

Securing the Bomb 2006

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TABLE OF CONTENTS

EXECUTIVE SUMMARY	v
INTRODUCTION: UNDERSTANDING THE DANGER	1
<i>The Facts that Frame the Danger</i>	<i>1</i>
<i>Facing the Facts</i>	<i>5</i>
<i>A Roadmap for Our Report</i>	<i>6</i>
PREVENTING NUCLEAR TERRORISM: KEY REMAINING CHALLENGES	9
<i>Locking Down Nuclear Stockpiles around the World</i>	<i>9</i>
<i>What Improved Nuclear Security Can and Cannot Do</i>	<i>27</i>
<i>Potential State Transfer to Terrorists</i>	<i>27</i>
<i>Interdicting Nuclear Smuggling</i>	<i>30</i>
<i>Other Elements of Controlling Nuclear Stockpiles</i>	<i>32</i>
<i>The Need for Leadership</i>	<i>41</i>
TRACKING PROGRESS IN CONTROLLING NUCLEAR WARHEADS, MATERIALS, AND EXPERTISE	45
<i>Tracking Progress: Securing Nuclear Warheads and Materials</i>	<i>47</i>
<i>Tracking Progress: Interdicting Nuclear Smuggling</i>	<i>78</i>
<i>Tracking Progress: Stabilizing Employment for Nuclear Personnel</i>	<i>84</i>
<i>Tracking Progress: Monitoring Nuclear Stockpiles and Reductions</i>	<i>92</i>
<i>Tracking Progress: Ending Production</i>	<i>96</i>
<i>Tracking Progress: Reducing Nuclear Stockpiles</i>	<i>98</i>
<i>Summary: How Much of the Job is Done?</i>	<i>102</i>
UPDATE OF THE BUDGET PICTURE	105
<i>Highlights of the FY 2007 Budget Proposal</i>	<i>107</i>
<i>Recap of the FY 2006 Budget Cycle</i>	<i>109</i>
<i>Issues and Concerns for Budgets Going Forward</i>	<i>111</i>
<i>Total Threat Reduction Funding</i>	<i>119</i>
RECOMMENDATIONS	121
<i>Initiative 1: A Global Coalition to Prevent Nuclear Terrorism</i>	<i>122</i>
<i>Initiative 2: Effective Global Nuclear Security Standards</i>	<i>126</i>
<i>Initiative 3: An Accelerated Global Cleanout</i>	<i>130</i>
<i>Approach 1: Strengthening the Sense of Urgency and Commitment</i>	<i>137</i>
<i>Approach 2: Sustained High-Level Leadership</i>	<i>141</i>

<i>Approach 3: Building Genuine Nuclear Security Partnerships</i>	143
<i>Approach 4: Cooperating Without Compromising Nuclear Secrets</i>	147
<i>Approach 5: Ensuring Sustainability and Strong Security Cultures</i>	147
<i>Options for the U.S. Congress</i>	152
<i>A Long Road Yet to Travel</i>	157
ABOUT THE AUTHORS	159
ACKNOWLEDGEMENTS	161
ABOUT THE PROJECT ON MANAGING THE ATOM	163

EXECUTIVE SUMMARY

Urgent actions are needed to prevent a nuclear 9/11. Terrorists are actively seeking nuclear weapons and the materials to make them. With the needed nuclear materials in hand, making at least a crude nuclear bomb, capable of turning the heart of any modern city into a smoking ruin, is potentially within the capabilities of a sophisticated terrorist group. Yet scores of sites where the essential ingredients of nuclear weapons exist, in dozens of countries around the world, are clearly not well enough secured to defeat the kinds of threats that terrorists and criminals have demonstrated they can pose.

Wherever an insecure cache of potential nuclear bomb material continues to exist, there is a threat to U.S. homeland security and to the security of the world that must be addressed as quickly as possible. Keeping nuclear weapons or materials from being stolen in the first place is the most direct and reliable tool for preventing nuclear terrorism, for once such items have disappeared, the problem of finding them or stopping terrorists from using them multiplies enormously.

A dangerous gap remains between the urgency of the threat of nuclear terrorism and the scope and pace of the U.S. and world response. That gap has been narrowed in recent years, with actions such as the accord on nuclear security between U.S. President George Bush and Russian President Vladimir Putin at their 2005 summit in Bratislava, Slovakia, and the launch of the Global Threat Reduction Initiative (GTRI) in early 2004. But much more needs to be done.

SECURING STOCKPILES IN THE FORMER SOVIET UNION

In Russia and the other states of the former Soviet Union, there is some good news to report, but there is still far too much bad news. Nuclear security has improved substantially, but significant threats of nuclear theft remain. A decade and a half after the collapse of the Soviet Union, the most egregious nuclear security weaknesses of the early 1990s—gaping holes in fences, buildings with no detector at the door to sound an alarm if some one was carrying out plutonium—have largely been fixed through a combination of international assistance programs and the former Soviet states' own efforts. In the aftermath of the Bratislava summit, moreover, Russian and U.S. experts agreed on a joint plan for completing a specified list of security upgrades by the end of 2008—though the agreed list still leaves some nuclear warhead and nuclear material sites uncovered. The pace of progress has also accelerated: security and accounting upgrades were completed at more buildings holding nuclear material in fiscal year (FY) 2005 than in any previous year of the effort.

Security upgrades are far from complete, however, and the challenges to effective security are daunting. As of the end of FY 2005, U.S.-funded comprehensive security and accounting upgrades had been completed for 54% of the buildings in the former Soviet Union with potentially vulnerable weapons-usable nuclear material, leaving an immense amount of work to be done to meet the 2008 target. Many of the buildings not yet completed may still

be vulnerable to relatively modest threats, and even the buildings where comprehensive upgrades have been installed are unlikely to be able to defend against the huge threats terrorists and criminals have shown they can pose in today's Russia, from surprise attack by 30-40 heavily armed, well-trained suicidal attackers to insider theft conspiracies involving half a dozen or more well-placed insiders. Only modest progress has been made in consolidating nuclear weapons and weapons-usable materials into a smaller number of sites and in putting in place effective and effectively enforced nuclear security rules. And while the United States is paying to install effective, modern security and accounting equipment, that equipment will not provide high security unless nascent efforts to forge a strong "security culture" succeed, so that guards no longer patrol without ammunition in their guns and staff no longer turn off intrusion detectors or prop open security doors. Finally, whether Russia will provide the resources, incentives, and organizations needed to sustain high levels of security after international assistance phases out remains very much an open question; to date, Russian government funding for nuclear security remains far below what is needed.

SECURING STOCKPILES IN THE REST OF THE WORLD

In the rest of the world, there is even less good news.

