSA, March 2010.

sary capabilities. In some countries, such as Pakistan, no plausible level of security upgrades will be sufficient to achieve a low level of risk unless measures are also taken to reduce the chance that thieves would be able to mount large outsider attacks or insider conspiracies without detection (see further discussion below).

Of course, "low risk" of being stolen is a somewhat elastic concept. What seems sufficiently low to one observer may still seem worrisomely high to another. *Assessing the theft risks posed by different stocks around the world will have to be a continuous and ever-evolving part of the effort.* If, at the end of four years, the world has reached a state where the highest-risk remaining stockpiles pose much lower risks than do today's highest-risk stockpiles, the four-year effort will have "succeeded" in the sense of having secured the most vulnerable stockpiles, and in the sense of having substantially reduced the overall risk of nuclear theft.

Lastingly means that the international community has some reason to believe that these stocks are likely to continue to be effectively protected for years to come, long after the four-year objective has passed. For example, if a country has put in place regulations requiring its nuclear materials to be protected against a robust spectrum of insider and outsider threats, is effectively enforcing those regulations, and has arranged for appropriate resources to be available to meet those regulations, it would be reasonable to conclude that nuclear security in that country was likely to last. Of course, there are inevitably conflicts between doing things quickly and doing them in a way that will last, and difficult judgments will have to be made as the effort proceeds. If, at the end of four years, all or nearly all of the world's stocks have reached a state in which they are reliably protected against the main plausible threats in the countries where those stocks reside, and the operators managing these stocks are on a plausible *pathway* toward sustainability—even if they have not reached a sustainable state yet—the effort will have made enormous progress.

Realistically, not everything that should be done to improve nuclear security around the world will be done at the end of four years; the end of that period must not be the end of the road for international cooperation on nuclear security. Nuclear material control and accounting practices, in particular, are likely to be slower to improve than physical protection, and there will surely be sites where substantial improvement in material control and accounting will still be needed after the spring of 2013. Nuclear security systems must always evolve and improve, to keep pace with a changing world and an evolving threat. Indeed, the goal should be to instill a culture of constant improvement and emulation of best world practices; it is critical to avoid complacency, even once significantly improved nuclear security measures are in place. (See "Nuclear Security Cooperation After the Four-year Effort," p. 63.)

A Pakistan Example

What could be true in Pakistan in four years that might lead the international community to conclude the four-year effort had succeeded there? It is highly unlikely that by that time Pakistan will have adopted large clear zones, multiple layers of fencing, and other security approaches that might improve physical protection but would compromise the secrecy of its nuclear weapon sites and potentially make them vulnerable to a nuclear or conventional strike. Nor is it likely that in four years' time there will be no more terrorists in Pakistan, or that there would no longer be any individuals in the Pakistani security services or the Pakistani nuclear establishment with extreme Islamic sympathies.

Nuclear Security Cooperation After the Four-Year Effort

The need for international cooperation to ensure effective nuclear security will not come to an end when the four-year effort is completed. That effort will, if all goes well, have led to major improvements. But there will continue to be a need to address new problems as they are identified, exchange best practices, develop new technologies and approaches, refine and strengthen international standards and recommendations, strengthen security cultures, continue consolidating nuclear materials, and more. The goal of all nuclear security systems must be continuing improvement in performance.

Hence, existing cooperative nuclear security programs should not be seen as efforts that will come to an end in the spring of 2013, but as efforts that will then enter a new phase, a phase focused on sustaining and further improving nuclear security. In particular, as noted in the chapter, many HEU-fueled research reactors will not be able to convert to low-enriched fuels by the spring of 2013, as new high-density fuels are not expected to be licensed and commercially available until 2014 at best. Moreover, accounting and control procedures are likely to be slower to improve than physical protection, and will probably require continued improvement after the spring of 2013.

One important step that should be taken at the summit meeting of the Group of Eight (G-8) and the Group of 20 (G-20) in Canada in June 2010 is to renew the Global Partnership Against the Spread of Weapons and Materials of Mass Destruction, extending it for another ten years, expanding it to help countries around the world implement effective controls over nuclear, biological, and chemical materials and technologies (as required by UN Security Council Resolution 1540), and expanding the pledged funding stream. This would provide key resources for implementing the four-year effort and for sustaining effective nuclear security for the long haul after that effort is completed.

Similarly, within the United States, Congress should act to introduce some flexibility in current legislation that requires the administration to focus on achieving a nuclear security system in Russia sustained only with Russian resources by the end of 2012. While Russia should certainly bear the lion's share of the cost of nuclear security after 2012, the U.S. government should continue to budget reduced amounts to support continued work in a variety of areas, including on sustainability, regulatory effectiveness, and security culture.

But it *is* quite plausible that in four years, with sufficient effort and creative approaches, the international community could help Pakistan reach a state in which there was a very low risk of state failure or state takeover by extremists, and: (a) Pakistani protections against both outsider and insider theft attempts had been substantially improved (for both nuclear weapons and nuclear material, including nuclear material undergoing bulk processing); (b) Pakistan had in place a system of rules and regulations requiring facilities to sustain these high standards of security and to demonstrate in realistic tests that they could protect against the adversary threats the Pakistani government specified; (c) Pakistan had made plans to provide adequate resources to sustain these security systems over the long haul; and (d) a variety of political, development, and counter-terrorism steps had been taken that would make it substantially less probable that extreme Islamic terrorists could organize an insider theft conspiracy or launch a highly capable outsider attack without being detected in advance. The combination of strengthening the defense and weakening the likely adversaries the defenses had to protect against would substantially reduce the risk of nuclear theft, and make it possible to say that the four-year effort had "succeeded" in Pakistan.

Multiple Methods—and not Doing it all Ourselves

For some countries, the best approach may be similar to the one that has been taken in Russia—negotiating agreements, then negotiating upgrade contracts, and then doing upgrades largely paid for with U.S. money. (Even in countries where upgrades will be paid for with U.S. money, the U.S. government should seek faster methods, if the four-year goal is to be achieved.) In countries such as Belgium or Japan, however, the focus should be on convincing them to upgrade security themselves—with as much advice and exchange of best practices as they would like to have, but without much in the way of U.S. funding. The international community needs an approach that integrates a variety of such methods, picking the ones most likely to be effective in each country.

In all cases, winning the "hearts and minds" struggle—convincing key policymakers and nuclear managers that the threats of nuclear theft and terrorism pose real dangers to their countries' security that will require additional action to address—will be central to success, for unless they are convinced of that, they are unlikely to take or agree to the kinds of actions needed to achieve effective and lasting nuclear security. (This issue is discussed in more detail in the last chapter of this report.)

Consolidation

Improved nuclear security can only reduce the risk that nuclear material will be stolen from a particular building; it can never eliminate it. The only way to reduce that risk to zero is to remove the material itself, so that there is no weapons-usable material left to steal. Consolidating nuclear stockpiles to a smaller number of buildings and sites also makes it possible to achieve higher security at lower cost for the locations where these stocks remain. Hence, consolidation should be a central part of the nuclear security agenda, as one of several tools to accomplish the overall objective of ensuring a low risk of theft for all nuclear warheads, plutonium, and HEU worldwide. Consolidation should be thought of more broadly than simply converting HEU-fueled research reactors. Wherever there is plutonium, HEU, or nuclear warheads, the question should be asked: does this building or this site need these for some ongoing mission? Would removal be as politically achievable and cost-effective as lasting security upgrades? In some cases, the answer will be "no, removal is not a practical objective"—as in the case of removing Pakistan's nuclear warheads or removing all the tens of tons of separated plutonium at the French reprocessing plant at La Hague. In other cases, the answer is likely to be "yes, removal should be the primary goal, though the international community should pursue security upgrades to prevent theft until removal occurs." In the United States, a major consolidation effort has been underway for some time. Non-government experts now estimate that U.S. nuclear weapons are stored at 15 locations in the United States and six in Europe, whereas two decades ago, they were at as many as 75 sites in Germany alone.[3] Most U.S. HEU-fueled research

[3] Of the remaining 21 locations, most are military bases where nuclear delivery vehicles (missiles, submarines, or bombers) are deployed; long-term storage of non-deployed nuclear weapons has been consolidated to five locations (two of which are at major nuclear submarine bases and one of which is the dismantlement site, where nuclear weapons are stored pending dismantlement). The remaining two national-level storage sites are Kirtland Air Force Base in New Mexico and Nellis Air Force Base in Nevada. See Robert S. Norris and Hans M. Kristensen, "Nuclear Notebook: Worldwide Deployments of Nuclear Weapons, 2009," *Bulletin of the Atomic Scientists*, November/December 2009, pp. 86-98, http://thebulletin.metapress.com/content/xm38g50653435657/fulltext.pdf (accessed 8 February 2010).

reactors that once existed have either been shut down or have converted to use low-enriched fuel. DOE has eliminated all plutonium and other nuclear material from the former Rocky Flats nuclear "pit" production facility; has removed all significant HEU from Sandia National Laboratories; has removed all nuclear material from Technical Area 18 (TA-18) at Los Alamos, where tests had repeatedly revealed security weaknesses; has greatly reduced the number of buildings with weapons-usable nuclear material at other DOE sites; and plans to eliminate all weapons-usable nuclear material from the Lawrence Livermore National Laboratory by 2012.[4] This consolidation has been driven in large part by post-9/11 security rules that have made it very expensive to continue to have HEU or plutonium in a building, creating a substantial incentive to get rid of these materials wherever possible.

Much the same needs to be done in countries around the world. Today, the main consolidation effort is focused on HEU-fueled research reactors, which the U.S.-funded Global Threat Reduction Initiative (GTRI) and its international partners are seeking to convert to LEU or shut down, coupled with a major effort to remove HEU from these facilities and any other locations where it is no longer needed. The UN Security Council unanimously endorsed this effort in Resolution 1887, calling on all states to minimize the civilian use of HEU "to the greatest extent that is technically and economically feasible," including by converting research reactors to use LEU fuels and medical isotope production to use LEU targets.[5]

This consolidation effort should be continued, with the goal of eliminating the use of HEU wherever possible, and given adequate resources and political priority to succeed. It should also be expanded to include:

- Further consolidation of U.S. nuclear weapons and materials (including consolidating U.S. nuclear weapons in Europe to one or two secure U.S.-operated bases, or removing them entirely);[6]
- A major consolidation program in Russia, which, as described in the last chapter, still has some 110-130 nuclear weapon sites and roughly 250 buildings with weapons-usable nuclear material at dozens of sites. This should include a major effort to convert or shut down Russia's HEU-fueled research reactors, the largest fleet of such reactors in the world.
- An effort to limit, as much as practicable, the number of sites where plutonium separated from spent fuel is stored and used.

Not all the consolidation of nuclear weapons and materials that is desirable is likely to be accomplished within four years. In particular, even if all goes well, new high-density fuels needed to convert some high-performance research reactors are not expected to be available until 2014 (a year after the end of the four-year effort), and that date could still slip. Once those fuels are available, it will take a few years to get those reactors converted, which is

[4] U.S. Department of Energy, National Nuclear Security Administration, "NNSA Ships Additional Surplus Special Nuclear Material From Livermore," 9 February 2009, http://nnsa.energy.gov/2280.htm (accessed 10 February 2010).

[5] United Nations Security Council, "Resolution 1887," S/Res/1887 (New York: United Nations, 24 September 2009), http://daccess-ods.un.org/access.nsf/Get?Open&DS=S/RES/1887%20(2009)&Lang=E&Area=UNDOC (accessed 8 February 2010).

[6] In both the United States and Russia, the idea is to reduce the number of sites where nuclear weapons *not* deployed on strategic ballistic missiles are stored and handled, not to reduce the number of missile silos, submarines, or bombers more than is required by arms control agreements.

why GTRI plans to be spending more on reactor conversion and HEU removals in 2015 than it will during the years of the four-year effort.[7] Hence, eliminating the civil use of HEU cannot realistically be accomplished by the end of the four-year effort: instead, what can be done is to remove weapons-usable nuclear material from a large number of facilities and provide highly effective security wherever such material remains.

What consolidation steps might the world hope to accomplish during the four-year effort? With sufficient leadership, partnership, and resources, it might well be possible by April of 2013 to:

- Reduce the number of countries where HEU or plutonium exist by 50-60%.

- Reduce the number of buildings and bunkers where nuclear weapons, HEU, or plutonium exist by 30-50% (including converting or closing an additional 20-40 HEU-fueled research reactors).[8]

Such actions would make it possible to achieve higher security at lower cost at the sites where nuclear weapons, plutonium, or HEU will continue to exist.

[7] See U.S. Department of Energy, *FY2011 Budget Request: National Nuclear Security Administration*, Vol. 1 (Washington, DC: DOE, February 2010), p. 436.

[8] The GTRI program currently hopes to convert or shut down an additional 29 HEU-fueled research reactors by the end of fiscal year 2013. See DOE, *FY 2011 Congressional Budget Request: National Nuclear Security Administration*, p. 439. If Russia launched a major program to convert its research reactors or shut those that are now little used, and other governments and operators decided to shut down some of the other underutilized reactors, the total number of converted or shut-down reactors at the end of four years could be higher than GTRI now expects. In any case, because Russia has such a large number of nuclear weapon and weapons-usable nuclear material locations, the larger goal of reducing the total number of such locations by 30-50% could only be achieved if Russia undertook a major consolidation initiative.

Nuclear Security Improvements

In parallel with consolidating nuclear weapons and weapons-usable nuclear material at the smallest practicable number of locations, it is critical to provide effective protection from theft at the sites that will remain (and for those transports that will continue). What can be done in four years in improving nuclear security?

Technically, it is possible to implement substantial security at upgrades at many locations during that time. In Russia, major security and accounting upgrades at a number of highly complex facilities were completed within about two years after work had been started at those sites.

But when the time required for political discussions, negotiating contracts, and the like is included, it is clear that only a modest number of facilities in a modest number of countries could be upgraded using the methods that have been used in U.S.-Russian cooperation—even if all the relevant countries were willing to cooperate. Relying on those approaches everywhere where nuclear weapons or weapons-usable materials exist would certainly not lead to effective security for all of these stocks within four years.

But different methods can be used in different cases. Many countries will provide effective security for their nuclear stockpiles with their own money and experts, and will take those actions without extensive discussion or negotiation with the United States or other countries. Those actions could readily be taken within the four-year target—*if* countries became convinced that they needed to take nuclear security steps beyond those they had taken in the past. Hence, convincing countries that improvements are needed—including convincing them that there is a real threat of nuclear theft and terrorism against which they must protect—is fundamental to success in achieving the four-year objective. The United States and other countries seeking to achieve the four-year goal should push for countries to take immediate steps to put in place at least a baseline level of security that would protect these stocks against modest outsider and insider threats, while plans for sustainability are developed and longer term solutions are implemented.

How much nuclear security is enough? A balance must be drawn: one does not want to waste money protecting against imagined armies of ten-foot-tall terrorists, but at the same time, nuclear facilities must be protected against the most plausible adversary capabilities. Clearly, the capabilities of terrorists and thieves vary from one country to another. A nuclear security system sufficient to reduce the risk of nuclear theft or sabotage to a low level in Canada may not be sufficient in Pakistan. Each country with nuclear weapons, plutonium separated from spent fuel, or HEU must ensure that these stocks are effectively protected against the spectrum of outsider and insider capabilities that are most plausible in their country. These stocks should be protected against two sets of capabilities: first, capabilities that terrorists and criminals have shown they can bring together in that country (with whatever additional capabilities that country's intelligence agencies believe are most likely), and second, a set of capabilities that international terrorists might be able to bring to bear in any country. To accomplish this, countries controlling these stocks should establish and enforce rules that require that these stocks be protected against particular sets of adversary capabilities, known as the "design basis threat," (DBT).[9] Ideally, the threat assessment process should include experts who have access to all relevant threat information available to the state, and who are independent of those operating the nuclear facilities. The DBT should be reviewed regularly to ensure that it reflects an up-to-date assessment of the evolving threat.