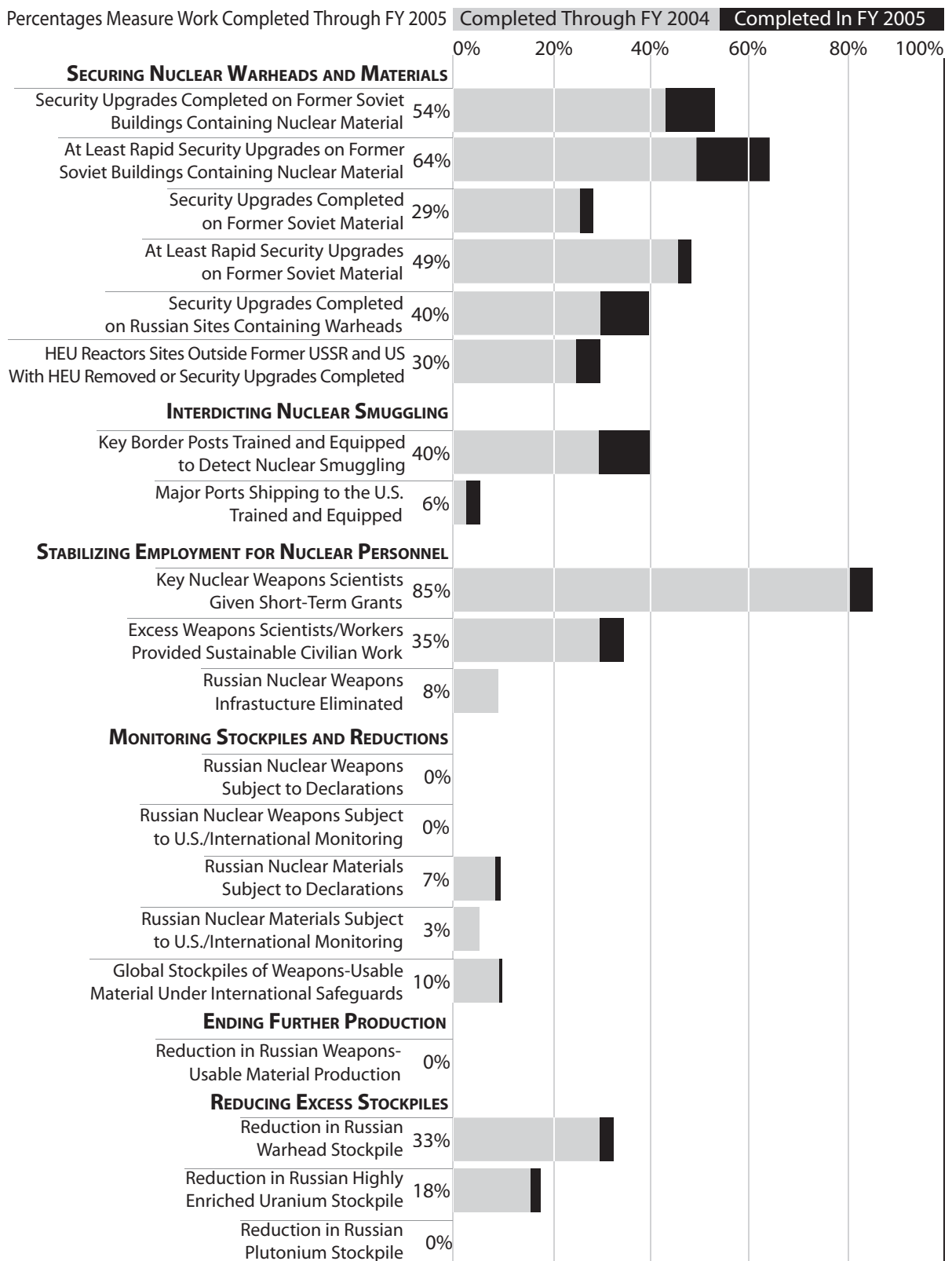
At many sites around the world, weapons-usable nuclear material remains dangerously vulnerable to either outsider or insider theft, even though many countries have strengthened their nuclear security rules since 9/11. Civilian facilities such as research reactors often have little more security than a night watchman and

a chain-link fence. Pakistan's stockpiles remain an urgent concern: while heavily guarded, they face immense threats, from armed remnants of al Qaeda to nuclear insiders with a proven willingness to sell nuclear weapons technology.

For most countries outside the former Soviet Union, U.S.-sponsored security upgrades have barely begun or are not yet even on the agenda. While the establishment of GTRI has significantly accelerated the pace of removing weapons-usable material from vulnerable sites around the world, major gaps in that effort have not yet been filled—including two-thirds of the U.S.-supplied highly enriched uranium (HEU) abroad that is still not covered by the U.S. take-back offer and dozens of HEU-fueled research reactors (representing nearly half of the global total) that are not yet targeted for conversion to safer fuels. The upgrades that are being done through GTRI, moreover, are designed to meet a minimal security standard far below the security level U.S.-funded upgrades are seeking to achieve in Russia, which in turn is less than what the Department of Energy requires at its own sites.

No fast-paced global coalition focused on securing nuclear stockpiles worldwide yet exists. Despite some worthwhile recent agreements related to nuclear security, no effective global nuclear security standards have been put in place, leaving the level of security provided to potential nuclear bomb material up to each of the dozens of states that have such material. Neither the U.S. government nor any other government or organization has a truly comprehensive plan for ensuring that *all* the nuclear warheads and caches of weapons-usable material around the world are secure and accounted for.

Figure ES-1
Controlling Nuclear Warheads, Material, and Expertise:
How Much Work Have U.S.-Funded Programs Completed?



CONTROLLING NUCLEAR WEAPONS, MATERIALS, AND EXPERTISE

Figure ES-1 shows what fraction of various parts of the job of controlling nuclear warheads, materials, and expertise in the former Soviet Union and worldwide were completed by U.S.-funded programs by the end of FY 2005. The measures of progress are divided into programs to secure nuclear stockpiles, to interdict nuclear smuggling, to stabilize employment for nuclear personnel, to monitor nuclear stockpiles, to end production of nuclear materials, and to reduce the stockpiles of nuclear weapons and weapons-usable nuclear materials that already exist. All of these measures are only rough indicators of progress: from forging strong security cultures to strengthening nuclear security regulation, a great deal that is not captured in these measures also needs to be done.

Nevertheless, Figure ES-1 makes clear that a similar story of “some good news, but still too much bad news” can be told across the spectrum of these efforts. The programs targeted on these objectives have demonstrably reduced the danger of nuclear theft at scores of buildings in the former Soviet Union and a few buildings elsewhere; they have permanently destroyed thousands of bombs’ worth of nuclear material; they have put radiation detection equipment at scores of key border crossings around the world; and they have offered at least temporary civilian re-employment for thousands of nuclear experts who were no longer needed in weapons programs. These efforts have represented an excellent investment in U.S. and world security. Hundreds of experts and officials from the United States, Russia, and other countries and organizations have worked hard, and often creatively, to achieve this progress, and the world is significantly more secure as a result of their efforts.

But in virtually every category of effort, there is much more to be done. The blank space on the chart represents thousands of nuclear weapons and enough material for thousands more at buildings and bunkers with security upgrades not yet installed; hundreds of high-priority border crossings around the world without effective nuclear security detectors yet in place; thousands of nuclear workers with potentially dangerous nuclear knowledge not yet re-employed; and tens of thousands of bombs’ worth of plutonium and HEU that is no longer needed for military purposes but has not yet been destroyed.

BUDGETS AND POLITICAL RESOURCES

For FY 2007, the Bush administration has requested a total of \$1.077 billion for programs focused on controlling nuclear warheads, materials, and expertise around the world—an amount essentially identical to the previous year’s appropriation in nominal terms, and a slight decrease in real terms. While this represents only one quarter of one percent of U.S. defense spending, the reality is that for most of these programs, progress is constrained more by limited cooperation with foreign partners and bureaucratic impediments than it is by lack of funds. There are a few exceptions, however, where modestly increased investments could significantly accelerate the pace of progress. The most fundamental missing ingredient of the U.S. and global response to the nuclear terrorism threat to date is sustained high-level leadership. On the one hand, President Bush has repeatedly emphasized the danger of nuclear terrorism and the need for action to address it. Indeed, with the significant acceleration of nuclear security work with Russia that resulted from the February 2005 summit accord with President Putin, he demonstrated the difference that presidential leadership can make.