As just noted, facing terrorists with global reach, there are adversary capabilities that *all* stocks of nuclear weapons, plutonium, or HEU must be protected against, no matter what country they are in. All such stocks should *at least* be protected against:

- A modest group of well-trained outside attackers, capable of operating as more than one team, with armaments that might include automatic weapons, rocket-propelled grenades,[10] and explosives;
- A well-placed insider, with knowledge of the security system, who might carry out a theft himself or herself, or might provide passive or active assistance to outsiders;
- Deception attacks, where thieves might, for example, have military uniforms and forged identification papers, or even forged documents authorizing material to be removed from a site for shipment;

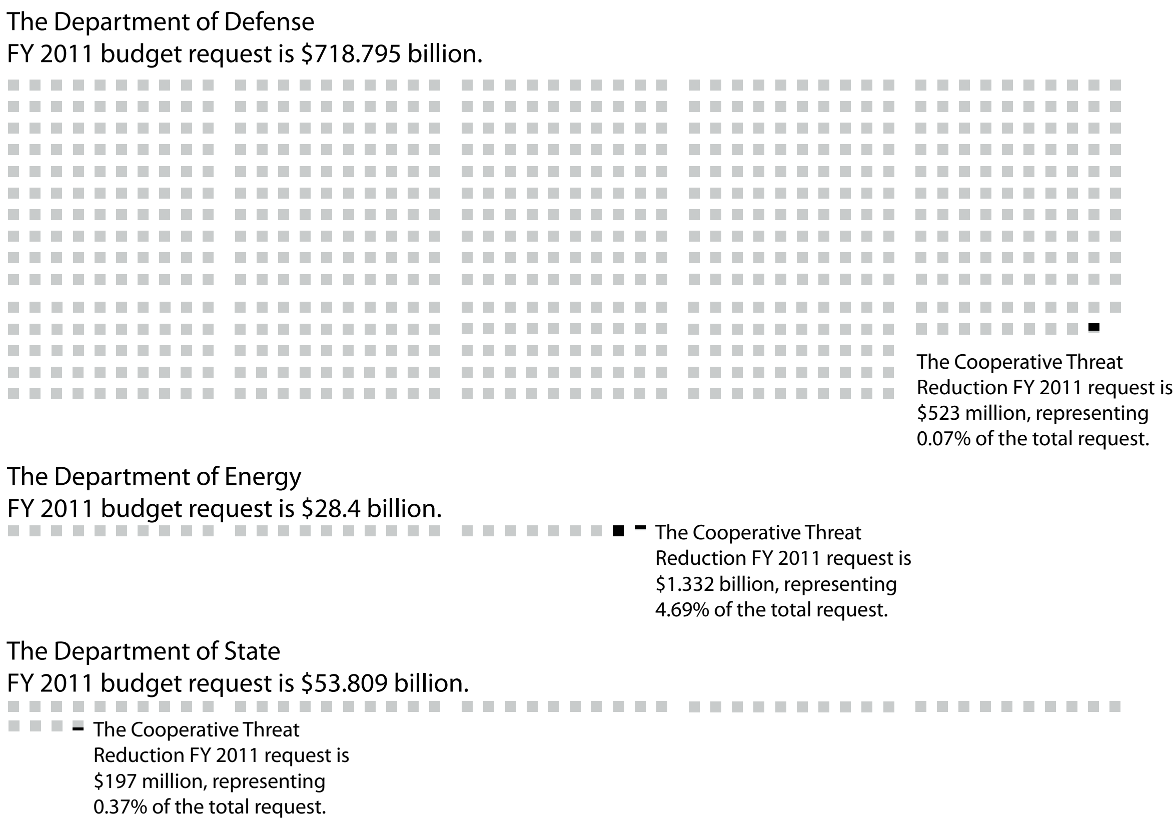
[9] International Atomic Energy Agency, *The Physical Protection of Nuclear Material and Nuclear Facilities*, INFCIRC/225/Rev.4 (Corrected) (Vienna: IAEA, 1999) http://www.iaea.or.at/Publications/Documents/Infcircs/1999/infcirc225r4c/rev4_content.html (accessed 30 October 2009), and International Atomic Energy Agency, *Development, Use, and Maintenance of the Design Basis Threat: Implementing Guide*, Nuclear Security Series No. 10 (Vienna: IAEA, 2009), http://www-pub.iaea.org/MTCD/publications/PDF/Pub1386_web.pdf (accessed 30 October 2009).

[10] Unfortunately, rocket-propelled grenades are widely available to terrorist groups, and have been used extensively in Lebanon, in Iraq, in Afghanistan, and elsewhere. Fortunately, in the case of defending fixed sites such as nuclear facilities, simple and cheap defenses—such as strong wire mesh in front of a wall to be protected—can cause the grenade to detonate harmlessly away from the wall. See "Systems Under Fire," (video), U.S. Department of Energy, Office of Independent Oversight and Performance Assurance, 2003.

How much might it cost to secure nuclear materials worldwide?

No one knows for sure how much it would cost to provide high levels of security for all nuclear weapons and weapons-usable nuclear material worldwide. The number of buildings and bunkers worldwide where these materials exist is not known precisely, and as discussed in the chapter, how many of these require upgrades and how extensive the needed upgrades might be depends on the level of security that is set as the goal. (No matter how many security measures have already been taken, additional steps can always be put in place.)

Figure 4.1: Components of Departments of Energy, State, and Defense FY 2011 Budget Requests Devoted to Cooperative Threat Reduction Programs
(each full box represents $1 billion)



Source: U.S. Department of Defense, Defense Threat Reduction Agency, *Fiscal Year (FY) 2011 Budget Estimate: Cooperative Threat Reduction* (Washington, D.C.: U.S. Department of Defense, February 2010), p.803. U.S. Department of Energy, *FY 2011 Budget Request: National Nuclear Security Administration, vol. 1, DOE/CF-0047* (Washington, D.C.: U.S. Department of Energy, February 2010). U.S. Department of State, *FY 2011 International Affairs (Function 150) Executive Budget Summary* (Washington, D.C.: U.S. Department of State, February 2010).

In Russia, which has the world's largest and most dispersed nuclear stockpiles, NNSA spent roughly $1.3 billion on MPC&A improvements through the end of fiscal year (FY) 2006, by which time upgrades had been completed for 139 buildings containing weapons-usable nuclear material, an average of nearly $10 million per building (though nearly $500 million of this total financed a wide range of training, regulatory development, and other efforts separate from upgrading security and account

How much might it cost to secure nuclear materials worldwide? (cont)

ing equipment at particular buildings).[1] In addition, DOE and the Department of Defense together spent just under $800 million on upgrading security for nuclear warhead storage sites in Russia through the end of FY2006, and had completed upgrades at 62 warhead sites by that time, an average cost in the range of just under $13 million per site.[2] Russia, of course, is paying the costs of providing guard forces, security personnel, and the like, as well as its own investments in security and accounting equipment. The costs of consolidation are also significant: GTRI expects to spend hundreds of millions of dollars a year for years to come on converting HEU-fueled research reactors and removing HEU (and plutonium, in a few cases) from sites around the world.[3]

While prices have increased somewhat since then, and there are arguments in some cases as to whether the upgrades are sufficient to meet the threat (especially in the case of insider theft), these figures provide a reasonable order-of-magnitude understanding of the cost of upgrading nuclear security. It appears very likely that similar levels of security could be provided for all the nuclear weapon and weapons-usable nuclear material sites and transport operations in the world for an initial capital cost in the range of $4-$8 billion (much of which, of course, should be paid by the countries where these stockpiles exist, or by other donor states, rather than putting the entire burden on the United States). Even with an expanded consolidation effort included as well, it appears very likely that the total cost over the four-year effort would be $10 billion or less.

That figure does not include the costs of guard forces, security personnel, regulators, and all the other elements of an effective nuclear security system; these ongoing costs will have to be paid by the operators of the facilities and transports handling nuclear weapons and weapon-usable materials or the governments of their countries. For many facilities, effective security could be provided for 2-3% of annual operating costs. There are some cases, however, such as small research reactors with little revenue, where the annual cost of a more substantial security system might be a substantial fraction of the facility's total current operating budget; in those cases, governments will have to subsidize security or encourage less-needed facilities to shut down.

Beyond these costs for nuclear security, the U.S. government or other donor states may wish to help countries take other steps (as they have in the former Soviet Union), from re-employing nuclear scientists to paying to destroy stocks of HEU or plutonium, to strengthening countries' ability to interdict nuclear smuggling. These efforts would add additional costs.

But the bottom line is that nuclear security is affordable: a level of nuclear security that could greatly reduce the risk of nuclear theft could be achieved for less than two percent of annual U.S. defense spending, spread over several years. (Figure 4.1 shows what a tiny fraction of the budgets of the Defense, Energy, and State Departments is devoted to all threat reduction activities combined, going well beyond nuclear security.) Lack of money should not be allowed to constrain the effort to keep nuclear stockpiles out of terrorist hands.

---

[1] For the funding figure, see U.S. Congress, Government Accountability Office, *Nuclear Nonproliferation: Progress Made in Improving Security at Russian Nuclear Sites, but the Long-Term Sustainability of U.S.-Funded Security Upgrades Is Uncertain*, GAO-07-404 (Washington, D.C.: GAO, 2007), http://www.gao.gov/new.items/d07404.pdf (accessed 31 March 2010), pp. 12, 16. For the number of buildings, see Figure Figure 3.1.

[2] U.S. Congress, *Nuclear Nonproliferation: Progress Made in Improving Security*, p. 18. For the number of warhead sites completed by the end of FY2006, see Matthew Bunn, *Securing the Bomb 2008* (Cambridge, Mass.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, November 2008), p.95, http://www.nti.org/securingthebomb (accessed 13 February 2010).

[3] DOE, *FY 2011 Congressional Budget Request: National Nuclear Security Administration,* pp. 435-445.

- Bombs that could be carried on a person's body, or in a car or van; and
- Unusual vehicles or routes.

It is particularly important that the DBT include the possibility of an insider. All of the real cases of theft of HEU or plutonium whose origins are documented were perpetrated by insiders or with the assistance of insiders. Hence, it is essential to maintain a strong personnel reliability program that conducts background checks before giving employees access to nuclear weapons, materials, or nuclear security information, and that also includes ongoing monitoring so that suspicious changes in behavior may set off warnings. But even where effective personnel reliability programs are in place, it is still essential to protect against insider theft. Some managers may believe that their employees are trustworthy and they could never have an insider problem at their facility. But it should be remembered that even trustworthy insiders could be coerced. In one case in Northern Ireland, for example, a bank had a security system that required two senior officers of the bank to work together to open the vault—but a gang kidnapped the families of two of the senior officers of the bank, and sure enough, they opened the vault.[11] Where practical, it may even be desirable to require operators to at least explore options that would make theft attempts involving more than one insider more difficult and risky.

Each of these types of adversary capability has been repeatedly demonstrated in terrorist attacks and thefts from guarded non-nuclear facilities around the world. Indeed, the Pelindaba incident described above—two teams attacking from opposite sides, apparently with insider knowledge of how to defeat the intrusion detectors—makes clear that this is a realistic level of threat against which stockpiles of nuclear weapons, plutonium, or HEU worldwide must be protected.[12]

Countries and operators should not use a DBT that represents a single point estimate of the threat, but rather should protect against a spectrum of possibilities. A theft attempt involving a small number of people with convincing official uniforms and paperwork is not a *lesser* attack than a dozen attackers arriving with guns blazing, it is a *different* attack, requiring different types of defensive procedures.

Of course, establishing a requirement that operators be able to protect against such a DBT is only the first step. Operators must then develop and implement security designs, plans, and procedures capable of protecting against the full spectrum of possibilities included in the DBT. Regulators must review these arrangements to confirm that they really will provide effective protection against the DBT. Assessments of operators' security arrangements should include a range of testing, including not only component tests—such as tests to ensure that detectors detect intrusions, or that response forces arrive in response to a call—but also exercises designed to test the full system's ability to defeat intelligent adversaries. In the United States, for example, "force on force" exercises testing sites' protection against outsider attacks—sometimes using laser-tag weapons to avoid anyone actually being shot in the exercise—have often revealed impor-

[11] For a good introduction to the Northern Bank case, see Chris Moore, "Anatomy of a £26.5 Million Heist," *Sunday Life*, 21 May 2006. The thieves also used deception in this case, appearing at the bank managers' homes dressed as policemen. One of these managers, however, was later charged with participating voluntarily in the crime; he denied the charge.

[12] For a description, see Bunn, *Securing the Bomb 2008*, pp. 3-4, and "60 Minutes: Assault on Pelindaba," *CBS News*, 23 November 2008, http://www.cbsnews.com/stories/2008/11/20/60minutes/main4621623.shtml (accessed 30 October 2009).

tant weaknesses in security systems that looked good on paper.

Facilities will inevitably vary in their abilities to maintain effective security against a spectrum of threats of this kind. Military organizations have long focused on security for their operations and are generally already protected against these kinds of threats—though the focus at both military and civilian facilities must always be on constant vigilance and continual improvement. For large commercial facilities, effective security can be achieved and maintained for a cost that represents a small fraction of total operating budgets, perhaps in the range of 1-3%. For small research reactors with little operating revenue, however, the costs of protecting against the kinds of threats outlined above may seem prohibitive. Governments, which generally already subsidize the operation of such reactors, should pay for their security, to the extent that governments believe their continued operation provides a benefit to society worth the cost. The costs of security will also provide an additional incentive to convert from the use of HEU to other fuels that do not require such stringent protection.

If efforts to convince countries of the urgency of action succeed, it is quite plausible that by the end of the four-year effort, all countries that still have stockpiles on their soil will have effectively enforced national rules requiring these stockpiles to be protected against a DBT that includes the characteristics just described—at least a modest group of well-armed and well-trained attackers (capable of operating as more than one team), a well-placed insider, or both together, using a range of possible tactics. With considerable effort, it may also be possible to ensure that countries facing terrorist adversaries with more substantial capabilities have protection against even more capable DBTs in place. It is also plausible that by the end of four years, all states with these stockpiles exist would have effective nuclear material control and accounting measures in place; that they would have made arrangements to ensure that sites and transporters would have the resources needed to maintain strong nuclear security and accounting measures even after international assistance phases out; that they would have strong programs in place to strengthen security culture among all personnel relevant to nuclear security; and that they would be implementing regular performance tests to ensure that their nuclear security systems really were effective in countering intelligent adversaries doing their best to figure out how to overcome them.

Should the four-year effort lead to such results, it should be considered a resounding success, for it will have greatly strengthened global nuclear security and greatly reduced the risk of nuclear theft and terrorism worldwide.

5 METHODS FOR JUDGING PROGRESS

Means for assessing progress are essential for managing any large and important government program. Progress measures help to identify where good progress is being made and where obstacles have been encountered that must be addressed. They can be used to structure performance incentives, allocate budgets, and more.

Metrics that do not fully reflect the actual goals being pursued can be dangerous, however, misdirecting efforts from meeting the real goals to meeting the metrics, in a process known as "goal displacement." If a manager is being judged on how many sites are equipped with radiation detection equipment, for example, that manager will have an incentive to focus on getting many sites equipped quickly, rather than on the quality of the installations, the degree to which the people at the sites are trained and motivated to use the equipment, or other approaches to interdicting nuclear smuggling.[1]

Unfortunately, reducing the risk of nuclear theft and terrorism is a problem that combines all of the features that make realistic measurement and assessment of progress extraordinarily difficult: it involves countering intelligent adversaries who will adapt to efforts to stop them (and therefore "success" in blocking one route or tactic may not have a large effect on reducing risk if other routes or tactics are available); it involves stopping activities that by their nature take place in secret (so it is difficult to know if an increase or decrease in, say, reported incidents of nuclear smuggling comes from a real change in the amount of nuclear smuggling, or from a change in how well smuggling is being detected and reported); and it involves addressing activities that are rare, where even one case may be catastrophic, making it difficult to rely on statistical analysis of incidents over time to assess progress in reducing the risk.[2]

As a result, efforts to assess progress in reducing the risk of nuclear theft and terrorism are based on (a) assessing the most likely pathways for terrorist acquisition of a nuclear bomb; (b) assessing what policies would be most likely to reduce the probability that terrorists pursuing those pathways would succeed; and then (c) assessing progress in implementing those policies. In particular, the U.S. government approach and the focus of this report both reflect the judgment that getting a stolen nuclear weapon or stolen nuclear material is the most likely pathway for terrorists to get a nuclear bomb, and that improving security for

---

[1] For a classic paper outlining how common and damaging such misdirected metrics and incentives are in almost every walk of life, see Steven Kerr, "On the Folly of Rewarding A, While Hoping for B," *Academy of Management Executive,* Vol. 9, No. 1 (1995), pp. 7-14 http://www.sba.oakland.edu/Faculty/york/Readings434/Readings/On%20the%20folly.pdf (accessed 10 February 2010). This version is an update from the original 1975 article.

[2] For an excellent discussion of how these characteristics of risks complicate efforts to control them, and approaches that different types of agencies have taken to try to address such risks and measure their progress in doing so, see Malcolm K. Sparrow, *The Character of Harms: Operational Challenges in Control* (Cambridge, U.K.: Cambridge University Press, 2008). The three categories of harm Sparrow identifies as most difficult to control—each of which gets its one chapter in the book—are ones where there is "a brain behind the harm" (an intelligent adversary); "invisible harms" (ones that take place in secret); and "catastrophic harms." Nuclear theft and terrorism combine all three characteristics.

nuclear weapons and materials is the most promising policy tool for blocking that pathway. Hence, the measures discussed below relate primarily to progress in improving security for nuclear weapons and materials. Even there, it is difficult to develop metrics or indicators that provide a real reflection of progress.

Ideally, one would like to measure how much the risk of nuclear theft has been reduced—overall, and at particular locations. But by its nature, the probability that terrorists or thieves will successfully steal nuclear material or a nuclear weapon from a particular location is extraordinarily difficult to assess. Both the defenders and the adversaries maintain considerable secrecy about their capabilities, and are continuously adapting and evolving, which makes assessing the likelihood that the adversaries could overcome the defenders a major challenge.

As a result, there is no single, definitive answer to questions such as: How many sites would have to have their security upgraded to achieve the four-year objective? How extensive would the needed upgrades be? How much would upgrading these sites cost? It is always possible to invest more in security or to invest less—there is no well-defined endpoint that can be considered "enough"—and in any case, security is an ever-evolving process, in which improvements made one year may erode by the next, or new policies and approaches may be instituted. Hence the answers to such questions depend on how secure the relevant facilities and transports already are, how secure the effort should seek to make them be, how capable adversaries are in different countries, and how those adversary capabilities will evolve over time.

Moreover, many of the most important elements of nuclear security—whether the staff take security seriously and are constantly on the watch for anything unusual that might indicate a problem, whether there are problems of insider corruption and theft, how well-trained and well-motivated the guard force is—cannot readily be encapsulated in a single measure. As Albert Einstein is reported to have said, "not everything that counts can be counted, and not everything that can be counted, counts." Though there is good reason to believe that installing major improvements in security and accounting equipment will reduce the risk of nuclear theft, it is difficult to assess how *much* that risk has been reduced by any particular improvement.

In addition, nuclear security cooperation programs may have important intangible benefits—such as promoting dialogue and exchange of ideas between U.S. and foreign nuclear security experts, improving transparency and building confidence that nuclear security is being managed appropriately, exchanging best practices, and the like—which should also be considered in assessing the value of these programs. As one expert put it: "Gary Powers was shot down trying to spy on Chelyabinsk-70. Today we can walk in the front door of Chelyabinsk-70."[3] Congress has recognized the need for metrics that go beyond simply counting how many missiles have been dismantled, and asked the National Academy of Sciences to help the Department of Defense develop improved measures of progress for these efforts.[4]

Nevertheless, despite these many difficulties, it is essential to develop the best measures one can to assess the progress of the four-year nuclear security effort. The U.S. government and the governments of other major countries, drawing on a range

[3] Ken Luongo, presentation, Managing the Atom seminar, 9 February 2010. Chelyabinsk-70 is a closed Russian nuclear city, now known as Snezhinsk, that housed one of Russia's two principal nuclear weapons design laboratories.

[4] *National Defense Authorization Act for Fiscal Year 2010,* Public Law 111-84, Section 1304.

of classified and unclassified information, can in principle track measures that are more reflective of the complex reality than is possible with the limited unclassified information available with the resources of a single researcher. This chapter describes both measures the U.S. government should use to track the progress of these efforts, and measures used in this report.

Three general classes of measures are typically used to assess programs:

- *Input measures* assess the level of effort being devoted to a problem, including such items as budgets devoted to resolving it, people assigned to the task, level of leadership applied, and so on. In themselves, they do not offer information on how much progress is being made.
- *Output measures* assess the level of activity generated by the inputs—for example, the number of patrols a police force provides in a given area, or the number of arrests they make.
- *Outcome measures* seek to assess the actual reduction in the problem being targeted, seeking to measure, for example, reductions in crime rates rather than numbers of arrests.

The kinds of performance measures that U.S.-sponsored programs such as the International Nuclear Materials Protection and Cooperation (INMPC) program and the Global Threat Reduction Initiative (GTRI) rely on today—so many reactors converted, so many kilograms of HEU removed, so many buildings with upgraded nuclear security equipment installed—are primarily output measures. But they are intended to offer at least a general idea about changes in the actual outcome (that is, reductions in the risk of theft)—if the number of buildings where modern nuclear security equipment has been installed grows, then presumably the likelihood of nuclear theft shrinks, and in cases where the weapons-usable nuclear material has been entirely removed, we have a real and lasting outcome measure, for then the risk of nuclear theft from that location has been reduced to zero, in a permanent way.

Input Measures

The key input measures used in this report include:

- *Budget.* Are the funds allocated sufficient to carry out the needed tasks?
- *Personnel.* Has the U.S. government assigned enough of the right people, particularly in key leadership posts, to get the needed jobs done?
- *Leadership and planning.* Have top-level leaders been willing to invest their time and political capital to move this agenda forward, and laid out cohesive plans for doing so?

In general, these input measures should be compared less to whatever went before than to what is likely to be needed to reach the designated goals. A budget cut for a nuclear security program might mean the program was not getting enough money, or it might mean that program had largely accomplished its mission and was winding down.

Other potentially important indicators might include the number of countries that contribute to cooperative nuclear security efforts, such as the International Atomic Energy Agency's Office of Nuclear Security or nuclear security improvement programs sponsored as part of the Global Partnership Against the Spread of Weapons and Materials of Mass Destruction, or the scale of these contributions. These contributions are both inputs to the effort to improve nuclear security, and indications of national commitments to the effort—one potential outcome of efforts to convince policymakers around the world that urgent action to improve nuclear security is required.[5]

Output measures

Output measures are useful for informing broader assessments of real reductions in risk, but they provide limited information in and of themselves, and should not be relied on too heavily. This report uses information from the U.S. government on measures such as:

- The fraction of the buildings with weapons-usable material, or sites with nuclear weapons, in Russia and the other Eurasian states where U.S. programs have funded a completed set of security and accounting equipment upgrades and associated training.
- The fraction of the world's HEU-fueled research reactors that have shut down or converted to low-enriched uranium (LEU) fuel that cannot be used in a nuclear bomb.
- The quantity of HEU and plutonium (in kilograms) removed from research reactors and related sites around the world and shipped back to the country of origin for secure storage and disposition.

Outcome measures

The best single measure of progress would be *the fraction of buildings or transport routes judged to be high or medium risk at the outset that are low or zero risk* at the time of assessment.[6] This would be an indicator, in essence, of the fraction of the total job of getting all facilities and transports to a low-risk state that had been accomplished. While the U.S. government may be able to track this metric—with some considerable uncertainties in the risk judgments—there is simply not sufficient publicly available data for public reports like this one to offer accurate assessments of this metric. As noted above in the previous chapter, "low" risk might be achieved through security upgrades or a combination of security upgrades and steps to reduce likely adversary capabilities.

Some potential related indicators, each of which may be easier to measure, include:

- *The fraction of sites where all weapons-usable nuclear material has been eliminated*. Eliminating all the HEU from a research reactor site, for example, is the only way to reduce the risk of nuclear theft at that site to zero. Converting the reactor to LEU would be only one step toward that HEU-removal objective.
- *The fraction of sites and transport routes with nuclear security and accounting systems that are performing effectively*. This would attempt to assess the fraction of the buildings containing warheads or nuclear material that had demonstrated, in realistic performance tests, the ability to defend against a specified threat. Unfortunately, for nuclear warheads and materials in the former Soviet Union, such data do not yet exist (and even less information of this kind is available for nuclear stockpiles in much of the rest of the world). One element of the four-year effort may be focused on attempting to get states to exchange more data on nuclear security that would help in making these kinds of judgments (see discussion below).

---

[5] In some cases, however, small contributions to these efforts may be an easy way for countries to appear to be contributing to nuclear security, while avoiding more difficult and important steps such as expensive improvements to their own nuclear security arrangements.

[6] This indicator and the others in this report are focused on fixed sites such as buildings; they should be adapted to include transport routes as well.

- *The fraction of buildings with nuclear weapons and weapons-usable nuclear materials that exist in countries whose governments give high priority to nuclear security and accounting.* This could be assessed on the basis of senior leadership attention and resources assigned to the effort, along with statements of priority, decisions to step up nuclear security requirements, and the like. (This would be one measure of how much progress was being made in the "hearts and minds" campaign to convince countries that nuclear theft and terrorism are real threats requiring urgent action.)

- *The fraction of buildings with nuclear weapons and weapons-usable nuclear materials that exist in countries with stringent and effectively enforced nuclear security and accounting regulations.* Since most nuclear managers will only invest in expensive security measures if the government tells them they have to, effective regulation is essential to effective and lasting nuclear security. The effectiveness of regulation of nuclear security and accounting could be judged by whether rules have been set which, if they were followed, would result in effective nuclear security and accounting programs, and whether approaches have been developed and implemented that successfully convince facilities to abide by the rules to a degree sufficient to achieve that objective. Such an assessment would have to rely on expert judgment, rather than simply counting a specific number of regulations written, enforcement actions taken, and the like, as such measures of the *quantity* of regulatory action are usually almost unrelated to the actual *effectiveness* of regulation.

- *The fraction of buildings with nuclear weapons and weapons-usable nuclear materials that exist at sites with long-term plans in place for sustaining their nuclear security and accounting systems, and resources budgeted to fulfill those plans.* The National Nuclear Security Administration (NNSA) has been contracting with facilities to develop cost estimates and plans for maintaining and operating their nuclear security and accounting systems. This metric would assess the fraction of sites that have completed such an estimate, and which appear to have a realistic plan for funding those costs once international assistance comes to an end. A simple metric along the same lines would be the total amount of money a particular country (or facility) is investing in nuclear security and accounting, compared with an assessment of overall needs. Similar estimates could be made for personnel resources as well as financial resources. For both money and personnel, however, such data is often unavailable.

- *The fraction of buildings with nuclear weapons and weapons-usable nuclear materials that exist at sites with strong "security cultures."* Effective organizational cultures are notoriously difficult to assess, but critically important. Ideally, nuclear security culture should be measured by actual day-in, day-out behavior—but developing effective indicators of day-to-day security performance has proven difficult. Potential measures of *attitudes* that presumably influence behavior include the fraction of security-critical personnel who believe there is a genuine threat of nuclear theft (both by outsiders and by insiders), the fraction who understand well what they have to do to achieve high levels of security, the fraction who believe that it is important that they and everyone else at their site act to achieve high levels of security, the fraction who understand the security rules well, and the fraction who believe

Nuclear Security: How Would We Know?

A key question for any effort to assess progress in improving nuclear security is: how would the world know how effective security for any particular site or transport route is, when the specific security measures in place are secret? If states make nuclear security commitments, at the nuclear security summit or other bilateral or multilateral fora, how can other participants confirm that those commitments are being fulfilled? How can states balance building the necessary international confidence in their nuclear security arrangements with maintaining the needed secrecy surrounding those arrangements?

There are several means to address these problems that should be considered. Most important, international nuclear security peer reviews can provide an in-depth look at nuclear security arrangements, and many states already routinely accept such international reviews. Under U.S. law, the U.S. government is required to carry out expert visits to countries that have received U.S. nuclear materials and key U.S. nuclear technologies to ensure that these recipients are providing adequate security for these U.S.-origin materials. These visits have been taking place since the mid-1970s, and give the U.S. government a reasonable overview of the nuclear security arrangements in dozens of countries. Similarly, by early 2010, some 46 countries had voluntarily hosted IAEA-led International Physical Protection Advisory Service (IPPAS) reviews of their physical protection arrangements, including some 16 states that possess HEU or plutonium separated from fission products. Finally, when the United States or another donor state finances nuclear security improvements somewhere, they usually end up with a good understanding of nuclear security practices in that country, though this varies with the specifics of the cooperation. For example, in Russia, U.S. experts typically visit a particular building or bunker multiple times during the course of the upgrades process, and get a sense for what security equipment is in place, what access procedures are followed, and the like. But even in that case, there are many aspects of an effective security system that the United States knows little about—from internal monitoring of personnel for signs of unusual behavior to the real performance of guard forces in the event of an attack to day-to-day implementation of security procedures when no visitors are around. As upgrades are completed and U.S. personnel visit less frequently (or not at all, in some cases), U.S. knowledge of the continuing security situation declines. Pakistani officials, by contrast, have publicly said that U.S.-Pakistani nuclear security cooperation has not involved any U.S. access to nuclear weapon or sites or the most important nuclear material facilities, leaving U.S. experts with much more limited knowledge of the real state of nuclear security.

it is important to follow the security rules. Such attitudes could be assessed through surveys, as is often done to assess safety culture—though enormous care has to be taken in designing the specifics of the approach, to avoid employees simply saying what they think they are supposed to say.[7] NNSA and Rosatom have jointly developed a methodology for assessing security culture that has been applied at two U.S. and two Russian facilities on a pilot basis, but little information is publicly

[7] For a brief discussion of such safety culture surveys, see International Atomic Energy Agency, *Safety Culture in Nuclear Installations: Guidance for Use in the Enhancement of Safety Culture*, IAEA-TEC-DOC-1329 (Vienna: IAEA, 2002), http://www-pub.iaea.org/MTCD/publications/PDF/te_1329_web.pdf (accessed 9 February 2010).

Nuclear Security: How Would We Know? (cont)

A variety of other, less intrusive measures could also contribute to international confidence in nuclear security. Public statements outlining a country's nuclear security requirements, improvements being made, and the like can be very useful. States may also choose to exchange information privately that they would not wish to see provided to other states or the general public. (Russia, for example, has confidentiality agreements with the United States and other countries it is cooperating with.) These private exchanges concerning the state of nuclear security can be helpful in building international confidence. States may also choose to share information about how they assess the performance of their nuclear security systems—so that other states will know that rigorous assessments are being performed, and to share best practices in conducting such assessments with others—and even to reveal certain information about the results of those assessments.

The kind of information about national physical protection and accounting rules and procedures that is already routinely discussed at international conferences could be systematized into a common format asking common questions, to make comparison easier. Nations could publish much of their physical protection and MC&A regulations and procedures (excluding only a small number of elements they considered might be helpful to potential adversaries seeking to overcome them). Nations could exchange information on what kind of performance tests and other measures they take to assess security at their own nuclear sites, and then exchange data on what fraction of their sites have scored well on such national assessments. (In the United States, for example, NNSA sets targets every year for the fraction of its facilities that it hopes will receive high marks in nuclear security inspections, and then publishes the actual percentages, without compromising any information on weaknesses that may have been found at particular sites.)[1] Diplomatic efforts at the nuclear security summit and afterward should include gaining as wide agreement as possible on such mechanisms for building confidence that nuclear security commitments are being fulfilled.

In the end, nuclear security judgments will have to be made on the basis of analysis of all the sources of information available, including results of international reviews and cooperative programs, published statements and regulations, satellite photography, and more.

[1] See, for example, U.S. Office of Management and Budget, "Detailed Information on the National Nuclear Security Administration: Safeguards and Security Assessment" (Washington, D.C.: OMB, 9 January 2009), http://www.whitehouse.gov/omb/expectmore/detail/10000126.2004.html (accessed 10 February 2009).

available about this tool, or the results of these initial assessments.[8]

- *The fraction of buildings with nuclear weapons and weapons-usable nuclear materials that exist at sites with an effective infrastructure of personnel, equipment, organizations, and incentives to sustain MPC&A*. Each of these areas would likely have to be addressed by expert reviews, given the difficulty of quantification.

NNSA's MPC&A program is now putting a substantial focus on progress toward strong security cultures and long-term sustainability. But there is still more to be done to develop performance measures that adequately reflect the real state of progress, but are simple enough to be useful to policymakers.

[8] Interview with DOE laboratory expert, February 2008.

6 PROGRESS SO FAR IN THE FOUR-YEAR NUCLEAR SECURITY EFFORT

As described in earlier chapters, nuclear security efforts since 1992 have made major progress in improving security for many nuclear stockpiles around the world. The new four-year effort to ensure effective security for nuclear weapons and the materials needed to make them around the world announced by President Barack Obama in April 2009 is now under way. But after less than one year, it is too soon to judge the outcomes of that effort. The best way to assess the effort so far is to examine the *inputs,* the level of effort devoted to the problem, in three key categories: leadership and planning; funding; and personnel.

Leadership and Planning

The Obama administration deserves high marks for leadership on security for global nuclear stockpiles. In his Prague speech in April 2009, President Obama for the first time set a specific objective of securing all vulnerable nuclear material worldwide within four years, making preventing nuclear terrorism a key plank of his nuclear policy. He also announced that he would host a summit meeting of world leaders focused specifically on nuclear security. While in the past, this subject had often been handled by deputy office directors in foreign ministries or nuclear ministries, now presidents, prime ministers, and their staffs would be forced to engage, potentially making many decisions possible that had not been possible before.

In September of 2009, President Obama personally chaired a meeting of the UN Security Council with all the leaders of the other Security Council states, and focused it entirely on preventing the spread of nuclear weapons. This resulted in UN Security Council Resolution 1887, which transformed the four-year objective from an American hope to a unanimously endorsed objective of the Security Council.

Meanwhile, the individual programs focused on improving nuclear security prepared analyses of what they hoped they could accomplish over four years, and what resources accomplishing those goals might require.[1] Rather than simply adding those individual program plans together, the National Security Council staff led an intensive review process, doing country-by-country "deep dives" to explore what specific steps needed to be taken and how they might best be accomplished.[2] As befits an effort to ensure effective security for all nuclear material worldwide, this planning went well beyond the traditional threat-reduction focus on Russia and the former Soviet Union, considering a variety of other countries around the world as well. By September of 2009, the administration had settled on an overall strategic plan for the four-year nuclear security effort, grouping different nuclear stockpiles by the level of priority the United States would assign to eliminating them or improving their security.[3]

Some gaps in this effort appear to have remained, however. As has been the case in previous administrations, nearly all of the attention ended up focused on developing and transition countries, reflecting

---

[1] Interviews with National Nuclear Security Administration officials, May, July, and September 2009.

[2] Interviews with National Security Council officials, July and September 2009.

[3] Interview with National Security Council official, January 2010.

an implicit assumption that wealthy countries pose lower risks. Most of the effort to convince wealthy countries to upgrade security for their stocks remained in the hands of a single deputy undersecretary with limited staff at the Department of Energy (DOE). As described in earlier chapters, while it is probably true that wealthy countries pose lower overall risks of theft than some other countries, action will be needed in wealthy countries as well – including in the United States – if the goal of effective security for all stocks of weapons-usable nuclear material worldwide is to be achieved.

Funding

With respect to funding for this four-year effort, the Obama administration got off to an unimpressive start in 2009, but has then requested a substantial funding increase in the budget submitted in early 2010. While much of the effort to secure nuclear stockpiles around the world will be based on convincing countries to do more for security of their own materials, rather than on new efforts paid for entirely by the United States, it is nevertheless clear that achieving the four-year objective will require U.S.-funded programs to do more, faster, and that this will require additional funding.

Inaction in FY 2010

In late 2008 and again in 2009, past reports in this series recommended that Congress appropriate an additional $500 million for nuclear security efforts, to allow the Obama administration to hit the ground running with an expanded and accelerated set of nuclear security programs.[4] But the Obama administration made no effort to secure additional nuclear security funding for fiscal year (FY) 2010.

Although then-Senator Obama had articulated the four-year nuclear security objective during the campaign, the Prague speech did not come until well after the administration's first budget request was submitted to Congress; hence, that request included no additional funding for nuclear security in FY2010. The administration could have made a supplemental appropriation request after the formal announcement of the four-year objective, but they had taken a high-level political decision not to distort the normal budget process with repeated supplemental requests, and that decision was not overridden in this case. The administration made no supplemental request.