But like President Clinton before him, President Bush and his top White House leadership have not provided the sustained, day-in and day-out focus needed to overcome the myriad obstacles to ensuring that nuclear stockpiles around the world are secure and accounted for. In many cases, problems have been allowed to fester unresolved for years at a time. To take just three of the examples documented in this report:

- The giant secure-storage facility for nuclear weapons material built with U.S. funds at Mayak, in Russia, still stands empty some two and a half years after it was completed;
- The Global Partnership Against the Spread of Weapons and Materials of Mass Destruction, launched with great fanfare at the 2002 summit of the Group of Eight (G8) industrial democracies, has been allowed to drift into focusing primarily on dismantling attack submarines and destroying chemical weapons, with only a dribble of non-U.S. funds going to improving security for nuclear stockpiles; and
- No initiative on nuclear security was included in the negotiation of the U.S.-India nuclear deal, though lower-level officials had been trying to convince India to cooperate on nuclear security improvements for years. Achieving rapid improvements in nuclear security will require sustained leadership from the top levels of the White House and its counterparts in leading states around the world. Success is within reach: President Bush, President Putin, and their counterparts still have an opportunity to leave as one lasting legacy a world heading toward dramatic reductions in the risk of nuclear terrorism.

RECOMMENDATIONS TO REDUCE THE RISK

The danger of nuclear theft and terrorism is a global problem, requiring a global response. The presidents of the United States and Russia, along with the heads of state of other leading nuclear weapon and nuclear energy states, should join together in taking three actions:

- launching a global coalition to prevent nuclear terrorism;
- forging effective global nuclear security standards; and
- accelerating and broadening current efforts toward a global cleanout, in which weapons-usable material would be removed from the world's most vulnerable sites as rapidly as possible.

Numerous other actions to strengthen programs to block terrorists on later steps in their pathway to a nuclear bomb are also critical, though these efforts will provide less leverage in reducing the risk of nuclear terrorism than will steps to secure and consolidate nuclear stockpiles, which are the focus of our recommendations.

A Global Coalition to Prevent Nuclear Terrorism

President Bush should immediately begin working with Russia and other leading nuclear-weapon and nuclear-energy states to gain their agreement to participate in a global coalition to prevent nuclear terrorism. This coalition could be built around a fundamentally reenergized and refocused Global Partnership, or, if that proves impossible, it could be a new, complementary initiative. The participants in this coalition would agree to protect all of their nuclear stockpiles to an agreed standard sufficient to defeat the threats

terrorists and criminals have shown they can pose; to encourage, assist, and pressure other states to do likewise; to sustain effective nuclear security for the long haul using their own resources; to reduce the number of locations where nuclear weapons and weapons-usable nuclear materials are located (thereby achieving higher security at lower cost); and to take other steps to cooperate to reduce the dangers of nuclear terrorism, from expanding intelligence and law enforcement cooperation targeted on nuclear theft and smuggling to putting in place criminal laws making actual or attempted nuclear theft or terrorism a crime comparable with murder or treason. As part of the effort, the coalition partners would also work to expand the mission, personnel, and resources of the International Atomic Energy Agency's Office of Nuclear Security, allowing that agency to substantially increase its contribution to preventing nuclear terrorism. The participants should commit to providing the resources necessary to ensure that lack of funding does not constrain the pace at which nuclear stockpiles around the world can be secured and consolidated.

Deliberate decisions by hostile states to provide nuclear bomb materials to terrorists are a smaller part of the danger of nuclear terrorism than nuclear theft, because regimes focused on their own survival know that any such act would risk overwhelming retaliation. Nevertheless, gaining international agreement on packages of carrots and sticks large and credible enough to convince Iran and North Korea that it is in their interests to verifiably abandon their nuclear weapons efforts would be a key contribution to reducing the danger of nuclear terrorism, and should also be a focus of the global coalition.

This global coalition should include the G8 industrialized democracies, along

with China, India, Pakistan, and, ideally, Israel (which is believed to have a significant stockpile of nuclear weapons) and South Africa (which once had nuclear weapons, and still has one of the largest stockpiles of HEU among the developing non-nuclear-weapon states). All of these states should be offered roles as co-leaders of this global effort, rather than as mere recipients of assistance currently unable to properly secure their own stockpiles.

To be effective, the coalition would need a strong mechanism for ensuring that the initial commitments were fulfilled. A standing group of senior officials appointed by the leader of each coalition partner would be responsible for implementing the global coalition commitments, developing agreed plans with measurable milestones, devising means to overcome obstacles to success, and reporting on the coalition's progress to the leaders of the participating states on a regular basis.

Such a coalition would still have much to do in Russia to complete the cooperative upgrades now under way, to ensure that security measures are put in place that are sufficient to meet the threats that exist in today's Russia, to forge a strong security culture, and to see that high levels of security for nuclear stockpiles will be sustained after international assistance phases out. But the work with Russia should become a true partnership, framed as one part of this global coalition. Continuing bilateral cooperation with other countries should similarly be based on partnership, as one part of the global coalition, focusing on the same central objectives. To succeed, the approaches that have been developed in cooperation with the former Soviet states will have to be adapted to the different national cultures, approaches to secrecy, and legal frameworks that exist in other countries. The United States and other co-

alition partners should take steps to ensure that states and facilities have strong incentives to provide effective nuclear security, from working with states to put in place effective nuclear security regulation to establishing preferences in all contracts for facilities that have demonstrated superior nuclear security performance.

Effective Global Nuclear Security Standards

As part of a global coalition to prevent nuclear terrorism, President Bush and other leaders of major nuclear-weapon and nuclear-energy states should immediately seek agreement on a broad political commitment to meet at least a common minimum standard of nuclear security. Effective global standards are urgently needed, for in the face of terrorists with global reach, nuclear security is only as good as its weakest link. The standard should be designed to be rigorous enough that all stockpiles with security measures meeting the standard are well protected against plausible insider and outsider threats, but flexible enough to allow each country to take its own approach to nuclear security and to protect its nuclear secrets. For example, the agreed standard might be that all nuclear weapons and significant caches of weapons-usable nuclear materials be protected at least against two small groups of well-armed and well-trained outsiders, one to two well-placed insiders, or both outsiders and insiders working together.

United Nations Security Council Resolution 1540, which legally requires all states to provide “appropriate effective” security and accounting for any nuclear stockpiles they may have, provides an excellent opportunity, as yet unused, to back up such a high-level political commitment. 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.

Hence, the United States should seek the broadest possible agreement that UNSCR 1540 already legally binds states to meet a minimum level of nuclear security. The United States should immediately begin working with the other coalition participants and the IAEA to detail the essential elements of an “appropriate effective” system for nuclear security, to assess what improvements countries around the world need to make to put these essential elements in place, and to assist countries around the world in taking the needed actions. The United States should also begin discussions with key nuclear states to develop means to build international confidence, without unduly compromising nuclear secrets, that states have fulfilled their commitments to take effective nuclear security measures.

Complementing such government efforts, the nuclear industry should launch its own initiative focused on bringing the worst security performers up to the level of the best performers, through definition and exchange of best practices, industry peer reviews, and similar measures—a World Institute for Nuclear Security (WINS) on the model of the World Association of Nuclear Operators (WANO) established to improve global nuclear safety after the Chernobyl accident.

An Accelerated and Expanded Global Cleanout

The only foolproof way to ensure that nuclear material will not be stolen from a particular site is to remove it. As part of the global coalition to prevent nuclear terrorism, the United States should immediately begin working with other countries to take steps to accelerate and

expand the removal of weapons-usable nuclear material from vulnerable sites around the world. Where material cannot immediately be removed, the United States should speed steps to ensure that high levels of security will be put in place and maintained. The goal should be to remove the nuclear material entirely from the world's most vulnerable sites within four years—substantially upgrading security wherever that cannot be accomplished—and to eliminate all HEU from civilian sites worldwide within roughly a decade. The United States should make every effort to build international consensus that the civilian use of HEU is no longer acceptable, that all HEU should be removed from all civilian sites, and that all civilian commerce in HEU should be brought to an end as quickly as possible.