The House Armed Services Committee (HASC) observed that expanding and accelerating nuclear security efforts would require more money, and added $403 million for threat reduction programs focused on nuclear security in its proposed defense authorization bill.[5] The administration did nothing to support this congressional initiative; it was not even mentioned in the statement of administration policy on the HASC bill, and the administration did not reach out to any of the other congressional committees to ask them to support the HASC approach.[6]

[4] See, Matthew Bunn, *Securing the Bomb 2008* (Cambridge, Mass., and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, November 2008), pp. 178-179, and Andrew Newman and Matthew Bunn, "Funding for U.S. Efforts to Improve Controls for Nuclear Weapons, Materials, and Expertise Overseas: A 2009 Update" (Cambridge, Mass.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, June 2009).

[5] See U.S. Congress, House of Representatives, Committee on Armed Services, "H.R. 2647: FY 2010 National Defense Authorization Act: Summary" (Washington, D.C.: Committee on Armed Services, June 2009), http://armedservices.house.gov/pdfs/HASCFY10NDAA061709.pdf (accessed 31 March 2010), p. 12.

[6] See Executive Office of the President, Office of Management and Budget, "Statement of Administration Policy: H.R. 2647, National Defense Authorization Act for Fiscal Year 2010" (Washington, D.C.: OMB, 24 June 2009), http://www.

As a result, neither the Senate authorizing committee nor the appropriations committees took similar action, and virtually none of the money the HASC proposed made it into the final appropriation.

In the end, Congress added $20 million to the request for the International Materials Protection and Cooperation program, all of which Congress directed be applied to the Civilian Nuclear Sites element of the program (which supports both security upgrades at civilian sites in the former Soviet Union and nuclear security cooperation with China and South Asia), and cut $20 million from the Global Threat Reduction Initiative (GTRI) program, while also requiring GTRI to find an additional $20 million from its available resources to finance the establishment of U.S. medical isotope production not using HEU.[7] Ironically, with a Democratic President committed to an expanded and accelerated nuclear security effort backed by a Democratic Congress, GTRI found itself suffering its first-ever budget cut, a reduction of over $60 million from the FY 2009 appropriation.[8] Though GTRI can shift some resources from its efforts to secure radiological materials, the reduced budget will inevitably limit what GTRI can do to accelerate reactor conversions and HEU removals. Since FY 2011 does not begin until 1 October 2010, a year and a half of the four-year effort announced by President Obama in April 2009 will have gone by before additional funds to accelerate and expand nuclear security efforts become available.

Requested Budget Increases for FY2011

For FY2011, the Obama administration has requested a substantial increase in funding for nuclear security, including a $225 million (67%) increase for the Global Threat Reduction Initiative (GTRI) and a new $74.5 million line in the Cooperative Threat Reduction (CTR) program at the Department of Defense (DoD) known as "Global Nuclear Lockdown."[9] With a modest increase for nuclear security efforts in the International Nuclear Materials Protection and Cooperation (INMPC) program, better known as materials protection, control, and accounting (MPC&A) and a small decrease in funding for DoD nuclear warhead security efforts (which are nearing completion), the overall increase for international nuclear security efforts is $311 million. See Table 6.1. Coming in a time of substantial budget stringency, these increases represent an important commitment.

The request for GTRI will finance expanded efforts to remove HEU from sites around the world, along with an increase in funding for upgrading security for HEU-fueled research reactors and radiological materials that could be used in a "dirty bomb." The "Global Nuclear Lock-

---

whitehouse.gov/omb/asset.aspx?AssetId=1436 (accessed 15 January 2009).

[7] U.S. Congress, Committee on Appropriations, *Energy and Water Development and Related Agencies Appropriations Act, 2010: Conference Report to Accompany H.R. 3183*, House Report 111-278 (Washington, D.C.: Government Printing Office, 2009), http://thomas.loc.gov/cgi-bin/cpquery/R?cp111:FLD010:@1%28hr278%29 (accessed 19 February 2010), p. 131.

[8] Congress appropriated $333.5 million for GTRI, compared to a request of $353.5 million and an FY 2009 appropriation of $395 million. See Committee on Appropriations, *Energy and Water Development and Related Agencies Appropriations Act, 2010*, p. 131, and U.S. Department of Energy, *FY2011 Budget Request: National Nuclear Security Administration*, Vol. 1 (Washington, DC: DOE, February 2010), p. 443. While a significant part of the reduction in the request arose from the fact that GTRI's efforts to move the BN-350 fuel in Kazakhstan were coming to an end and no longer required funding, the request also reduced funding for HEU reactor conversions, for Russian research reactor fuel return, and for U.S. research reactor fuel return, all of which would need additional funds to meet an accelerated schedule.

[9] See sources in Table 6.1.

down" line will finance efforts to secure and eliminate irradiated HEU naval fuel in Russia; additional training and sustainability work in Russia; and a new effort to establish several regional nuclear security "centers of excellence" around the world, which would provide training, host workshops and exchanges of best practices, and demonstrate modern security and accounting equipment.[10]

There is bad news in this budget also. It is clear that the MPC&A effort is not currently planning on expanding to additional countries, despite the goal of securing *all* nuclear material worldwide in four years. Programs at the State Department are largely maintained at a steady level (though there is an increase for the Nonproliferation and Disarmament Fund, a contingency fund that can be used for a wide range of nonproliferation purposes).[11] The funding GTRI envisions for securing nuclear and radiological materials around the world is far higher *after* the four-year plan than it is during the four-year plan; some of those funds should be made available sooner than currently planned, to achieve as much progress on nuclear security as possible during the four-year effort President Obama envisioned. Moreover, NNSA reportedly originally sought an even larger increase for its nonproliferation programs, to $3.04 billion, but the Office of Management and Budget (OMB) trimmed this figure by some $350 million, reducing the proposed increase by nearly 40%.[12]

The Obama administration's FY2011 request would also boost funding for biological threat reduction programs, and would restart funding for supporting disposition of excess plutonium in Russia. Under the newly negotiated protocol to the 2000 Plutonium Management and Disposition Agreement (PMDA), the United States would provide up to $400 million over 30-35 years, subject to the availability of appropriated funds, to support Russian use of its excess weapons plutonium as fuel for its fast-neutron reactors, and the FY 2011 budget includes the first $113 million of this total.[13]

As Figure 6.1 makes clear, the combination of nuclear security investments and all other threat reduction spending remain a tiny fraction of the budgets of the departments that carry out these programs. Even in times of budget stringency, the U.S. government could easily afford substantial increases in these programs if needed. The message is simple: nuclear security is affordable. The Obama administration and the Congress should act to ensure that lack of funds is never a constraint on how rapidly action to reduce the risk of nuclear terrorism moves forward.

[10] U.S. Department of Defense, "Fiscal Year 2011 Budget Estimate: Cooperative Threat Reduction Program" (Washington, D.C.: DOD, February 2010), http://comptroller.defense.gov/defbudget/fy2011/budget_justification/pdfs/01_Operation_and_Maintenance/O_M_VOL_1_PARTS/CTR_FY11.pdf (accessed 31 March 2010).

[11] U.S. Department of State, "Executive Budget Summary: Function 150 and Other International Programs: Fiscal Year 2011" (Washington, D.C.: DOS, February 2010), http://www.state.gov/documents/organization/135888.pdf (accessed 31 March 2010).

[12] Todd Jacobson, "NNSA Set for Big Increase in FY2011 Budget Request," *Nuclear Weapons and Materials Monitor*, 18 January 2010. According to this report, NNSA's weapons programs fared better, with OMB only reducing an original $7.09 billion proposal – more than twice the nonproliferation budget – to $7.01 billion in the final budget, a cut in the range of $80 million. In other words, weapons programs suffered a cut from NNSA's proposal roughly one-quarter as large, from a budget roughly twice as big.

[13] DOE, *FY2011 Budget Request: National Nuclear Security Administration*, p. 435.

Figure 6.1. U.S. Appropriations to Improve Controls on Nuclear Weapons, Materials, and Expertise
(Current Dollars, in Millions)

Goal/Program		FY09 Approp.	FY10 Approp.	FY11 Request	Change from FY10 Approp.	
Total, Improving Controls on Nuclear Weapons, Material, and Expertise		**1,315**	**1,290**	**1,684**	**394***	**31%**
Securing Nuclear Warheads and Materials		**756**	**707**	**1,018**	**+311**	**+44%**
Material Protection, Control, & Accounting (excl. SLD) [1]	Energy	280	300	325	+25	+8%
Nuclear Weapons Storage Security - Russia	Defense	16	22	10	-12	-56%
Global Threat Reduction Initiative	Energy	395	334	559	+225	+68%
Nuclear Weapons Transportation Security - Russia	Defense	59	46	45	-1	-2%
International Nuclear Security	Energy	6	6	5	0	-7%
Global Nuclear Lockdown	Defense	0	0	74	+74	NP**
Interdicting Nuclear Smuggling		**300**	**425**	**421**	**-4**	**-1%**
Second Line of Defense (part of MPC&A budget line)	Energy	175	272	265	-7	-3%
Export Control and Related Border Security Assistance	State	46	54	62	+8	+14%
WMD Proliferation Prevention	Defense	69	84	80	-4	-5%
International Counterproliferation [2]	Defense	10	14	14	0	0%
Stabilizing Employment for Nuclear Personnel		**81**	**94**	**94**	**0**	**0%**
Global Threat Reduction Program	State	62	70	72	+2	+3%
Global Initiatives for Proliferation Prevention	Energy	15	20	18	-1	-7%
Civilian Research and Development Foundation [3]	State	4	4	4	0	0%
Monitoring Stockpiles and Reductions		**33**	**36**	**34**	**-1**	**-4%**
HEU Transparency Implementation	Energy	17	18	18	0	0%
Warhead and Fissile Material Transparency	Energy	16	18	17	-1	-7%
Ending Further Production		**141**	**25**	**0**	**-25**	**-100%**
Elimination of Weapons Grade Plutonium Production	Energy	141	25	0	-25	-100%
Reducing Excess Stockpiles		**1**	**1**	**113**	**+112**	**11,200%**
Russian Plutonium Disposition	Energy	1	1	113	+112	11,200%
Cross-Cutting Initiatives		**3**	**3**	**3**	**0**	**0%**
WMD Terrorism	State	2	2	2	0	0%
Coordinator for Threat Reduction	State	1	1	1	0	0%

Notes

Source: "Interactive Budget Database," in *Nuclear Threat Initiative Research Library: Securing the Bomb* (Cambridge, Mass., and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, 2010; available at http://www.nti.org/e_research/cnwm/overview/funding.asp as of 4 February 2010), updated by Andrew Newman, February 2010.

Except where noted, figures are taken from the following budget documents: U.S. Department of Defense, Defense Threat Reduction Agency, *Fiscal Year 2011 Budget Estimate, Cooperative Threat Reduction Program* (Washington, D.C.: DOD, February 2010); U.S. Department of Energy, *FY 2011 Congressional Budget Request: National Nuclear Security Administration*, vol. 1, DOE/CF-0047 (Washington, D.C.: DOE, February 2010); U.S. Department of State, *Executive Budget Summary: Function 150 & Other International Programs – Fiscal Year 2011* (Washington, D.C.: DOS, February 2010).

Values may not add due to rounding.

* All figures in this column represent the difference between the FY2010 Appropriation and the FY2011 request, in current dollars, in millions.

** New program proposed for FY2011

1. The fiscal year 2009 total includes a $55 million supplemental appropriation requested by the President in April and passed by the House and Senate in May 2009.
2. U.S. Department of Defense, *Fiscal Year 2011 Budget Estimates: Defense Threat Reduction Agency* (Washington, D.C.: U.S. Department of Defense), p.501.
3. FY2009 and FY2010 funding is estimated based on Michelle Marchesano and J. Raphael Della Ratta with contributions from Kenneth N. Luongo, *Funding Analysis of the Fiscal Year 2010 Budget Request for International WMD Security Programs,* Partnership for Global Security Policy Update, May 2009 and interview with CRDF official, May 2008. The FY2011 figure is an estimate based on FY2009 and FY2010 appropriations. The figures here include only funds provided to CRDF for its own programs, not funds from other programs listed here which use CRDF as a facility for spending money on their programs.

The Nuclear Security Summit

On April 12-13, 2010, President Obama will host a global summit meeting intended, in his words, "to discuss steps we can take to secure loose nuclear materials; combat smuggling; and deter, detect, and disrupt attempts at nuclear terrorism."[1]

Leaders from over 40 countries are expected to attend the nuclear security summit, including all of the countries that possess significant stocks of HEU or separated plutonium (except those with whom the United States currently has poor relations, including North Korea, Iran, and Belarus).

The Obama administration expects three main products from the nuclear security summit. First, they hope for a joint communiqué "pledging efforts to attain the highest levels of nuclear security."[2] The leaders' communiqué is likely to be phrased in quite general terms, so experts are also working on a more detailed "work plan" that would be issued along with the communiqué. Finally, officials are discussing individual nuclear security pledges and commitments that countries may make, either publicly or privately, on the occasion of the nuclear security summit or in its aftermath. A series of meetings among the "sherpas" helping countries prepare for the summit took place during late 2009 and early 2010, along with other diplomatic discussions to prepare for the summit.

Beyond the specific commitments made at the summit itself, the summit may have other important outcomes. First, the series of briefings on and discussions about the threat of nuclear theft and terrorism in the lead-up to the summit and at the summit itself may help to convince foreign leaders that nuclear terrorism is a real threat to their countries' security, requiring additional action to prevent it beyond what their countries' have done in the past. As described in the next chapter, making that case is essential to overcoming the political and bureaucratic obstacles to securing all nuclear material within four years. Second, the process of preparing for the summit, focusing unprecedented high-level political attention on nuclear security, may lead a number of countries to establish new approaches to organizing their response to the nuclear terrorism threat (such as appointing a single coordinator able to reach across agency lines, or a new interagency group to coordinate these efforts), and to reassess the adequacy of their existing nuclear security efforts. Third, the summit process may also establish new channels for diplomatic communication on nuclear security, at higher political levels than the matter has typically been handled before. All of these effects could substantially contribute to accelerating and expanding progress in securing nuclear materials worldwide.

---

[1] President Barack Obama, press conference, 10 July 2009, http://www.whitehouse.gov/the_press_office/Press-Conference-by-the-President-in-LAquila-Italy-7-10-09 (accessed 31 March 2010). See also The White House, "Addressing the Nuclear Threat: Fulfilling the Promise of Prague at the L'Aquila Summit," 8 July 2010, http://www.whitehouse.gov/the_press_office/Addressing-the-Nuclear-Threat-Fulfilling-the-Promise-of-Prague-at-the-LAquila-Summit/ (accessed 31 March 2010).

[2] The White House, "Addressing the Nuclear Threat: Fulfilling the Promise of Prague at the L'Aquila Summit."

Personnel

Getting the right people with the right expertise and authority working the problem is another critical input to nuclear security efforts or any other major government program. Here, the Obama administration's record is mixed.

On the positive side, the Obama administration filled the Congressionally-mandated position of White House Coordinator for Arms Control and Weapons of Mass Destruction, Proliferation, and Terrorism, which the Bush administration had not done. President Obama also appointed, for the first time, a Senior Director on the National Security Council staff with full-time responsibility for preventing nuclear and biological terrorism.

At the State Department, the Obama administration created another new posi-

The Nuclear Security Summit (cont)

The nuclear security summit represents a crucial opportunity to move the nuclear security agenda forward. No similar event is likely to occur for at least another two years – by which time three years of the four-year nuclear security effort will already have passed. To be judged a success, the nuclear security summit should result in:

- Commitments to improve nuclear security and consolidate nuclear stockpiles that, if fulfilled, would go much of the way toward fulfilling the objective of ensuring effective security for all nuclear material within four years, and are specific enough to make it possible to judge whether countries are fulfilling their commitments;
- A new sense of urgency to take action to reduce the danger of nuclear theft and terrorism among some or all of the key participants;
- New channels of communication within and between governments to discuss specific steps to advance nuclear security; and
- A process to follow-up on the commitments made and develop new ones as necessary.

This last element is particularly crucial, to ensure that the commitments made are fulfilled; there is, unfortunately, a long history of commitments at G8 and other summits that are unfulfilled and largely forgotten. The nuclear security initiative launched at the Bratislava summit between U.S. President George W. Bush and Russian President Vladimir Putin provides a model of what might be done: the two Presidents each designated a senior official to be responsible to them for accomplishing the objectives of the initiative and reporting to them on progress every six months. Following the summit, the two sides worked out a detailed implementation plan for the initiative, and then met regularly to assess progress and work through obstacles as they arose. Of course, that effort involved only two countries, and establishing a comparable follow-up mechanism among many countries would inevitably be more complex. But some mechanism for reporting and assessing progress, identifying remaining gaps, and developing new commitments as needed is likely to be essential if the nuclear security summit is to lead to rapid and lasting progress in nuclear security around the world.[3]

[3] For a useful summary of what might be required, see Kenneth N. Luongo, "Making the Nuclear Security Summit Matter: An Agenda for Action," *Arms Control Today*, January/February 2010, http://www.armscontrol.org/act/2010_01-02/Luongo (accessed 31 March 2010).

tion, an ambassador-level Coordinator for Threat Reduction Programs. At the Defense Department, President Obama appointed committed advocates of cooperative threat reduction to head the relevant programs. These are surely positive steps as well.

But there are also important gaps in the Obama administration's assignments of people to handle the problem of nuclear security. Most importantly, a year into the new administration, no one has been appointed to the post that oversees all of the most important nuclear security programs, the Deputy Administrator for Defense Nuclear Nonproliferation at DOE's National Nuclear Security Administration (NNSA), leaving that position without a political leader identified with and able to shape the Adminsitration's nonproliferation goals. Similarly, at the State Department, no one has been appointed to be Assistant Secretary for Nonproliferation. The new NSC Senior Director was not brought into place until some six months into the administration, long after most of the rest of the NSC staff was in place.

Outputs and Outcomes

While it is too soon to judge what the outcomes of these efforts will be – and in particular, the nuclear security summit may lead to new progress in a variety of areas – it is worth reviewing a few of the nuclear security achievements and disappointments of the Obama administration's first year.

The Obama administration has made a major effort to "reset" relations with Russia in particular. While there have been some notable improvements, U.S.-Russian relations are still difficult. And although threat reduction cooperation continues apace, no significant breakthroughs with Russia have been achieved. While the agencies charged with actually managing nuclear weapons and materials remain eager to cooperate, the political elements of the Russian government have often not been eager to move forward. These political officials have taken the view that Russia is no longer on its knees and new agreements should not be framed in terms of U.S. assistance, but at the same time have resisted providing Russian financing for cooperative efforts, making it difficult to reach agreement on expanded cooperation. Obama administration officials had hoped that at the Obama-Medvedev summit in July, they would launch a successor to the highly successful nuclear security initiative begun by U.S. President George W. Bush and Russian President Vladimir Putin at their Bratislava summit in 2005, but no such agreement was reached. Nor was an expected accord on cooperation on consolidating and blending down HEU, or a protocol that would have allowed the 2000 Plutonium Management and Disposition Agreement to come into force. As of early 2010, these accords had not yet been signed, though the government was reporting that negotiations on the plutonium disposition protocol had been completed.[14] But Russia has continued to support the Global Initiative to Combat Nuclear Terrorism and the nuclear security summit; indeed, it appears that Russia will host a follow-up summit perhaps two years after the 2010 nuclear security summit.[15]

The Obama administration has held extensive discussions with Pakistan concerning Pakistan's nuclear security arrangements and possibilities for additional cooperation to strengthen them. The results of these discussions, whether positive or negative, remain classified.

Progress has continued in the U.S. nuclear security dialogue with China, but in late 2009 China again rejected extending that dialogue to explicitly include the military agencies that manage most of China's fissile materials.[16] As of early 2010, India had not agreed to cooperate on nuclear security and accounting, though both India and China will be taking part in the nuclear security summit. There is no evidence that nuclear security was a major focus of President Obama's 2009 trip to China or Indian Prime Minister Manmohan Singh's state visit to the United States.

South Africa, by contrast, having already converted its Safari-I research reactor to use low-enriched uranium (LEU) fuel

[14] See U.S. Department of Energy, *Department of Energy FY2011 Budget Request: National Nuclear Security Administration,* Vol. 1., DOE/CF-0047, p. 394

[15] The White House, Office of the Press Secretary, "Press Conference by President Obama and President Medvedev of Russia," The Kremlin, Moscow, Russia, 6 July 2009, http://www.whitehouse.gov/the-press-office/press-conference-president-obama-and-president-medvedev-russia (accessed 31 March 2010).

[16] Interview with NNSA officials, January 2010.

rather than HEU, announced in mid-2009 that it would also phase out the use of HEU targets for producing medical isotopes.[17] South Africa also privately agreed to cooperate on security upgrades for the Pelindaba site, to prevent a recurrence of the 2007 break-in. Both of these are potentially major breakthroughs.

Progress in nuclear security upgrades and consolidation efforts has also continued during the Obama administration. Most strikingly, perhaps, by early 2010, four countries had eliminated all weapons-usable nuclear material on their soil since President Obama's April 2009 speech, including Romania, Taiwan, Libya, and Turkey.[18] Post-Bratislava upgrades and work on sustainability, regulation, security culture, and the exchange of best practices continue in Russia. Cooperation continued in Pakistan and China as well, though specifics with respect to Pakistan are classified.

Achieving the objective of effective security for all HEU and plutonium worldwide within four years will require a substantial acceleration of current progress – but such an acceleration, of course, is precisely what the nuclear security summit and other ongoing discussions are intended to achieve.

[17] Nuclear Energy Corporation of South Africa (NECSA), "Nuclear Reactor Uses Only Low-Enriched Uranium (LEU) for the First Time" (Pelindaba: NECSA, 29 June 2009), http://www.necsa.co.za/Portals/1/Documents/322e00a9-02e8-4522-8e29-947ef896d6e5.doc (accessed 31 March 2010).

[18] Data provided by NNSA, January 2009. NNSA completed the removal of the HEU from Turkey in January 2010. See National Nuclear Security Administration, "NNSA Announces Highly Enriched Uranium Removed from Turkey," 12 January 2010 http://www.nnsa.energy.gov/news/2785.htm (accessed 31 March 2010).

7 NEXT STEPS TO SECURE NUCLEAR STOCKPILES

Programs to improve nuclear security have made enormous progress since the early-to-mid 1990s, making a major contribution to the security of the world. But real risks—and difficult obstacles to progress—remain. The pace of improvement in nuclear security today is simply not sufficient to secure all nuclear material worldwide in four years—the world is not yet on the track to succeed in meeting the four-year nuclear security objective. The Obama administration is well aware of that mismatch: the purpose of the nuclear security summit and the follow-up to it is to shift these efforts onto the faster and broader trajectory that would be needed to achieve the four-year goal. This situation is illustrated conceptually in Figure 7.1.

At the nuclear security summit and beyond, President Obama, working with other world leaders, must forge a global campaign to lock down every nuclear weapon and every significant stock of potential nuclear bomb material worldwide, as rapidly as that can possibly be done—and to take other key steps to reduce the risk of nuclear terrorism. If, as President Obama has emphasized, nuclear terrorism is the most urgent threat to global security, then this effort must be at the center of U.S. national security policy and diplomacy—an issue to be raised with every country with stockpiles to secure or resources to help, at every level, at every opportunity, until the job is done.

2010: A Critical Year

The year 2010 is absolutely critical if the four-year nuclear security effort is to succeed. Only if a substantial acceleration of nuclear security improvements around the world can be achieved by the end of the year—by which time the four-year effort will be nearly half over—can the world avoid having the four-year target slip out of reach.

Fortunately, this year will see several opportunities for high-level international leadership to accelerate and expand the nuclear security effort. First, and most important, is the nuclear security summit in April. If that summit succeeds, the leaders who participate will come away with a new understanding of the threat of nuclear theft and terrorism and a new sense of urgency to take action to address it, along with new sets of commitments and new mechanisms for cooperating to implement them. The ultimate success of the summit will be measured by nuclear security improvements on the ground; it may take 6-12 months to judge how much difference the summit has made.

Second, the nuclear security summit will be followed quickly by the five-year nuclear Nonproliferation Treaty (NPT) review conference in May. While that conference is not likely to see major new commitments on nuclear security, it can and should reemphasize the importance of additional action to prevent nuclear terrorism as an essential foundation for the three pillars of the NPT—nonproliferation, disarmament, and peaceful use of nuclear energy. Moreover, a successful NPT review could help address political disputes between nuclear weapon states and non-nuclear-weapon states and between North and South that could otherwise interfere with cooperation to improve nuclear security.

Third, the next plenary meeting of the Global Initiative (GI) to Combat Nuclear Terrorism will occur in June. This creates an opportunity to use the GI as a mechanism for implementing the agenda coming out of the nuclear security summit, and to lay out a program of efforts designed to build the sense of urgency about the threat of nuclear theft and terrorism and commitment to action to reduce the threat (see discussion below).

Finally, in late June, the G8 and G20 summits will be held in Canada. This G8 meeting, the first in Canada since the 2002 G8 decision to establish the $20 billion, 10-year threat reduction effort known as the Global Partnership Against the Spread of Weapons and Materials of Mass Destruction, is slated to consider the future of that initiative after its currently-scheduled completion date of 2012. The G8 leaders should agree to make the Global Partnership a central instrument for providing the funding needed to meet the four-year nuclear security goal, and for implementing all the other improved controls over nuclear, chemical, and biological weapons and materials around the world mandated by UN Security Council Resolution 1540. They should firmly put the "global" back in the Global Partnership, re-focusing it from an effort primarily focused on the former Soviet Union to a global effort. And they should extend it to last another 10 years, with a similar level of funding to the first ten.[1]

President Obama and the other leaders seeking to prevent nuclear terrorism should seek to come out of these events with:

- Greatly strengthened international understanding of the threat of nuclear theft and terrorism, and commitment to take action to address it;
- Broad international understanding of the baseline of nuclear security today and the work that needs to be done to accomplish the four-year nuclear security objective;
- National and multilateral commitments that, once fulfilled, would go a long way toward meeting the four-year goal;
- Agreement on a substantial funding stream to help states meet those commitments;
- Clear decisions by key states as to who in their countries will be in charge of overseeing implementation of these commitments; and
- An established mechanism for following up on these commitments, reviewing progress, continuing dialogue, and expanding cooperation where needed.

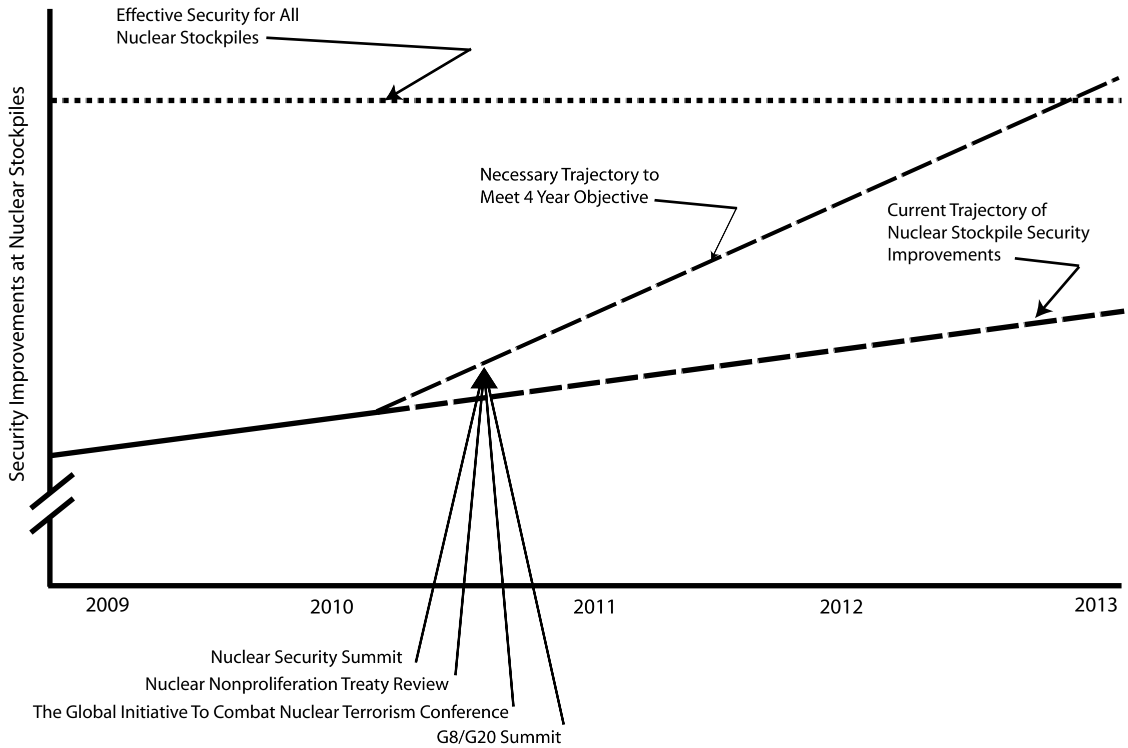
As described in Chapter 5, the goal must be to ensure that *all* nuclear weapons and weapons-usable nuclear material worldwide are effectively and lastingly secured. Terrorists will get the material to make a nuclear bomb wherever the combination of their strength and the security systems' weakness makes it easiest to steal. The world therefore cannot afford to let gaps between different programs leave some vulnerable stocks without security upgrades.

The four-year objective is a very ambitious target.[2] The many obstacles to success—

[1] When the Global Partnership was established in 2002, the idea was that the United States would provide $1 billion per year for 10 years for threat reduction, and the other G8 participants would match that figure—hence the initiative was sometimes known as "10 plus 10 over 10." Since then, the United States has increased average annual threat reduction spending to much more than $1 billion, while the non-U.S. participants in total have provided significantly less than the $1 billion a year originally pledged. For a follow-on 10 years, the non-U.S. participants should provide $500 million to $1 billion per year for the full range of cooperative threat reduction efforts in countries around the world.

[2] I originally proposed the four-year objective years ago, and always intended it as an ambitious one, designed to drive the system to improve nuclear security as quickly as possible. In the more than four years since I first proposed a four-year target, many nuclear security improvements have

Figure 7.1: Nuclear Security Improvement Over Time



posed by complacency about the threat, political disputes, sovereignty concerns, pervasive secrecy, and bureaucratic obstacles—will take tremendous effort to overcome. (See "Why is This Hard?" p. 96.)

As discussed in the previous chapter, the Obama administration has already taken many important steps to strengthen the nuclear security effort. But success in the four-year effort is likely to require taking the additional steps outlined below. (These should be seen as supplements to strengthen existing efforts, not substitutes for them or reasons to abandon them.)

been accomplished, making the objective easier to achieve; but a variety of political disputes that affect nuclear security cooperation have continued to fester, and with increasing time since the 9/11 attacks, complacency about the threat has returned in many quarters, making the objective more difficult to achieve. The four-year target first appeared in 2002 as an objective to complete upgrades in Russia within four years and remove or secure the most vulnerable nuclear material elsewhere within a "few years." See Matthew Bunn, John P. Holdren and Anthony Wier, *Securing Nuclear Weapons and Materials: Seven Steps for Immediate Action* (Cambridge, MA: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, May 2002).

Build the Sense of Urgency and Commitment Worldwide

The fundamental key to success in preventing nuclear terrorism is to convince political leaders and nuclear managers around the world that nuclear terrorism is a real and urgent threat to *their* countries' security, worthy of a substantial investment of their time and money—something many of them do *not* believe today. If they come to feel that sense of urgency, they will be likely to take the needed actions to prevent nuclear terrorism; if they remain complacent, they will not. Some of the critical work of building this sense of urgency is already being done, especially in lead-up to the nuclear security summit and in the context of the Global Initiative to Combat Nuclear Terrorism. But much more needs to be done, if President

Obama's objective of ensuring effective security for all vulnerable nuclear weapons and weapons-usable materials worldwide is to be achieved. There are three layers of complacency that must be overcome: (1) the belief that terrorists could not plausibly make a bomb; (2) the belief that nuclear security measures are already adequate, so that terrorists could not plausibly get the materials needed for a bomb; and (3) the belief that even if terrorists could get nuclear material and could make a crude bomb, it is the United States' problem, not a problem other countries need to worry about very much.

President Obama should work with other countries to take several steps to overcome this complacency and build the needed sense of urgency and commitment, including:

- **Joint threat briefings.** Upcoming summits and other high-level meetings with key countries should include detailed briefings for both leaders on the nuclear terrorism threat, given jointly by U.S. experts and experts from the country concerned. These would outline both the very real possibility that terrorists could get nuclear material and make a nuclear bomb, the global economic and political effects of a terrorist nuclear attack, and steps that could be taken to reduce the risk. U.S. briefings for U.S. and Russian officials highlighting intelligence on continuing nuclear security vulnerabilities were a critical part of putting together the Bush-Putin Bratislava nuclear security initiative.
- **Intelligence-agency discussions.** In many countries, the political leadership gets much of its information about national security threats from its intelligence agencies. It is therefore extremely important to convince the intelligence agencies in key countries that nuclear terrorism is a serious and urgent threat—and that plausible actions, taken now, could reduce the risk substantially. During the second Bush term, DOE intelligence was actively working with foreign intelligence services to make this case, and to build cooperation against the threat. This effort should be renewed and expanded to include focused efforts by the Director of National Intelligence, the Central Intelligence Agency, and other U.S. intelligence agencies as well.[3]
- **The "Armageddon Test."** President Obama should direct U.S. intelligence—possibly working in cooperation with agencies in other countries—to establish a small operational team that would seek to understand and penetrate the world of nuclear theft and smuggling. The team would be instructed to seek to acquire enough nuclear material for a bomb. If they succeeded, this would dramatically highlight the continuing threat, and potentially identify particular weak points and smuggling organizations requiring urgent action. If they failed, that would strongly suggest that terrorist operatives would likely fail as well, building confidence that measures to prevent nuclear terrorism were working.[4]
- **Nuclear terrorism exercises.** Building on the exercise program that has begun in the Global Initiative to Combat Nuclear Terrorism, the United States and other leading countries should organize a series of exercises with senior policymakers from key states. These exercises should have scenarios focused on theft of nuclear material, the realistic possibility that terrorists could

[3] I am grateful to Rolf Mowatt-Larssen for discussions of this approach.

[4] This concept was originally developed by Rolf Mowatt-Larssen. Care would have to be taken to structure the effort in a way that avoided creating perceptions of a market for nuclear material that might contribute to additional nuclear thefts.

construct a crude nuclear bomb if they got enough HEU or plutonium, just how difficult it would be to stop them once they had the material, and how much *all* countries would be affected if a terrorist nuclear bomb went off.[5] Participating in such a war game can reach officials emotionally in a way that briefings and policy memos cannot. A program of such exercises should become a central element of the Global Initiative.