Achieving these goals will require a strengthened, broadened effort, including substantial packages of incentives to give up nuclear material, targeted to the needs of each facility and host country. The U.S. take-back offer should be expanded to cover *all* stockpiles of U.S.-supplied HEU, and, on a case-by-case basis, other weapons-usable nuclear material that poses a proliferation threat. The United States should seek agreement from Russia, Britain, France, and possibly other countries to receive and manage high-risk materials when the occasion demands. Those HEU-fueled research reactors that can convert to non-weapons-usable low-enriched uranium (LEU) using existing fuels should be given strong incentives to do so. The remaining HEU-fueled reactors that are still needed and cannot yet convert should be converted to LEU as soon as appropriate fuels are developed, and provided with high levels of security in the meantime. Aging and unneeded research reactors using HEU fuel should be given strong incentives to shut down—a step in many cases cheaper and quicker than conversion to LEU—perhaps as part of an IAEA-led

“Sound Nuclear Science Initiative” focused on getting the science, training, and isotope production the world needs at minimum cost, with a smaller number of more broadly shared research reactors. To not only remove threats from inside U.S. borders but also to enable U.S. leadership in convincing others to do the same, the United States should also convert or adequately secure its own HEU-fueled research reactors.

The focus on HEU should not lead the world community to ignore the burgeoning global stockpiles of separated civilian plutonium. The Bush administration should renew the effort to negotiate a 20-year U.S.-Russian moratorium on separating weapons-usable plutonium that was almost completed by 2001 and should work actively to ensure that its reconsideration of modified approaches to reprocessing in the Global Nuclear Energy Partnership does not encourage the spread of plutonium separation facilities.

Ingredients of Success

None of these initiatives will be easy. A maze of political and bureaucratic obstacles must be overcome quickly if the world's most vulnerable nuclear stockpiles are to be secured before terrorists and thieves get to them. The job of keeping nuclear weapons and their essential ingredients out of terrorist hands requires broad international cooperation affecting some of the most sensitive secrets held by countries around the globe. Sustained leadership from the highest levels of government, in the United States and around the world, will be needed. The United States should make nuclear security a central item on its diplomatic agenda, an item to be addressed at every opportunity, with every relevant state, at every level, until the job is done. Several ingredients will be critical to success.

First and most important, if political leaders and facility managers around the world are to take the actions necessary to achieve high levels of nuclear security, they must be convinced that nuclear theft and terrorism is a real and urgent threat to their own countries. Many of them are not convinced of this today. The United States and other countries should take several steps to build the needed sense of urgency and commitment, including:

- sponsoring briefings for political leaders of key countries, given jointly by U.S. and domestic nuclear experts, that outline both the very real possibility that terrorists could get nuclear material and make a nuclear bomb, and the global economic and political effects of a terrorist nuclear attack;
- encouraging leaders of key states to pick teams of security experts they trust to carry out fast-paced reviews of nuclear security in their countries assessing whether facilities are adequately protected against a set of threats the leaders would specify;
- working with key states to put in place regular systems of realistic testing of security performance;
- carrying out war games and similar exercises with senior policy-makers of key states; and
- creating shared databases of unclassified information on actual security incidents that offer lessons for the threats policy-makers and facility managers need to consider in deciding on nuclear security levels and the steps that can be taken to defeat those threats.

Second, success is likely to require mechanisms to keep the issue of nuclear security on the front burner at the top levels of

government, day-in and day-out. To lead these efforts in the United States, President Bush should appoint a senior full-time White House official with the access needed to walk in and ask for presidential action when needed. That official would be responsible for setting overall priorities, for eliminating overlaps, for seizing opportunities for synergy, and for finding and fixing the obstacles to progress in the scores of existing U.S. programs scattered across several cabinet departments of the U.S. government that are focused on pieces of the job of keeping nuclear weapons out of terrorist hands. As part of the global coalition described above, President Bush should lean on Russian President Putin and the leaders of other coalition participants to appoint a similar top-level official.

Third, the United States should base its international nuclear security approaches on genuine partnership, with experts from each country where these stockpiles reside playing key roles in the design, implementation, and evaluation of the entire effort in their countries. Experts from these countries will inevitably know more about their countries' stockpiles and what can and cannot be done there than U.S. experts will, and data from a wide range of other types of international assistance efforts make clear that the long-term success rate is far higher when assistance recipients are deeply involved in project design and implementation than when this is not the case. Strategic plans, timetables, and milestones should therefore be developed jointly by the country where the nuclear stockpiles in question exist and its foreign partners, using both the country's own funds and foreign funds. Steps to enhance or limit cooperation with particular countries on other matters—particularly with respect to nuclear technologies—should be considered in the light of their potential effect on cooperation to ensure effective nuclear security.

Finally, the United States and other providers of nuclear security assistance should take a flexible approach to ensuring that their taxpayers' funds are spent appropriately without unduly demanding that states open up their nuclear secrets. Methods that have proven effective include: providing training, software, and other tools that states can use to assess vulnerabilities and upgrade security themselves; providing U.S.-funded nuclear security equipment that recipient states install at their own expense; relying on photographs, videos, operational reports, and certifications by senior officials to ensure that equipment is installed and used as agreed; and using "trusted agents" from the country where cooperation is taking place, who have security clearances from that country but who are employed by a contractor from the donor country, to certify that equipment has been installed and used appropriately.

Options for the U.S. Congress

The U.S. Congress can also act to help reduce the chance that terrorists could acquire a nuclear weapons capability. In particular, Congress should consider:

- mandating fast-paced efforts to secure nuclear stockpiles and interdict nuclear smuggling worldwide;
- eliminating certification requirements and restrictions on threat reduction assistance;
- adding approximately \$50 million to the requested budget for GTRI, to expand the effort to cover additional at-risk materials and reactors, to fund needed incentives to states and facilities to give up their weapons-usable materials, to strengthen and accelerate the effort to upgrade security at HEU-fueled research reactors, and to

accelerate efforts to control radiological sources around the world;

- appropriating an additional \$5-\$10 million for the IAEA Office of Nuclear Security (with flexibility to spend it on the highest-priority tasks);
- adding approximately \$10 million to the requested budget for the Global Initiatives for Proliferation Prevention program, which now has opportunities for new work that were not envisioned when the FY 2007 budget was prepared;
- providing additional funding for programs to help ensure that partner states can and will sustain effective nuclear security for the long haul;
- offering a conditional appropriation in the range of \$200-300 million to finance accelerated blend-down of HEU in Russia to LEU, if U.S. and Russian negotiators reach accord on such an initiative; and
- increasing budgets and broadening authorities for programs at the Departments of Defense, Energy, and State to interdict nuclear smuggling and help countries improve export controls, to meet the charge of UNSCR 1540.

A LONG ROAD YET TO TRAVEL

As President Bush has said, the nations of the world must do "everything in our power" to ensure that terrorists never gain control of the fearsome power of a nuclear bomb. The steps recommended above could lead the way toward a faster, more effective, and more comprehensive effort to lock down the world's nuclear stockpiles before terrorists and criminals can get to them. There is still time to win the race to prevent a nuclear 9/11.