- **Fast-paced nuclear security reviews.** The United States and other leading countries should encourage leaders of key states to pick teams of security experts they trust to conduct fast-paced reviews of nuclear security in their countries, assessing whether facilities are adequately protected against a set of clearly-defined threats—such as a well-placed insider, or two teams of well-armed, well-trained attackers. (In the United States, such fast-paced reviews after major incidents such as 9/11 have often revealed a wide range of vulnerabilities that needed to be fixed.)
- **Realistic testing of nuclear security performance.** The United States and other leading countries should work with key states around the world to implement programs to conduct realistic tests of nuclear security systems' ability to defeat either insiders or outsiders. (Failures in such tests can be powerful evidence to senior policymakers that nuclear security needs improvement.)
- **Shared databases of threats and incidents.** The United States and other key countries should collaborate to create shared databases of unclassified information on actual security incidents (both at nuclear sites and at non-nuclear guarded facilities) that offer lessons for policymakers and facility managers to consider in deciding on nuclear security levels and particular threats to defend against. The World Institute for Nuclear Security (WINS) could be a forum for creating one version of such a threat-incident database. In the case of safety, rather than security, reactor operators report each safety-related incident to groups such as the Institute of Nuclear Power Operations (the U.S. branch of the World Association of Nuclear Operators), and these groups analyze the incidents and distribute lessons learned about how to prevent similar incidents in the future to each member facility—and then carry out peer reviews to assess how well each facility has implemented the lessons learned.[6]

Broaden Consolidation and Security Upgrade Efforts

Today, U.S.-funded cooperative nuclear security upgrade efforts are focusing primarily on the former Soviet Union, South Asia, and a few HEU-fueled research reactors elsewhere. (Nuclear security cooperation with China has so far focused on dialogue and exchanges of best practices, not on U.S.-funded upgrades.) U.S.-funded consolidation programs focus primarily on converting HEU-fueled reactors and removing Soviet-supplied HEU and a fraction of U.S.-supplied HEU.

To secure all nuclear stockpiles in four years, both security upgrades and consolidation efforts must be broadened. The

[5] The model would be the "Black Dawn" exercise organized by the Center for Strategic and International Studies (and sponsored by the Nuclear Threat Initiative) for key NATO officials. For a description, see *Black Dawn: Scenario-Based Exercise* (Washington, DC: Center for Strategic and International Studies, 2004), available at http://www.csis.org/media/csis/pubs/040503_blackdawn.pdf (accessed 26 May 2009).

[6] See Joseph V. Rees, *Hostages of Each Other: The Transformation of Nuclear Safety since Three Mile Island* (Chicago: University of Chicago Press, 1994).

Why is this Hard?

To succeed, the effort to achieve effective security for all nuclear stockpiles worldwide within four years will have to overcome a maze of obstacles posed by complacency, political disputes, secrecy, sovereignty concerns, cost issues, and bureaucratic obstacles.

Complacency. Many policymakers around the world believe, as Anatoliy Kotelnikov, then in charge of security for Russia's nuclear complex, put it in 2002, that it would be "absolutely impossible" for terrorists to make a nuclear bomb even if they got the needed nuclear material.[1] Even more believe that existing nuclear security measures are adequate, so that there is little chance of terrorists getting enough nuclear material for a bomb. At most nuclear facilities, for example, there have been no thefts or attacks in decades of operation, so how can the security measures in place be insufficient? Policymakers and nuclear managers simply will not put in the level of effort required to achieve major improvements in nuclear security unless they believe those improvements are necessary—making the effort to overcome complacency a fundamental element of a global nuclear security campaign.

Political disputes. Some of the countries that ought to be cooperating to improve nuclear security have political disagreements that get in the way. India, for example, has refused to cooperate with the United States on nuclear security for many years, in part because of the U.S. sanctions on India's nuclear establishment that were in place ever since India's 1974 nuclear test; even the recent U.S.-India civilian nuclear cooperation agreement was not enough to overcome those decades of distrust in the area of nuclear security. As another example, neither Iran nor Belarus were invited to the nuclear security summit, though Belarus has a substantial stock of HEU and Iran has a few kilograms of irradiated research reactor fuel left over from the Shah's days. Remarkably, threat reduction cooperation between the United States and Russia has managed to continue despite the many ups and downs of U.S.-Russian relations—but that cannot be taken for granted indefinitely. Intensive efforts are needed to find ways to overcome these disputes and to cooperate even where political disputes continue.

Secrecy. As discussed in the text, most countries keep the specifics of what they do to protect their nuclear stockpiles as closely guarded secrets. This often makes in-depth nuclear security cooperation far more difficult. As just one example, Pakistani officials have made clear that they have not allowed U.S. experts to actually visit Pakistan's nuclear weapons facilities to assess what improved security measures might be needed, or even to know where these facilities are. Disputes over access to sensitive sites in Russia have delayed progress at some sites for years, and blocked progress at a few sites entirely. In Russia, a variety of creative approaches have been developed and tested to address secrecy constraints, including the use of photographs and videotapes of equipment installed and in use, and in some case the use of "trusted agents" (Russians with Russian security clearances who the United States has reason to trust, such as screened employees of U.S. firms) who are able to certify that certain work has been done. Creative leadership is needed to find such approaches for each case, as the most workable methods are likely to vary from one country and secrecy system to the next.

[1] Aleksandr Khinshteyn, "Secret Materials," trans. BBC Monitoring Service, "Russian Central TV," 29 November 2002.

United States and other donor countries should seek to help countries carry out security upgrades that:

- **Cover more facilities in more countries.** Many countries can and should upgrade their nuclear security systems with their own resources, though they can benefit from exchanging best practices and engaging in other forms of international cooperation. But the United States and other donor states should expand the number of countries

Why is this Hard? (cont)

Sovereignty concerns. States seek to preserve their prerogative to make their own nuclear security decisions, without other countries or international agencies telling them what to do. In some cases, concerns over sovereign rights cause countries to resist signing up to any sort of global standards for nuclear security, or any accountability mechanisms that might provide a forum for other countries to question whether they were doing enough. Finding the balance between national sovereignty and the strong common interest of the international community will be a difficult challenge.

Cost issues. Nuclear security measures cost money, and every dollar spent on nuclear security is a dollar not spent on activities that will bring in revenue. Managers who believe their existing security arrangements are fully adequate will inevitably resist any suggestion that they should adopt additional expensive measures. The impact of this factor varies from one type of facility to another, however. Military facilities in most cases already have extensive nuclear security measures and substantial budgets set aside for security. For large commercial nuclear facilities, an expenditure of 1-3% of revenue is likely to be sufficient, in most cases, to provide highly effective security—and can be seen as an excellent investment in corporate risk management, in much the same way that measures to achieve excellence in nuclear safety are viewed. But for a small research reactor, the cost of providing any significant force of round-the-clock guards might be a major fraction of the reactor's total annual budget, at a time when most research reactors are struggling to get by. This is another reason to focus on eliminating weapons-usable nuclear material entirely from as many research reactors as possible. In the meantime, governments—which subsidize the operation of most research reactors in any case—should step in to provide the money needed to finance effective security at these facilities.

Bureaucratic obstacles. A wide range of bureaucratic difficulties can slow steps to improve nuclear security, from disputes between agencies over who has what authority, to disputes between countries over tax and liability provisions related to cooperation, to lengthy and uncertain processes for approving agreements, contracts, and visits. These kinds of disputes can sometimes delay cooperation for years at a time.

Synergistic barriers. These barriers frequently reinforce each other. Secrecy, for example, by making real outside scrutiny of performance very difficult, contributes to complacency about how good that performance is today. Complacency encourages officials not to address cost issues or bureaucratic obstacles. Sustained high-level leadership, not only from Washington but from other capitals around the world, will be needed to overcome these obstacles and achieve the objective of securing all nuclear weapons and materials worldwide.

in which they are willing to help finance nuclear security improvements.

- **More extensive security upgrades.** The goal of cooperative nuclear security improvements should be not just to ensure that facilities' security measures are generally consistent with those the IAEA recommends, but to ensure that all HEU and plutonium are protected against a robust set of outsider and insider threats, as described below. This means that more facilities will require improvements, and those improvements must be more extensive. It also requires not just installing equipment, but increasing countries' capacity and commitment to implement effective nuclear security on their own—through training, exchanges of best practices, improvements in regulation, sustainability support programs, work on security culture, and more. This effort should also include the regional nuclear security "centers of excellence" that President Obama and some European countries have proposed, which could provide central locations for training, demonstrating modern equipment, exchange of best practices, and the like.[7]

Consolidation efforts should also be expanded, and should be a central element of the four-year nuclear security effort, as protecting fewer locations makes it possible to achieve higher security at lower cost. The Global Threat Reduction Initiative (GTRI) has greatly accelerated the pace at which research reactors are being converted from HEU to low-enriched uranium (LEU) that cannot be used in a nuclear bomb, and the pace of removing HEU from these sites to secure locations.

The consolidation effort should be expanded to include:

- reducing the number of sites where nuclear weapons exist (particularly in Russia);
- limiting the accumulation of stockpiles of separated plutonium, and the number of places where plutonium is processed, stored, and used; and
- removing HEU from a far broader set of the sites where it now exists, with the goal of eliminating the HEU from the most vulnerable sites during the four-year effort, and eliminating all civil HEU within roughly a decade.

The United States and Russia should work together to reduce the number of buildings and bunkers with nuclear weapons, HEU, or plutonium as much as practically possible. They should carefully assess whether each location where these items exist is still needed, or whether there are other alternatives to these locations whose balance of costs, benefits, and risks would be better.

The United States and other countries should offer new incentives to convince operators to shift away from the use of HEU. These should include (a) offering to help reactor operators so that they would be better off (e.g., higher performance, or more funding for research) after ending their use of HEU than they were before; and (b) adopting policies that would end exports of HEU for medical isotope production and imports of medical isotopes made using HEU as soon as sufficient supplies made without HEU are available. (The latter step would create a strong incentive for isotope producers to convert their production so that it no longer uses HEU, to avoid being frozen out of the U.S. market, the world's largest.) New incentives should also be offered so that a much larger fraction of the world's HEU will be sent back to its country of origin or otherwise eliminated (including many of the tons of U.S.-origin HEU not covered in current GTRI removal plans). This might include, for example, offering something in the range of $10,000 per kilogram of HEU to any operator willing to send the United States its HEU.[8] A new

[7] These regional centers of excellence would receive $30 million in the Department of Defense budget request. See , "Fiscal Year 2011 Budget Estimate: Cooperative Threat Reduction Program" (Washington, D.C.: DOD, February 2010), http://comptroller.defense.gov/defbudget/fy2011/budget_justification/pdfs/01_Operation_and_Maintenance/O_M_VOL_1_PARTS/CTR_FY11.pdf (accessed 31 March 2010), p. CTR-803.

[8] This would include, of course, arrangements to ensure that they were not producing or importing more HEU. The program would be intended to clear out small stocks of HEU from facilities around the world, not to address

program should be established to give unneeded reactors incentives to shut down (an approach which may be cheaper and quicker than converting them to use LEU, especially for difficult-to-convert reactors). Over time, the United States should seek an end to all civil use of HEU, and to eliminate HEU from civil sites.

The United States should undertake new efforts to limit the production, use, and stockpiling of weapons-usable separated civilian plutonium—including renewing the nearly-completed late-1990s effort to negotiate a 20-year U.S.-Russian moratorium on plutonium separation. And as nuclear energy expands and spreads, the United States should not encourage that spread to be based on approaches that involve reprocessing and recycling plutonium, as some of the approaches envisioned in the Bush-era Global Nuclear Energy Partnership (GNEP) would have done. Even the proposed GNEP processes that would not separate "pure plutonium" would tend to increase, rather than decrease, the risk of nuclear theft and proliferation compared to not reprocessing this fuel.

Get the Rules and Incentives Right

Effectively enforced *national* rules for nuclear security and effective *global* nuclear security rules are both key elements of the effort to secure nuclear stockpiles around the world.

As most nuclear managers only invest in expensive security measures when the government tells them they have to, effective regulation is essential to effective and lasting security. Hence, President Obama and other leaders seeking to improve nuclear security should greatly increase the focus on ensuring that countries around the world put in place and enforce effective nuclear security and accounting regulations, giving all facilities strong incentives to ensure those stockpiles are effectively secured—including the possibility of being fined or shut down if facilities do not meet nuclear security regulations. Regulators in each country must have the authority, independence, expertise, and resources needed to do their jobs effectively—and countries must ensure that operators have the resources needed to follow the rules. These rules should include requirements for realistic testing of the performance of nuclear security systems against intelligent and creative insider and outsider adversaries.

Some of this effort can best be pursued through bilateral cooperation with particular countries. In other cases, the International Atomic Energy Agency

---

the huge excess stockpiles that will remain in Russia after the current 500-ton HEU purchase is complete; those stocks should be addressed in separate agreements designed for that purpose. The program might offer smaller amounts for HEU in forms that would be more difficult for terrorists to make a bomb from, such as material that was only 20-50% enriched or irradiated material. The proposal here would be in addition to existing incentives. In developing and transition countries, GTRI already encourages reactors to convert to low-enriched uranium (LEU) fuel and send back their fresh and spent HEU fuel by providing new LEU fuel (valued at some $15,000 per kilogram) free of charge, and paying the costs of packaging, transport, and disposition. Many research reactors, however, already have enough HEU fuel for their projected reactor lifetimes, or for many years to come; for them, supply of LEU fuel offers little incentive to switch to LEU and ship away their HEU. Where needed, GTRI sometimes offers additional incentives in the form of technical assistance to improve reactor efficiency or to replace shut-down reactors as well as providing technical training. Most civil HEU, however, is located in high-income countries such as France, Germany, and Japan, to which GTRI does not currently offer incentives to give up their HEU, arguing that these countries should pay for managing their HEU themselves. But the costs of offering incentives to eliminate civil HEU stocks in all countries would be small by comparison to the security stakes. If the proposal was extraordinarily successful, and countries agreed to eliminate 10 tons of HEU in this way, the cost of this incentive would be $100 million over several years (plus the costs of transport and management, if the United States also agreed to pay for those costs); in reality, it would be substantially less, since (a) much of the relevant HEU is in less-enriched or irradiated forms, for which lower per-kilogram incentives might be offered, and (b) it is unlikely that a quantity as large as 10 tons of HEU would be addressed through such an effort.

(IAEA) and its Office of Nuclear Security may be best suited to work with countries on strengthening their nuclear regulatory systems, drawing on what works in other countries around the world.

Nuclear security is only as strong as its weakest link. Hence, it is also important to seek effective *global* nuclear security rules that will help ensure that each country where stockpiles of nuclear weapons and weapons-usable materials exist puts effective national rules and procedures in place. Today, there are no binding agreements that specify what level of security nuclear weapons and weapons-usable nuclear materials should have—that is left primarily to the sovereign decisions of each state possessing such stockpiles. Unfortunately, because of complacency about the threat, concerns over national sovereignty, worries over the cost of more stringent measures, and differing national approaches, past efforts to negotiate global treaties specifying how secure nuclear weapons or weapons-usable materials should be have not succeeded, and such a treaty-negotiation approach is not likely to succeed in the future. (As discussed in Chapter 3, there is a Convention on Physical Protection and a 2005 amendment to it that provide useful guidelines, but these accords set no specific requirements for how secure weapons-usable nuclear material should be.)

The process by which IAEA nuclear security recommendations are developed has been somewhat more successful, with a series of revisions over the years to the basic recommendations on physical protection, known as Information Circular 225 (INFCIRC/225).[9] The current version is the fourth revision, agreed in 1999 (before the 9/11 attacks). While these are only recommendations, many countries follow them, and some are required to do so by agreements with nuclear suppliers such as the United States. As described in Chapter 3, INFCIRC/225 is more specific than the physical protection convention, but is still quite general. It does not specify what kinds of threats all weapons-usable nuclear material should be protected against, or how effective measures such as fences, locks, barriers, and intrusion detectors should be. A fifth revision, expected to be significantly more detailed (though still without answers on many of these critical issues of how well the system should perform) is slated for completion in 2010, if all goes well.

The United States should certainly continue to work to get states to ratify the physical protection convention and its 2005 amendment and to strengthen INFCIRC/225 and other IAEA guides and recommendations. But there is little prospect for success in getting agreement on effective global nuclear security standards by attempting to negotiate another amendment to the convention, a new treaty, or yet another revision of INFCIRC/225. UN Security Council Resolution (UNSCR) 1540 may offer a more promising path. UNSCR 1540 legally requires all countries to provide "appropriate effective" security and accounting for all their nuclear stockpiles—but no one has yet defined what that means. The United States should develop a concept of what essential elements are needed for nuclear security systems to be considered to meet the "appropriate effective" standard, and should begin working with other countries to try to build a political-level consensus around a set of elements that every state with dangerous nuclear stockpiles should have in place to protect them, if its security and accounting systems are to be considered

[9] The IAEA now has a substantial and growing body of additional recommendations and guides in the Nuclear Security Series, covering everything from detection of radiation at borders to strengthening nuclear security culture. But INFCIRC/225 remains the internationally recognized document incorporating the principal recommendations on security for nuclear materials and facilities.

appropriate and effective.[10] It should then work with other donor states to help (and pressure) countries around the world to put those essential elements in place. If broad agreement could be reached on the essential elements of an "appropriate effective" nuclear security system, that would, in effect become a legally binding global standard for nuclear security. Indeed, the entire global effort to put in place stringent nuclear security measures for all the world's stockpiles of nuclear weapons and weapons-usable nuclear materials can be considered simply as the implementation of the unanimously approved obligations of UNSCR 1540.