1

INTRODUCTION: UNDERSTANDING THE DANGER

Touring the devastation of Hurricane Katrina in September 2005, President George W. Bush said that the U.S. Gulf Coast looked as though it had been “obliterated by the worst kind of weapon you can imagine.”¹ Unfortunately, he was profoundly wrong: the devastation that would be wreaked by a terrorist nuclear bomb, while concentrated in a smaller geographic area, would make the damage of Katrina pale by comparison. There would be no warning, and no one would have the chance to evacuate. Rather than hundreds to a few thousand deaths, there would be tens to hundreds of thousands of deaths. Hundreds of thousands more would be injured, burned, or irradiated, requiring immediate medical help—but most of the area’s medical facilities would have been obliterated. Rather than being submerged in water, the heart of the targeted city would be utterly destroyed by blast and fire, with any hope of rebuilding thrown into doubt by lingering radiation. Many police, fire department, and National Guard personnel would be killed in the initial blast, and much of their equipment destroyed. No one would know if the terrorists had another such weapon—and they might well claim they did, sowing uncertainty and panic. America and the world would be changed forever.

THE FACTS THAT FRAME THE DANGER

Today, there is still an unacceptable danger that terrorists might succeed in their

¹Quoted in Peter Baker, “An Embattled Bush Says ‘Results Are Not Acceptable,’” *Washington Post*, 3 September 2005.

quest to get and use a nuclear bomb, turning a modern city into a smoking ruin.² There remains a dangerous gap between the scope and pace of the U.S. and world response and the urgency of the threat—though that gap has narrowed significantly in recent years, with actions such as an accord on nuclear security between U.S. President George W. Bush and Russian President Vladimir Putin at their summit in Bratislava, Slovakia, in early 2005, and the launch of the Global Threat Reduction Initiative in early 2004.

²For recent assessments of the danger of nuclear terrorism and actions that should be taken to address it from other authors, see, for example, Graham T. Allison, *Nuclear Terrorism: The Ultimate Preventable Catastrophe*, 1st ed. (New York: Times Books/Henry Holt, 2004); Christopher F. Chyba, Hal Feiveson, and Frank Von Hippel, *Preventing Nuclear Proliferation and Terrorism: Essential Steps to Reduce the Availability of Nuclear-Explosive Materials* (Palo Alto, Cal.: Center for International Security and Cooperation, Stanford Institute for International Studies, Stanford University, and Program on Science and Global Security, Woodrow Wilson School of Public and International Affairs, Princeton University, 2005; available at http://iis-db.stanford.edu/pubs/20855/Prvnt_Nuc_Prlf_and_Nuc_Terror_2005-0407.pdf as of 1 April 2006); Charles D. Ferguson, William C. Potter, and Leonard S. Spector (with Amy Sands, and Fred L. Wehling), *The Four Faces of Nuclear Terrorism* (Monterey, Cal.: Center for Nonproliferation Studies, Monterey Institute of International Studies, 2004; available at http://www.nti.org/c_press/analysis_4faces.pdf as of 1 April 2006); Anna M. Pluta and Peter D. Zimmerman, “Nuclear Terrorism: A Disheartening Dissent,” *Survival* 48, no. 2 (Summer 2006).

For views more skeptical of the danger (though still generally supporting similar policies to further reduce the risk), see, for example, Robin M. Frost, “Nuclear Terrorism after 9/11,” *Adelphi Papers*, no. 378 (2005); Corine Hegland and Gregg Webb, “The Threat,” *National Journal* (15 April 2005; available at <http://nationaljournal.com/about/njweekly/stories/2005/0415nj1.htm> as of 7 April 2006).

The facts that frame the danger are stark.

First, by word and deed, al Qaeda and the global movement it has spawned have made it clear that they want nuclear weapons. Osama bin Laden has called acquiring nuclear weapons a “religious duty.”³ Al Qaeda operatives have repeatedly attempted to obtain nuclear material and recruit nuclear expertise. The U.S. government has formally charged that bin Laden has been seeking nuclear weapons and the materials to make them since the early 1990s⁴—and by 1996, the CIA’s bin Laden unit had documented a “professional” nuclear acquisition effort leaving “no doubt that al-Qaeda was in deadly earnest in seeking nuclear weapons.”⁵ Two senior Pakistani nuclear weapons scientists met with bin Laden at length and discussed nuclear weapons.⁶ Documents recovered in Afghanistan re-

veal a significant nuclear research effort.⁷ Long after the removal of al Qaeda’s Afghanistan sanctuary, bin Laden sought and received a religious ruling or *fatwa* from a radical Saudi cleric authorizing the use of nuclear weapons against American civilians.⁸

Second, if terrorists could obtain the HEU or plutonium that are the essential ingredients of a nuclear bomb, making at least a crude nuclear bomb might well be within the capabilities of a sophisticated

³ Rahimullah Yusufzai, “Interview with Bin Laden: World’s Most Wanted Terrorist,” *ABC News* (1999; available at <http://www.islamistwatch.org/blogger/localstories/05-06-03/ABCInterview.html> as of 4 April 2006).

⁴ “Text: US Grand Jury Indictment against Usama Bin Laden” (New York: United States District Court, Southern District of New York, 1998; available at http://www.fas.org/jrp/news/1998/11/98110602_nlt.html as of 4 April 2006).

⁵ Anonymous [Michael Scheuer], “How Not to Catch a Terrorist,” *Atlantic Monthly* (December 2004; available at <http://www.theatlantic.com/doc/200412/anonymous> as of 8 June 2006).

⁶ Kamran Khan and Molly Moore, “2 Nuclear Experts Briefed Bin Laden, Pakistanis Say,” *Washington Post*, 12 December 2001; Kamran Khan, “Pakistan Releases Nuclear Scientists for Ramadan’s End,” *The Washington Post*, 16 December 2001; Peter Baker, “Pakistani Scientist Who Met Bin Laden Failed Polygraphs, Renewing Suspicions,” *Washington Post*, 3 March 2002. The most thorough available account of the incident and related issues is David Albright and Holly Higgins, “A Bomb for the Ummah,” *Bulletin of the Atomic Scientists* (March/April 2003; available at <http://www.thebulletin.org/issues/2003/ma03/ma03albright.html> as of 17 July 2005). Ummah is a term for the worldwide Islamic community.

⁷ For useful accounts of al Qaeda’s nuclear efforts, see, for example, David Albright, “Al Qaeda’s Nuclear Program: Through the Window of Seized Documents,” *Nautilus Institute Special Forum* 47 (2002; available at http://www.nautilus.org/archives/fora/Special-Policy-Forum/47_Albright.html as of 17 June 2006); David Albright, Kathryn Buehler, and Holly Higgins, “Bin Laden and the Bomb,” *Bulletin of the Atomic Scientists* (January/February 2002; available at <http://www.isis-online.org/publications/terrorism/binladenandbomb.pdf> as of 3 June 2006); 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; available at http://www.rand.org/pubs/documented_briefings/2005/RAND_DB458.sum.pdf as of 3 June 2006). For a quick summary of open reporting on al Qaeda’s efforts, see Weapons of Mass Destruction Terrorism Research Program, “Chart: Al Qaeda’s WMD Activities” (Monterey, Cal.: Center for Nonproliferation Studies, Monterey Institute of International Studies, 2005; available at http://cns.miis.edu/pubs/other/sjm_cht.htm as of 23 May 2006). For a useful discussion of the early days of al Qaeda’s efforts, see text and sources in Gavin Cameron, “Multitrack Microproliferation: Lessons from Aum Shinrikyo and Al Qaeda,” *Studies in Conflict and Terrorism* 22, no. 4 (October-December 1999).