Every country with nuclear stockpiles has its own approach to nuclear security. For countries where labor is cheap and technology is expensive, the best approach will inevitably be different from the best approach where the reverse is true. Thus, any effort to forge a global approach should be focused on how well the system performs, not on what specific security measures it includes. To be successful, an international standard must be general and flexible enough to allow countries to pursue their own specific approaches as long as they are effective enough to meet the threats, yet at the same time be specific enough to provide guidance for effective security and the basis for questioning, assessment, and review.[11]

If the words "appropriate effective" mean anything, they should mean that nuclear security systems could effectively defeat threats that terrorists and criminals have shown they can pose. Thus one possible definition would be that to meet its UNSCR 1540 physical protection obligation, every state with nuclear weapons or weapons-usable nuclear materials should have a well-enforced national rule requiring that every facility with a nuclear bomb or a significant quantity of nuclear material must have security in place capable of defeating a specified design basis threat (DBT) including outsider and insider capabilities comparable to those terrorists and criminals have demonstrated in that country (or nearby). As discussed in Chapter 4, in an age of terrorists with global reach, all countries where nuclear weapons and weapons-usable nuclear materials exist should protect them against a range of potential outsider and insider threats. At a bare minimum, such stocks should be protected against a well-placed insider or against two small teams of well-trained, well-armed attackers, possibly with inside help, as occurred at Pelindaba. (In countries facing threats from more capable adversaries, even greater levels of protection are needed.)[12]

---

[10] For an initial cut at defining the essential elements that must be included for nuclear security and accounting systems to meet the obligation to be "appropriate effective," see Matthew Bunn, "'Appropriate Effective' Nuclear Security and Accounting — What is It?", presentation to "'Appropriate Effective' Material Accounting and Physical Protection," Joint Global Initiative/UNSCR 1540 Workshop, Nashville, Tennessee, 18 July 2008, http://belfercenter.ksg.harvard.edu/files/bunn-1540-appropriate-effective50.pdf (accessed 2 March 2010).

[11] Questions designed to clarify a country's compliance with this standard could include such items as: is there a rule in place specifying that all facilities with nuclear weapons or significant quantities of weapons-usable nuclear material must have security in place capable of defending against specified insider and outsider threats? Are those specified threats big enough to realistically reflect demonstrated terrorist and criminal capabilities in that country or region? How is this requirement enforced? Is there a program of regular, realistic tests, to demonstrate whether facilities' security approaches are in fact able to defeat the specified threats? Are armed guards used on-site at nuclear facilities, and if not, how is the system able to hold off outside attack or insider thieves long enough for armed response forces to arrive from elsewhere? For a brief discussion of other standards that have been proposed, see *Securing the Bomb 2008*, pp. 149-150.

[12] See discussion in Chapter 4, and in Matthew Bunn and Col.-Gen. Evgeniy Maslin (ret.), "All Stocks of Weapons-Usable Nuclear Material Worldwide Must be Protected Against Global Terrorist Threats," paper prepared for the workshop on

The Global Initiative to Combat Nuclear Terrorism offers one potentially effective venue for discussing the essential elements of appropriate and effective nuclear security and accounting systems. Its activities should be sustained and expanded, with achieving high standards of security for nuclear stockpiles worldwide an increased priority of the initiative.

Incentives are as important as rules. Given the strong incentives to save money and time by cutting corners on nuclear security, states, agencies, facilities, managers, and staff must be given strong incentives to focus on achieving high nuclear security performance.[13] If the effort to build a sense of urgency around the world about the threat of nuclear terrorism succeeds, the desire to address real threats will provide the most important incentive. President Obama should also make clear to countries around the world that cooperating to ensure effective security for nuclear stockpiles and taking other steps to prevent nuclear terrorism is as essential to good relations with the United States, as compliance with arms control and nonproliferation agreements has been for many years. At the same time, the United States should seek to ensure that each country with dangerous nuclear stockpiles establishes financial and other rewards for strong nuclear security performance (comparable, for example, to the bonus payments contractors managing DOE facilities can earn for high performance), and for those who identify nuclear security problems and propose practical solutions. The U.S. government should take the position that only facilities that can demonstrate that they maintain highly effective security will be eligible for U.S. government-funded contracts for cooperative R&D and related efforts, and should seek to convince other governments to do likewise. Ultimately, effective security and accounting for weapons-usable nuclear material should become part of the "price of admission" for doing business in the international nuclear market.

“Protecting Nuclear Programmes From Terrorism,” World Institute for Nuclear Security and American Academy of Arts and Sciences, Vienna, 19-20 November 2009.

[13] For a more detailed discussion, see Matthew Bunn, "Incentives for Nuclear Security," in *Proceedings of the 46th Annual Meeting of the Institute for Nuclear Materials Management, Phoenix, Ariz., 10-14 July 2005* (Northbrook, Ill.: INMM, 2005), http://belfercenter.ksg.harvard.edu/files/inmmincentives205.pdf (accessed 3 March 2010).

Take a Partnership-Based Approach

To succeed, a global nuclear security improvement effort must be based not just on donor-recipient relationships but on real partnerships, which integrate ideas and resources from countries where upgrades are taking place in ways that also serve their national interests. For countries like India and Pakistan, for example, it is politically untenable to accept U.S. assistance that is portrayed as necessary because they are unable to adequately control their nuclear stockpiles on their own. But joining with the major nuclear states in jointly addressing a global problem may be politically appealing. U.S.-Russian relations are still rocky despite President Obama's efforts to "reset" them, making a real nuclear security partnership with Russia difficult to achieve, but no less essential; shared U.S.-Russian interests in keeping nuclear material out of terrorist hands remain. Such partnerships will have to be based on creative approaches that make it possible to cooperate in upgrading nuclear security without demanding that countries compromise their legitimate nuclear secrets. Specific approaches should be crafted to accommodate each national culture, secrecy system, and set of circumstances. As a central element of this partnership-based approach, the Global Initiative to Combat Nuclear Terrorism should be reinvigorated, with a focus on building the international sense of urgency and commitment to action to reduce the risk of nuclear terrorism, and on meeting the four-year nuclear security objective.

Broaden Best Practices Exchanges and Security Culture Efforts

Opportunities for nuclear security operators to share ideas—problems they have encountered, ways they have found to resolve them, cost-effective means to protect against particular adversary tactics, and more—are another critical element of improving nuclear security for the long haul. As people see what other countries are doing, this kind of sharing of best practices can be a powerful motivator for change, building both the sense of urgency and the sense of possibility. While the specifics of nuclear security arrangements have long been shrouded in secrecy, operators can discuss many of the common issues they face without revealing sensitive information. The United States and Russia have greatly expanded their sharing of best practices in recent years, and these exchanges have expanded to include British experts as well. The United States and China are also engaged in a substantial set of dialogues on best practices in nuclear material security and accounting.

Most important, perhaps, a new organization, the World Institute for Nuclear Security (WINS) was established in 2008 precisely to promote sharing of best practices in nuclear security. WINS organizes workshops where experts can exchange ideas on a particular aspect of nuclear security, and then publishes best practice guides to help operators implement the best available ideas on improving nuclear security.

Targeted efforts to improve nuclear security culture, so that guards are no longer falling asleep on the job or turning off intrusion detectors, are also critical. Building strong security cultures is a difficult policy challenge, requiring intense commitment from the top management of nuclear facilities. The most important single element is convincing nuclear managers and all their security-relevant staff of the urgency of the threat. The United States and Russia have established a security culture program that is operating at a few sites, the IAEA has just produced its first guidance on the subject, and security culture was the subject of WINS' first best practice guide.[14]

But much more needs to be done both on exchanging nuclear security best practices and on strengthening security culture. President Obama and other leaders seeking to improve nuclear security should work with *all* countries where nuclear weapons and weapons-usable nuclear materials exist—as well as countries with major nuclear facilities that might be subject to sabotage—to exchange best practices and strengthen nuclear security culture. The ultimate goal should be to ensure that every facility and transporter handling nuclear weapons and weapons-usable nuclear material participates in programs to exchange best practices, and has a targeted program in place to continually assess and strengthen its nuclear security culture.

Create Mechanisms to Follow Up and Build Confidence in Progress

Mechanisms to follow up on commitments made and to build confidence that they are being implemented—and that states are maintaining effective nuclear security systems—will be essential if the commitments of the nuclear security summit are to have a real and lasting impact.

[14] See International Atomic Energy Agency, *Nuclear Security Culture: Implementing Guide*, Security Series No. 7 (Vienna: IAEA, 2008) http://www-pub.iaea.org/MTCD/publications/PDF/Pub1347_web.pdf (accessed 31 March 2010), and World Institute for Nuclear Security, *Nuclear Security Culture: A WINS Best Practice Guide for Your Organization*, Rev. 1.4 (Vienna: WINS, September 2009).

First, each participating state should designate one or a small number of key officials to be responsible for implementing their states' efforts, and groups of these officials should meet regularly in the months and years after the summit to review progress and assess next steps. If initial approaches are not working, or particular cooperating countries identify gaps that need to be filled or unexpected problems that need to be solved, these officials should have the authority to modify the cooperative nuclear security efforts. Simply getting each state to designate an official or a small group to be in charge of their nuclear security efforts would itself be a major step forward—particularly if these designated individuals were given the power needed to follow up effectively.

The nuclear security initiative launched by Presidents Bush and Putin at their Bratislava summit provides a compelling example. Each president designated a single senior official to be responsible for implementing the initiative, and those individuals were to report on progress every six months. The two sides drew up a list of facilities where security upgrades would take place, and a list of HEU-fueled reactors in third countries from which HEU would be removed, with particular schedules agreed. They then worked furiously to meet the agreed timetables; whenever a problem or delay arose, U.S. and Russian officials would talk (sometimes in person, sometimes by phone) to try to find a way to overcome the problem and get back on schedule. In the end, essentially all security improvements originally agreed to were completed by the end of December 2008, the deadline the two Presidents had originally set. Of course, that was a bilateral effort, and follow-up on multilateral commitments would be much more complex—but an effective mechanism to track progress and discuss ways to overcome obstacles is likely to be essential if the four-year effort is to succeed.

Second, it is important to build an international understanding of the work to be done. Through intelligence programs such as the Nuclear Materials Information Program (NMIP), the United States is developing its own classified understanding of the state of nuclear security around world. NMIP includes assessments of what is known and what is not known about sites with nuclear weapons or weapons-usable nuclear materials around the world, the security in place for those stocks, and at least limited information relating to the most plausible capabilities of adversaries who might seek to steal from those stocks in different parts of the world. The U.S. government should direct its intelligence agencies to place a high priority on collecting and analyzing information on crucial matters such as how security measures in different countries are assessed and tested, how much workers at remote research reactors are paid, where corruption is a serious problem, which facilities are in areas where terrorists or criminal groups have been particularly sophisticated about how to defeat defenses, and more.

But a common understanding of the state of nuclear security around the world is needed, to provide a baseline against which to judge progress of the four-year nuclear security effort. While many of the specifics of nuclear security arrangements in different countries will inevitably remain shrouded in secrecy, the United States and other countries working to achieve the four-year nuclear security objective should seek to convince countries of the importance of sharing as much information as they can. Each country should disclose the number of sites with nuclear stockpiles, what security measures are in place (at least in general descriptive terms), and the like. A more focused effort to simply compile and assess information that is already publicly available—in published laws, conference papers, facilities' websites, and the like—would be a good place to begin.

Third, countries should work together to develop means, within the confines of necessary secrecy, to build international confidence that states are taking the steps they have committed to and putting effective nuclear security measures in place. This will not be easy. Unfortunately, in international discussions to date, many countries have expressed intense opposition to proposals to broaden transparency around the topic of nuclear security, seeing complete secrecy about every aspect of the topic as the best approach. In the negotiations of the 2005 amendment to the physical protection convention, for example, a U.S. proposal that each country report on the steps it had taken to improve physical protection—including only as much detail as each country chose to include—was soundly rejected. It may be that more informal approaches, worked out in a spirit of partnership as part of the international cooperative effort to secure nuclear stockpiles, will be more successful.

International visits such as those that take place under U.S. nuclear supply agreements, IAEA-led peer reviews, and international cooperation on nuclear security upgrades are all effective mechanisms for expanding transparency to build confidence that effective nuclear security measures are in place, or are being put in place. As a high-level group commissioned by the IAEA recommended: "Ultimately, international reviews of both safety and security should become a regular part of business at nuclear facilities with HEU or separated weapons-usable plutonium."[15]

But additional approaches will be needed for sites that are unlikely to welcome international visitors in the near future—from U.S. and Russian nuclear warhead assembly plants to nuclear sites in Pakistan and Israel. Graham Allison has proposed that nuclear weapon states invite experts from another nuclear weapon state with which they have good relations to review their nuclear security arrangements and certify that they are effective. China, for example, which has long had close nuclear relations with Pakistan, might review and certify Pakistan's nuclear security system.[16]

Another approach might focus on providing, at least in general terms, the results of tests of security system effectiveness. The United States, for example, already openly publishes data on what percentage of DOE facilities have received high ratings in DOE security inspections—and uses that percentage as a measure of the effectiveness of ongoing steps to improve security.[17] In the case of U.S.-Russian cooperation, to build understanding of what was being tested and how, U.S. and Russian adversary teams might train together, and perhaps conduct tests of nuclear security systems together at non-sensitive sites in each country. Then the remaining sites could be tested by purely national teams, using similar approaches and standards, and broad descriptions of the results could be provided to the other country.[18]

[15] Commission of Eminent Persons, *Reinforcing the Global Nuclear Order*, p. 22. Norway was the first major developed state to request such an international peer review and encouraged all other states to do likewise, arguing that all states can benefit from international advice. Government of Norway, "Statement by Norway," to the 48th IAEA General Conference, Vienna, Austria, 20-21 September 2004.

[16] Allison, *Nuclear Terrorism: The Ultimate Preventable Catastrophe*, pp. 150-153.

[17] See, for example, U.S. Office of Management and Budget, "National Nuclear Security Administration: Safeguards and Security Assessment" (Washington, D.C.: OMB, original assessment 2004, updated 2009), http://www.whitehouse.gov/omb/expectmore/detail/10000126.2004.html (accessed 31 March 2010).

[18] In the case of tests that revealed vulnerabilities requiring immediate corrective action, U.S. and Russian officials would probably not want to reveal the specifics of those vulnerabilities to the other side until they had been corrected; the existence of

Approaches such as these are sensible goals to aim for, though they will be extremely difficult to achieve. In the immediate term, states should do more to provide general descriptions of their nuclear security approaches, photographs of installed equipment, and related data that could be made public and help build confidence that effective nuclear security measures are being taken without providing data that could help terrorists and criminals plan their attacks.

Build a Multi-Layered Defense

Nuclear security systems will never be perfect—and some nuclear material may already have been stolen and never recovered. Hence, a multilayered effort to block the terrorist pathway to the bomb is needed, with nuclear security as the first and most important layer.

Disrupt: counter-terrorism efforts focused on nuclear risks. President Obama should work with other countries to build an intense international focus on stopping the other elements of a nuclear plot—the recruiting, fundraising, equipment purchases, and more that would inevitably be required. Because of the complexity of a nuclear effort, these would offer a bigger and more detectable profile than many other terrorist conspiracies—although, as U.S. intelligence officials have pointed out, the observable "footprint" of a nuclear plot *might* be no bigger than that of the 9/11 plot. The best chances to stop such a plot lie not in exotic new detection technologies but in a broad counter-terrorist effort, ranging from intelligence and other operations to target high-capability terrorist groups to addressing the anti-American hatred that makes recruiting and fundraising easier, and makes it more difficult for other governments to cooperate with the United States. In particular, the United States should work with governments and non-government institutions in the Islamic world to build a consensus that slaughter on a nuclear scale is profoundly wrong under Islamic laws and traditions (and those of other faiths)—potentially making it more difficult for those terrorists wanting to pursue nuclear violence to convince the people they need to join their cause.

Interdict: countering the nuclear black market. Most of the past successes in seizing stolen nuclear material have come from conspirators informing on each other and from good police and intelligence work, not from radiation detectors. President Obama should work with other countries around the world to intensify police and intelligence cooperation focused on stopping nuclear smuggling, including additional sting operations, tiplines, and well-publicized rewards for informers to report on such plots, to make it even more difficult for potential nuclear thieves and buyers to connect. The United States should also work with states around the world to ensure that they have (a) units of their national police forces trained and equipped to deal with cases of smuggling of nuclear materials and weapons-related equipment, and other law enforcement personnel should be trained to call in those units as needed; (b) laws on the books making any participation in real or attempted theft or smuggling of nuclear weapons or weapons-usable materials, or nuclear terrorism, crimes with penalties comparable to those for murder or treason; (c) a commitment to catching

---

such vulnerabilities is considered a secret in each country. In cases where deficiencies were found, they could simply be silent about the results of the test, leaving the other side to draw its own conclusions, until after corrective action had been completed. Such an approach could provide substantially increased confidence to each side that the other's nuclear stockpiles were secure and were being tested effectively. In particular, an approach like this one might be used to confirm that Russia had taken action to provide security at sites that had been judged too sensitive to allow U.S. access that was comparable to the security measures at sites where U.S.-Russian cooperation had taken place, particularly the two remaining nuclear warhead assembly and disassembly facilities.

and prosecuting those involved in such transfers; and (d) standard operating procedures, routinely exercised, to deal with materials that may be detected or intercepted. The U.S. government should develop an approach that offers a greater chance of stopping nuclear smugglers at lower cost than the current mandate for 100 percent scanning of all cargo containers, focusing on an integrated system that places as many barriers in the path of intelligent adversaries attempting to get nuclear material into the United States by *any* pathway as can be accomplished at reasonable cost, and work with Congress to get the modified approach approved. (In particular, it is important to understand that neither the detectors now being deployed nor the Advanced Spectroscopic Portals in development will offer a high probability of detecting HEU metal if it has significant shielding.)

Prevent and deter: reducing the risk of nuclear transfers to terrorists by states. While the risk that a hostile state would consciously decide to transfer nuclear weapons or materials to terrorists is small—and represents only a small part of the overall risk of nuclear terrorism—this risk is not zero, and steps should be taken to reduce it further. The international community should continue to seek to put together packages of carrots and sticks large enough and credible enough to convince the governments of North Korea and Iran that it is in their interest to verifiably end their nuclear weapons efforts (and, in North Korea's case, to give up the weapons and materials already produced). The international community should also work to strengthen efforts to detect and interdict any shipment of nuclear material from these or other countries—though given the difficulties, undue reliance should not be placed on that tool. At the same time, the global effort to stem the spread of nuclear weapons should be strengthened wherever possible, reducing the chances that other states might someday gain nuclear weapons that might fall into terrorist hands. The United States should also put in place the best practicable means for identifying the source of any nuclear attack—including not just nuclear forensics but also traditional intelligence and law enforcement means—and announce that the United States will treat any terrorist nuclear attack using material consciously provided by a state as an attack by that state, and will respond accordingly. This should include both increased funding for R&D and expanded efforts to put together an international database of material characteristics. Policymakers should understand, however, that nuclear material has no DNA that can provide an absolute match: nuclear forensics will complement other sources of information, but will rarely make clear where material came from by itself.

Respond: global nuclear emergency response. President Obama should work with other countries to ensure that an international rapid-response capability is put in place—including making all the necessary legal arrangements for visas and the import of technologies such as the nuclear detectors used by the nuclear emergency search teams (some of which include radioactive materials)—so that within hours of receiving information related to stolen nuclear material or a stolen nuclear weapon anywhere in the world, a response team (either from the state where the crisis was unfolding, or an international team if the state required assistance) could be on the ground, or an aircraft with sophisticated search capabilities could be flying over the area.

Impede: impeding terrorist recruitment of nuclear personnel. President Obama should maintain existing scientist-redirection programs, but should reform them to use a broader array of tools and to focus on a broader array of threats, including not only top weapons scientists but workers with access to nuclear material, guards who could help steal nuclear material, and people who have retired from nuclear facilities but still have critical knowledge. The United States is not likely to have either the access or the resources to carry out this broader mission by itself, but must work closely with partner countries to convince them to take most of the needed actions themselves. President Obama should also work with key countries such as Russia and Pakistan to strengthen control of classified nuclear information and ensure that they monitor contacts and behavior of all individuals with key nuclear secrets—and should work with a broader set of countries to monitor and stop recruitment attempts at key sites, such as physics and nuclear engineering departments in countries with substantial extremist communities.

Reduce: reducing stockpiles and ending production. The United States, Russia, and other nuclear weapon states should join in an effort to radically reduce the size, roles, and readiness of their nuclear weapon stockpiles, verifiably dismantling many thousands of nuclear weapons and placing the fissile material they contain in secure, monitored storage until it can be safely and securely destroyed. Very deep reductions in nuclear stockpiles, if properly managed, would reduce the risks of nuclear theft—and could greatly improve the chances of gaining international support for other nonproliferation steps that could also reduce the long-term dangers of nuclear theft. President Obama should launch a joint program with Russia to reduce total U.S. and Russian stockpiles of nuclear weapons to something in the range of 1,000 weapons, and to place all plutonium and HEU beyond the stocks needed to support these low, agreed warhead stockpiles (and modest stocks for other military missions, such as naval fuel) in secure, monitored storage pending disposition. In particular, the United States and Russia should launch another round of reciprocal initiatives, comparable to the Presidential Nuclear Initiatives of 1991-1992, in which they would each agree to: (a) take several thousand warheads—including, but not limited to, all tactical warheads not equipped with modern, difficult-to-bypass electronic locks—and place them in secure, centralized storage; (b) allow visits to those storage sites by the other side to confirm the presence and the security of these warheads; (c) commit that these warheads will be verifiably dismantled as soon as procedures have been agreed by both sides to do so without compromising sensitive information; and (d) commit that the nuclear materials from these warheads will similarly be placed in secure, monitored storage after dismantlement. President Obama should also seek new ways to overcome the obstacles to negotiating a verified fissile material cutoff treaty—while also seeking to end all production of HEU for any purpose, and to phase out civilian separation of weapons-usable plutonium.

Monitor: monitoring nuclear stockpiles and reductions. President Obama should work with Russia to revive efforts to put in place a system of data exchanges, reciprocal visits, and monitoring that would build confidence in the size and security of each side's nuclear stockpile, lay the groundwork for deep reductions in nuclear arms, and confirm agreed reductions in nuclear warhead and fissile material stockpiles. Such a system should ultimately be expanded to cover other nuclear weapon states as well. In particular, President Obama should seek Russian agreement, before the 2010 NPT review, that each country will place large quantities of excess fissile material under IAEA monitoring.

Prepare: organize to respond to a nuclear attack. Finally, no matter what is done to prevent nuclear terrorism, it is essential that the United States get better prepared should such a catastrophe nevertheless occur. While some steps have been taken to prepare for the ghastly aftermath of a terrorist nuclear attack, a comprehensive plan and approach is needed. The United States needs a rapid ability to assess which people are in the greatest danger and to tell them what they can do to protect themselves. Better capabilities to communicate to everyone, when TV, radio, and cell phones in the affected area may not be functioning properly are also needed, as are much better public communication plans for the critical minutes and hours after such an attack. The U.S. government needs to do a much better job encouraging and helping people to take simple steps to get ready for an emergency. The United States also needs to put in place a better ability—including making use of the military's capabilities—to treat many thousands of injured people, along with more effective plans to keep the government and economy functioning while taking all the steps that will be needed to prevent another attack. (In particular, Congress has not yet acted to put a plan in place for reconstituting itself should most members of Congress be killed in a nuclear attack.) Many of these steps would help respond to any catastrophe, natural or man-made, and would pay off even if efforts to prevent a terrorist nuclear attack succeeded.

Provide the Needed Leadership, Planning, and Resources

Achieving effective security for all the world's stockpiles of nuclear weapons and weapons-usable nuclear materials poses an extraordinarily difficult challenge. Sustained high-level leadership will be needed to overcome a maze of obstacles posed by complacency about the threat, secrecy, political disputes, sovereignty concerns, and bureaucratic obstacles. Sustained engagement from presidents and prime ministers in the months and years following the nuclear security summit will be needed, not just occasional statements of support. Leaders will have to be willing to change outdated rules, overrule officials standing in the way of nuclear security cooperation, invest additional funds in nuclear security, and more. For President Obama, several steps will be particularly critical.

Structure for leadership. First, President Obama, building on the structure he has put in place, should give the National Security Council clear direction and authority to take the needed actions to move this agenda forward, and to keep this effort on the front burner at the White House every day. The staff focused on this topic need to wake up every morning thinking "what can we do today to prevent a nuclear terrorist attack?" President Obama should also encourage Russia and other key countries to put similar top-level structures in place, so that it is clear which officials other countries should talk to about nuclear security and nuclear terrorism.

A comprehensive, prioritized plan. Second, President Obama should direct the NSC staff to further develop a comprehensive, prioritized plan for preventing nuclear terrorism, integrating steps from implementing nuclear security upgrades to expanding intelligence cooperation focused on the nuclear terrorist threat to building the sense or urgency around the world. This plan will have to be continuously modified as circumstances change.

The resources to do the job. Third, President Obama and the Congress should work together to provide sufficient resources to ensure that steps that could significantly reduce nuclear terrorism risks are not slowed by lack of money. Achieving the four-year nuclear security objective will require doing more, faster, than in the past, which will inevitably require an increase in budgets. Yet nuclear security is eminently affordable: the entire sums spent on cooperative threat reduction each year are a tiny fraction of the budgets of the Departments of Defense, Energy, and

State. With increased budgets will inevitably also come a need for increasing available federal officials to oversee the work, and Congress should allow the relevant agencies to hire additional people as needed.

As part of providing sufficient resources, the leaders at the 2010 G8 summit should agree to extend the Global Partnership Against the Spread of Weapons and Materials of Mass Destruction for another ten years; continue providing $500 million to $1 billion per year above and beyond the funds allocated by the United States; and target the effort on helping states around the world provide effective nuclear security and meet their other obligations under UNSCR 1540.

Strengthening the IAEA's role in nuclear security is also an important element of providing sufficient resources for the nuclear security effort. While some donor countries have played down the IAEA's role, preferring to work directly with recipient countries, the IAEA, despite its sometimes bureaucratic nature, brings a powerful international legitimacy to the effort, and has a key role to play. The IAEA's recommendations and help are seen as having a value and legitimacy that no single country can muster. The United States and other countries participating in the nuclear security effort should: (a) work to increase the budget of the IAEA Office of Nuclear Security and shift it primarily to the IAEA's regular budget, rather than continuing to rely on unpredictable voluntary contributions; seek to empower the IAEA to undertake a broader set of nuclear security peer reviews and assistance efforts, encouraging all countries participating in the four-year nuclear security effort to request IAEA peer reviews of their nuclear security arrangements and ensuring that the IAEA has the resources and expertise to respond quickly when such reviews identify weaknesses that need to be fixed; (c) give the IAEA Office of Nuclear Security the people and mandate needed to expand its ability to analyze and assess nuclear security and nuclear terrorism threats, working with intelligence and police agencies around the world to improve global understanding of what nuclear avenues terrorists have actually pursued and what is going on in the shadowy world of nuclear smuggling, including in-depth investigations of important nuclear smuggling cases.

Information and analysis. Fourth, President Obama should take action to ensure that his administration has the information and analysis it needs to support effective policymaking. Information is crucial to identifying where the greatest risks, opportunities, and obstacles to progress lie. President Obama should direct U.S. intelligence agencies to place high priority on all aspects of the nuclear terrorism problem, from assessing and penetrating terrorist conspiracies and nuclear smuggling networks to assessing nuclear security measures around the world. President Obama and the Congress should also work together to fund non-government institutions to provide independent analysis and suggestions that can help strengthen these programs. The highest-leverage area for information collection and analysis is likely to be supporting policy efforts to improve security for nuclear stockpiles—answering questions ranging from which sites have particularly large and vulnerable stockpiles, to which nuclear facilities have poorly paid staff or corrupt guards, to which research reactors are underutilized, underfunded, and might be convinced to shut down with a modest incentive package.

Fifth, President Obama should work to put the United States' own house in order. Convincing foreign countries to reduce and consolidate nuclear stockpiles, to put stringent nuclear security measures in place, or to convert their research reactors from HEU to LEU fuel will be far more difficult if the United States is not doing the same at home. As part of that effort:

DOE and DOD should establish intensive programs to strengthen nuclear security culture wherever nuclear weapons and weapons-usable nuclear materials are stored and handled, in an effort to avoid future incidents of guards sleeping on duty or nuclear weapons being accidentally flown across the country without authorization.

- DOE and DOD should continue to seek to consolidate their nuclear stockpiles to the minimum possible number of locations.
- DOE should continue providing funding to convert U.S. research reactors to LEU.
- Congress should provide funding for DOE to help HEU-fueled research reactors, or research reactors that pose serious sabotage risks, to upgrade security voluntarily.
- At the same time, Congress should direct the Nuclear Regulatory Commission (NRC) to phase out the exemption from most security rules for HEU that research reactors now enjoy, and provide funding for DOE to help these reactors pay the costs of effective security.
- Congress should also insist that NRC revise its rule exempting modestly radioactive HEU from almost all security requirements, as recent studies make clear that the level of radiation specified in NRC rules would pose little deterrent to theft by determined terrorists.
- Congress should direct the NRC to strengthen its requirements for protection of potential nuclear bomb material to bring them roughly in line with DOE's rules for identical material (particularly since the NRC-regulated facilities handling this material are doing so mainly on contract to DOE in any case, so DOE will end up paying most of the costs of security as it does at its own sites).
- Congress should pass legislation requiring that as soon as sufficient supplies of medical isotopes produced without HEU are available, the United States will stop exporting HEU for medical isotope production and stop importing any isotopes made from HEU.

A Daunting but Essential Road

The obstacles to accelerated and expanded progress are real and difficult. But with sustained high-level leadership, a sensible strategy, partnership-based approaches, adequate resources, and good information, they can be overcome. The actions President Obama has already taken in laying out the four-year objective, gaining Security Council endorsement of it, and calling the nuclear security summit, open new opportunities. Now is the time to seize them. President Obama still has an enormous opportunity, and obligation—to reduce the danger of nuclear terrorism to a fraction of its current level during his first term in office.

ABOUT THE AUTHOR

Matthew Bunn is an Associate Professor at Harvard University's John F. Kennedy School of Government. His research interests include nuclear theft and terrorism; nuclear proliferation and measures to control it; the future of nuclear energy and its fuel cycle; and policies to promote innovation in energy technologies.

Before coming to Harvard, Bunn served as an adviser to the White House Office of Science and Technology Policy, as a study director at the National Academy of Sciences, and as editor of *Arms Control Today*. He is the winner of the American Physical Society's Joseph A. Burton Forum Award for "outstanding contributions in helping to formulate policies to decrease the risks of theft of nuclear weapons and nuclear materials," and the Federation of American Scientists' Hans Bethe Award for "science in service to a more secure world," and is an elected Fellow of the American Association for the Advancement of Science. He is a member of the Boards of Directors of the Arms Control Association and the Partnership for Global Security.

Bunn is the author or co-author of some 20 books and book-length technical reports, and over a hundred articles in publications ranging from *Science* and *Nuclear Technology* to *Foreign Policy* and *The Washington Post*. He appears regularly on television and radio.

Bunn holds a doctorate in technology, management, and policy from the Massachusetts Institute of Technology. He is married to Jennifer Weeks; they have two daughters.

ACKNOWLEDGEMENTS

This report was sponsored by the Nuclear Threat Initiative. Additional funding was provided by the John D. and Catherine T. MacArthur Foundation and the Belfer Center for Science and International Affairs. I would like to thank the many officials of the U.S. and Russian governments and international organizations, as well as experts at U.S. and Russian nuclear facilities, who have given generously of their time over the years in discussions of these critical issues. These officials and experts prefer to remain anonymous. The staff of the National Nuclear Security Administration have been particularly generous in providing data, insights, and suggestions. I would like to thank Andrew Newman for extensive research assistance and helpful suggestions. Neal Doyle ably laid out the report and designed the figures, going above and beyond the call of duty to publish a complex document in a short time. I am grateful to a wide range of colleagues who provided helpful comments, ideas, and suggestions, particularly including Joan Rohlfing, Page Stoutland, Corey Hinderstein, Deborah Blum, Brian Wilkes, and Cathy Gwin at the Nuclear Threat Initiative; Graham T. Allison, Martin Malin, William Tobey, Rolf Mowatt-Larssen, Sasha Talcott, and Patricia McLaughlin at Harvard University; William Potter at the Monterey Institute for International Studies; and Siegfried Hecker at Stanford University.

All responsibility for remaining errors and misjudgments, of course, is my own.

ABOUT THE PROJECT ON MANAGING THE ATOM

The Project on Managing the Atom (MTA) is Harvard University's primary group focused on reducing the risk of nuclear and radiological terrorism, stopping nuclear proliferation and reducing nuclear arsenals, lowering the barriers to safe and secure nuclear-energy use, and addressing the connections among these problems. The MTA project has been engaged since 1996 in research and analysis, public and policy-maker education, the development of policy proposals, and the training of pre- and post-doctoral fellows.

The MTA project is based in the Belfer Center for Science and International Affairs of Harvard University's John F. Kennedy School of Government, and represents a collaboration of the Center's programs on Science, Technology, and Public Policy; International Security; and Environment and Natural Resources.

The core members of the staff of the MTA project are:

- Matthew Bunn, Co-Principal Investigator; Associate Professor of Public Policy
- John P. Holdren, Co-Principal Investigator; Director, Science, Technology, and Public Policy Program (on leave)
- Henry Lee, Co-Principal Investigator; Director, Environment and Natural Resources Program
- Steven E. Miller, Co-Principal Investigator; Director, International Security Program
- Martin B. Malin, Executive Director
- Hui Zhang, Research Associate
- Andrew Newman, Research Associate
- Neal Doyle, Program Coordinator

In addition to these core staff members, the MTA project hosts research fellows and student associates engaged in research on critical issues affecting the future of nuclear energy, weapons, and nonproliferation.

Current research priorities include securing, monitoring, and reducing stockpiles of nuclear weapons and fissile material; strengthening the global nonproliferation regime; exploring conditions that would enable the prohibition of nuclear weapons; examining the future of nuclear energy, including management of spent nuclear fuel and radioactive wastes, and other means of limiting the proliferation risks of the civilian nuclear fuel cycle; and addressing regional security risks posed by nuclear programs in the Middle East, East Asia, and South Asia.

The MTA project provides its findings and recommendations to policy makers and to the news media through publications, briefings, workshops, and other events. MTA's current work is made possible by generous support from the John D. and Catherine T. MacArthur Foundation, the Nuclear Threat Initiative, the Ford Foundation, the Carnegie Corporation, and the Belfer Center for Science and International Affairs. For more information, including full-text versions of our publications, updates on current MTA activities, biographies of all participating researchers, and other features, visit our web site, at http://www.managingtheatom.org.