⁸ The translated quote is from testimony by then-Attorney General John Ashcroft, in Committee on the Judiciary, *United States Department of Justice*, U.S. House of Representatives, 108th Congress, 1st Session (5 June 2003; available at <http://judiciary.house.gov/media/pdfs/printers/108th/87536.PDF> as of 4 April 2006). The author of the fatwa is Nasser bin Hamed al-Fahd. He has since been arrested, and has publicly renounced some of his previous rulings, though whether this one is among them is not clear.

group.⁹ One study by the now-defunct congressional Office of Technology Assessment summarized the threat:

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.¹⁰

The 9/11 Commission offered a very similar warning, arguing that with the needed highly enriched uranium or plutonium, a terrorist group “could fashion a nuclear device that would fit in a van like the one Ramzi Yousef parked in the garage of the World Trade Center in 1993. Such a bomb would level Lower Manhattan.”¹¹ Even before the Afghan war, 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.”¹² Documents later seized

in Afghanistan provided “detailed and revealing” information about the progress of al Qaeda’s nuclear efforts that had not been available before the war.¹³

Third, hundreds of tons of nuclear material, not just in the former Soviet Union but in dozens of countries around the world, remain dangerously vulnerable to theft. There are no binding global nuclear security standards, and nuclear security around the world varies from excellent to appalling. In November 2004, for example, the U.S. government Accountability Office reported the results of a Department of Energy study that concluded that there are 128 nuclear research reactors or associated facilities around the world with 20 kilograms of HEU or more—a larger number of facilities with enough material for a bomb than had previously been publicly recognized.¹⁴ These facilities exist in dozens of countries around the world, and many have no more security than a night watchman and a chain-link fence.¹⁵

Most of the nuclear facilities around the world, including many in the United States, would not be able to provide a reliable defense against attacks as large as

⁹For a discussion of the vast difference between a safe, reliable, efficient weapon that can be carried on a missile, and a crude, inefficient, unsafe terrorist bomb that might be delivered in a rented truck, with references to relevant unclassified government studies, see Matthew Bunn and Anthony Wier, “Terrorist Nuclear Weapon Construction: How Difficult?” *Annals of the American Academy of Political and Social Science* 607 (September 2006). See also Pluta and Zimmerman, “Nuclear Terrorism.”

¹⁰U.S. Congress, Office of Technology Assessment, *Nuclear Proliferation and Safeguards* (Washington, D.C.: OTA, 1977; available at <http://www.wws.princeton.edu/ota/disk3/1977/7705/7705.PDF> as of 22 April 2006), p. 140.

¹¹National Commission on Terrorist Attacks upon the United States, *The 9/11 Commission Report: Final Report of the National Commission on Terrorist Attacks Upon the United States*, 1st ed. (New York: Norton, 2004; available at <http://www.gpoaccess.gov/911/index.html> as of 28 January 2006), p. 380.

¹²Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction, *Report to the President* (Washington, D.C.:

WMD Commission, 2005; available at <http://www.wmd.gov/report/> as of 5 April 2006), p. 276.

¹³Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction, *Report to the President*, p. 271.

¹⁴U.S. Congress, Government Accountability Office, *Nuclear Nonproliferation: DOE Needs to Take Action to Further Reduce the Use of Weapons-Usable Uranium in Civilian Research Reactors*, GAO-04-807 (Washington, D.C.: GAO, 2004; available at <http://www.gao.gov/new.items/d04807.pdf> as of 2 February 2006), p. 28.

¹⁵Matthew 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; available at http://www.nti.org/e_research/cnwm/overview/2004report.asp as of 1 February 2006), pp. 36-37.

terrorists have already proved they can mount, such as the four coordinated, independent teams of four to five suicidal terrorists each that struck on September 11, 2001, or the 30-plus terrorists armed with automatic weapons and explosives who seized a thousand hostages at the school in Beslan in September 2004. A conspiracy of several insiders working together—possibly coerced by terrorists to do so, as in past cases where insiders' families have been kidnapped—would be even more difficult to defend against.

Indeed, theft of the essential ingredients of nuclear weapons is not a hypothetical worry, it is an ongoing reality: the International Atomic Energy Agency (IAEA) has documented 18 cases of theft involving weapons-usable plutonium or HEU.¹⁶

Fourth, if terrorists could steal, buy, or make a nuclear bomb, there can be little confidence that the government could stop them from smuggling it into the United States. After all, thousands of tons of illegal drugs and hundreds of thousands of illegal immigrants cross U.S. borders every year, despite massive efforts to stop them.¹⁷ The essential ingredients of a nuclear bomb can fit easily into a briefcase,

¹⁶ See, for example, International Atomic Energy Agency, "Calculating the New Global Nuclear Terrorism Threat" (Vienna: IAEA, 2001; available at http://www.iaea.org/NewsCenter/PressReleases/2001/nt_pressrelease.shtml as of 16 February 2006). The IAEA subsequently removed one case from its list (apparently concluding that the amount of plutonium involved in that case was so minimal that it should be considered a radioactive source), bringing the total to down to 17. But then in 2003, 170 grams of HEU enriched to 89% U-235 was seized, bringing the total back to 18. This incident is described in International Atomic Energy Agency, *Annual Report 2004* (Vienna: IAEA, 2005; available at http://www.iaea.org/Publications/Reports/Anrep2004/anrep2004_full.pdf as of 16 February 2006), p. 56.

¹⁷ See, for example, Rensselaer Lee, *Nuclear Smuggling and International Terrorism: Issues and Options*

and the weak radiation these materials emit can be made quite difficult to detect with the use of modest amounts of shielding—particularly in the case of HEU, which is far less radioactive than plutonium.¹⁸ Even if effective detection systems and procedures were put in place at all U.S. ports and other official points of entry, there are myriad other ways that terrorists could get a nuclear bomb or its essential ingredients into the United States.

It is worth investing in improved border detection systems to make the smuggler's job more difficult and uncertain. But the world should not place undue reliance on this last-ditch line of defense. Defending primarily at the border is like a football team defending at its own goal line—but with that goal line stretched to thousands of kilometers, much of it unmonitored, with millions of legitimate people and vehicles crossing it every year.

Fifth, such a crude terrorist bomb would potentially be capable of incinerating the heart of any city. A bomb with the explosive power of 10,000 tons of TNT (that is, smaller than the bomb that obliterated Hiroshima), if set off in midtown Manhattan on a typical workday, could kill half a million people and cause more than \$1 trillion in direct economic damage.¹⁹ Devastating economic aftershocks would reverberate throughout the world.

for U.S. Policy, RL31539 (Washington, D.C.: Congressional Research Service, 2002).

¹⁸ For discussion, see John P. Holdren and Matthew Bunn, "Technical Background: A Tutorial on Nuclear Weapons and Nuclear-Explosive Materials," 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, 2002; available at http://www.nti.org/e_research/cnwm/overview/technical.asp as of 16 February 2006).

¹⁹ See Matthew Bunn, Anthony Wier, and John Holdren, *Controlling Nuclear Warheads and Materials:*

FACING THE FACTS

For these reasons, the need for accelerated action to reduce the threat of nuclear terrorism is not a partisan issue in the United States. In their 2004 presidential contest, President Bush and Senator John Kerry agreed that the danger that terrorists could get and use a nuclear bomb was real enough to constitute the single most serious threat to U.S. national security.²⁰ Similarly, the bipartisan 9/11 Commission concluded that “[t]here is simply no higher priority on the national security agenda” than preventing terrorist access to weapons of mass destruction.²¹ The Bush administration’s 2006 *National Security Strategy* highlights the danger posed by inadequately protected nuclear stockpiles around the world as a key threat to the United States, and calls for a “global effort to reduce and secure such materials as quickly as possible.”²²

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/overview/report.asp as of 1 February 2006), pp. 15-19.

²⁰ Commission on Presidential Debates, “September 30, 2004: The First Bush-Kerry Presidential Debate” (2004; available at <http://www.debates.org/pages/trans2004a.html> as of 28 March 2006).

²¹ “9/11 Public Discourse Project Holds a News Conference on Government Implementation of the 9/11 Commission’s Recommendations on Foreign Policy, Public Diplomacy and Nonproliferation - News Conference” (Washington, D.C.: Political Transcripts by CQ Transcriptions, 2005; available at http://www.9-11pdp.org/press/2005-11-14_remarks.pdf as of 24 April 2006).

²² *The National Security Strategy of the United States of America* (Washington, D.C.: U.S. National Security Council, 2006; available at <http://www.whitehouse.gov/nsc/nss/2006/> as of 23 May 2006), p. 21. In this report, we use the phrase “nuclear stockpiles” to refer both to stockpiles of nuclear weapons and to stockpiles of weapons-usable nuclear materials. Where we wish to refer to one type of stockpile or another, we specify that we are referring to weapons or to materials.

At the same time, while urgent actions to reduce the threat are justified, exaggeration and panic are not. Detonating an actual nuclear bomb would be among the most difficult types of attack for terrorists to accomplish, and the vast majority of terrorist activity around the world is focused on conventional means of destruction. But as the Bush administration’s *National Security Strategy* points out, “[n]uclear weapons are unique in their capacity to inflict instant loss of life on a massive scale,” which may give them “special appeal” to terrorists.²³

The partial and fragmentary publicly available information about al Qaeda’s nuclear efforts suggests only a modest level of nuclear expertise—but that offers only small comfort, given how little is known.²⁴ Terrorists’ nuclear pursuits are carried out in secret, and little is known about how far terrorists may have progressed. The Robb-Silberman commission on U.S. intelligence on weapons of mass destruction, which had full access to all classified information, pointed out that the U.S. government knew very little about al Qaeda’s nuclear efforts, and that key intelligence judgments about them cited virtually no evidence for the conclusions drawn.²⁵ Similarly, the world was largely unaware of Aum Shinrikyo’s years-long efforts to get a nuclear bomb until the group announced itself by launching a

²³ *The National Security Strategy of the United States of America*, p. 19.

²⁴ Matthew Bunn, Anthony Wier, and Joshua Friedman, 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 Nuclear Threat Initiative, 2005; available at http://www.nti.org/e_research/cnwm/threat/demand.asp as of 20 April 2006).

²⁵ Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction, *Report to the President*, pp. 267-278.

nerve gas attack in the Tokyo subway. Given that record, there can be little basis for confidence that the world would know that a terrorist group was putting together the capabilities needed to build a nuclear bomb before it was too late.

The removal of the Afghanistan sanctuary and the other disruptions al Qaeda has faced since 9/11 have almost certainly made it more difficult for al Qaeda to get the essential ingredients of nuclear weapons and make them into a bomb. But some part of the resilient, loosely linked global movement that is today's al Qaeda might well be able to put together the small group with modest, commercially available equipment needed to turn weapons-usable nuclear material into a bomb. And whether that bomb-making project took place in any of the scores of "stateless zones" around the world where U.S. intelligence fears that terrorists may be building their capabilities,²⁶ or even on a ranch or in a garage in a developed country, the effort might well succeed in remaining entirely secret. It is possible, in short, that there would be no warning that terrorists had made the leap from nuclear ambitions to real nuclear capabilities until it was too late.²⁷

Estimates from well-informed observers of the probability of a terrorist nuclear attack in the next decade range from one

²⁶Select Committee on Intelligence, *Current and Projected National Security Threats to the United States*, U.S. Senate, 108th Congress, 2nd Session (24 February 2004; available at <http://intelligence.senate.gov/0402hr/040224/witness.htm> as of 28 February 2006).

²⁷For an extensive discussion of the myths that lead many officials and analysts to unduly downplay the danger of nuclear terrorism, see "Debunking Seven Myths of Nuclear Terrorism and Nuclear Theft," in Bunn and Wier, *Securing the Bomb: An Agenda for Action*, pp. 10-30.

percent to 50 percent or more.²⁸ Given the immense uncertainties, immediate and substantial actions to lower the risk are justified—if only as an insurance policy against a huge but unlikely danger. The United States spent trillions of dollars over several decades in its efforts to reduce the already small danger of a Soviet nuclear attack, because of the unfathomable consequences of such an attack. A small fraction of the funds and high-level political focus devoted to that effort, over just a few years, could reduce the danger of nuclear terrorism dramatically.

A ROADMAP FOR OUR REPORT

This report, the fifth in an annual series, uses a variety of measures to assess the progress the United States and its international partners have made in the past year in improving controls over the world's stockpiles of nuclear weapons and their essential ingredients, to reduce the danger that they could fall into terrorist hands.²⁹ Like previous reports in

²⁸Former Secretary of Defense William Perry and former Assistant Secretary of Defense Graham Allison are among those who have estimated a 50% or more chance of a terrorist nuclear attack in the next ten years. See Nicholas D. Kristof, "An American Hiroshima," *New York Times*, 11 August 2004; Allison, *Nuclear Terrorism: The Ultimate Preventable Catastrophe*. David Albright, who has done some of the most detailed unclassified analyses of al Qaeda's nuclear efforts, has offered a 1 percent estimate. See Hegland and Webb, "The Threat."

²⁹The previous reports are: Matthew Bunn and Anthony Wier, *Securing the Bomb 2005: The New Global Imperatives* (Cambridge, Mass., and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, 2005; available at http://www.nti.org/e_research/report_cnmwupdate2005.pdf as of 6 June 2006); Bunn and Wier, *Securing the Bomb: An Agenda for Action*; Bunn, Wier, and Holdren, *Controlling Nuclear Warheads and Materials: A Report Card and Action Plan*. This report and its predecessors have an on-line companion, "Securing the Bomb" (available at <http://www.nti.org/securingthebomb>), which provides in-depth

this series, it focuses only on reducing the risk that terrorists might actually get and use a nuclear explosive. In particular, it addresses progress in efforts to improve controls over nuclear weapons, materials, and expertise that have been funded by the United States (which has been the pre-eminent, but not the only, sponsor of such threat reduction programs to date).³⁰

This report emphasizes that the danger of nuclear theft is a global problem, not just a Russia problem, and begins to shift toward providing more information (where it is available) on the global picture. But the reality is that the overwhelming majority of the work done to address this problem to date has taken place in the former Soviet Union, and after more than a decade of effort there, more comprehensive data about what has been accomplished and what remains to be done are available for the former Soviet Union than are available for any other part of the world. Hence, most of the data presented in this report still remain focused on the former Soviet Union. The limitations of the data available on the most urgent nuclear security priorities elsewhere in the world is a problem in itself: the reality is that neither the U.S.

supporting information, including the most comprehensive assessments available anywhere of the individual programs focused on keeping nuclear weapons, materials, and expertise out of terrorist hands; an interactive threat reduction budget database; technical background; legislative updates; scores of photographs; and hundreds of annotated links to the best information on these efforts available on the web.

³⁰ For further explanation and links to other useful resources, see Bunn and Wier, *Securing the Bomb 2005*, pp. 6-7. Also see Matthew Bunn and Anthony Wier, "About Securing the Bomb," 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; available at http://www.nti.org/e_research/cnwm/overview/about.asp as of 27 February 2006).

government nor any other government or organization around the world has a complete picture of all the factors involved in prioritizing where the most urgent threats of nuclear theft lie—not only where all the facilities with nuclear weapons and weapons-usable nuclear material are, but the quality of their security systems, and the scale of the threats those systems must address (ranging from the capabilities terrorists or criminals could plausibly bring to bear to steal weapons or materials, to morale, pay, and corruption among the facility staff). Putting together as much of that comprehensive picture as possible—and then building a genuinely prioritized plan to reduce the risks around such an assessment—is an urgent task.

After this introduction, the following chapter focuses on the key challenges to be faced in the global struggle to prevent nuclear terrorism. We highlight some of the most important developments over the last year, discussing how these developments have altered the shape of the challenges the United States and the world face and how these changes have affected the work remaining to be done.

From there we turn to a detailed assessment, using a set of quantifiable metrics, of both the progress U.S.-funded programs have made to date in reducing the threat posed by inadequate security for nuclear weapons, materials, and expertise in the former Soviet Union and around the world, and the rate at which further progress is being made. These measures attempt to gauge progress across a series of tasks in preventing nuclear terrorism.³¹

³¹ For an explanation of how the goals defined in Chapter 3 serve to reduce the threat of nuclear terrorism, see Matthew Bunn, Anthony Wier, and John Holdren, "Blocking the Terrorist Pathway to the Bomb," in *Nuclear Threat Initiative Research Library: Securing the Bomb* (Cambridge, Mass., and Washington, D.C.: Project on Managing the Atom, Harvard

We focus on U.S.-funded programs because they are dramatically larger than cooperative nuclear security programs sponsored by other countries, and because the data available to describe the progress of U.S.-funded programs are far better than the data available for the efforts of other donors.

We follow our progress assessment with a short chapter reviewing the current and proposed U.S. budgets focused on controlling nuclear warheads, materials, and expertise. In an environment in which higher budgets are being proposed for national security, homeland security, and diplomacy and international assistance while other activities are facing budget cuts, the administration is proposing a slight annual increase for the fiscal year starting in October 2006 for programs focused on controlling nuclear warheads, materials, and expertise. In most cases, simply adding more money to existing programs would not substantially accelerate progress if nothing else changed. But there are a few areas where money is a critical limiting factor, and small infusions

University, and Nuclear Threat Initiative, 2003; available at http://www.nti.org/e_research/cnwm/overview/path.asp as of 1 February 2006).

of additional funds could make a substantial difference in accelerating progress.

Finally, in the last chapter we outline an updated action agenda, offering ways that the United States, Russia, and other key states can build toward a global effort whose scope and pace might match the urgency of the threat. In particular, the time has come to launch a global coalition against nuclear terrorism, whose participants would agree to secure their own stockpiles to stringent standards, to step up intelligence sharing both on potential nuclear terrorist groups and on dangers of nuclear theft and smuggling, to cooperate in interdicting nuclear transfers, and to take other steps in partnership to lower the risk of nuclear terrorism. As former Senator Sam Nunn has said, the world is in a "race between cooperation and catastrophe."³² This is a race that the United States, Russia, and their partners cannot afford to lose; luckily, it is a race they still have a chance to win. There is still a good chance to prevent a nuclear terrorist catastrophe from ever occurring.

³² Sam Nunn, "The Race between Cooperation and Catastrophe-Reducing the Global Nuclear Threat: A Speech at the National Press Club" (Washington, D.C.: Nuclear Threat Initiative, 2005; available at http://www.nti.org/c_press/c1_speeches.html#pressclub as of 24 April 2006).

2 PREVENTING NUCLEAR TERRORISM: KEY REMAINING CHALLENGES

To prevent a nuclear 9/11, the world community must seek to block every step on the terrorist pathway to the bomb.¹ Doing everything possible to find and defeat terrorist groups with the ambition and sophistication needed for a nuclear attack is a crucial first step.

But these groups' ambitions cannot be fulfilled unless they can get a nuclear weapon or the materials needed to make one: no nuclear material, no nuclear terrorism. The step on the terrorist pathway to a nuclear attack that can most directly and reliably be stopped is the removal of nuclear warheads and materials from the facility housing them. Hence, the most critical step in protecting U.S. homeland security—and international security—from the danger of nuclear terrorism is securing stockpiles of nuclear weapons and weapons-usable material in the former Soviet states and around the world, or removing such stockpiles when they cannot be reliably secured. Reducing the small but real risk that states might transfer nuclear weapons, technology, or materials to terrorists is an important complementary step.

Improving global capabilities to find and recover nuclear material and interdict nuclear smuggling offers an important next line of defense, but these tasks are

¹ See the discussion in Matthew Bunn, Anthony Wier, and John Holdren, "Blocking the Terrorist Pathway to the Bomb," 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, 2003; available at http://www.nti.org/e_research/cnwm/overview/path.asp as of 1 February 2006).

so challenging that they offer less leverage in reducing the risk. Most of this report focuses on these two first lines of defense—securing nuclear stockpiles, and interdicting nuclear smuggling. Other measures to improve controls over nuclear warheads, materials, and expertise also require attention, however, from providing alternative employment for excess nuclear weapons workers to reducing the total size of the world's stockpiles of potential nuclear bomb materials, and these steps are also addressed in this report, though more briefly. In this chapter, we lay out some of the key remaining challenges facing these international cooperative efforts, and key developments that have affected these programs in the past year. Then, in the next chapter, we offer detailed measures of the progress of U.S.-funded efforts to keep nuclear warheads, materials, and expertise out of terrorist hands.

LOCKING DOWN NUCLEAR STOCKPILES AROUND THE WORLD

Terrorists have demonstrated global reach, and will not care where they get the essential ingredients to fuel their nuclear ambitions. Hence, nuclear weapons and the materials needed to make them must be made secure no matter where they are located. Substantial progress toward that goal has been made in the last few years—but dangerous gaps remain.

Locking Down Nuclear Stockpiles in Russia

The danger of nuclear theft is not a Russia problem, it is a global problem. Highly

enriched uranium (HEU) or separated plutonium exist in some 40 countries around the world, with widely varying levels of security.

But there are good reasons why post-Soviet Russia remains a focus of concern. Russia has the world's largest stockpiles of both nuclear weapons and the materials to make them, scattered among hundreds of buildings and bunkers at scores of sites. Over the past 15 years security for those stockpiles has improved from poor to moderate, but there remain immense threats those security systems must confront.

Dangerous threats. Russia remains the only country where senior officials have confirmed that terrorists have carried out reconnaissance at nuclear warhead storage facilities.² In late 2005, Russian Interior Minister Rashid Nurgaliev, in charge of the troops that guard most key nuclear facilities in Russia, 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."³ The scale of the threats terrorist groups in Russia pose has been demonstrated all too well in incidents like the 2004 attack by 32 terrorists on the school in Beslan and the 2002 takeover by 41 terrorists of a theater in Moscow—both of which involved well-trained terrorist teams armed with automatic weapons, rocket-propelled grenades, and explosives, who launched carefully planned attacks with no warning

²Pavel Koryashkin, "Russian Nuclear Ammunition Depots Well Protected—Official," *ITAR-TASS*, 25 October 2001.

³"Internal Troops to Make Russian State Facilities Less Vulnerable to Terrorists," *RIA-Novosti*, 5 October 2005.

and who were prepared to die for their cause.⁴

The possibility of insider conspiracies to steal nuclear weapons or material—or to help outsiders do so—is no less alarming. Corruption and insider theft of a wide range of valuables are endemic in today's Russia.⁵ These problems have deeply penetrated into the military and the security and law enforcement services (including the interior ministry forces charged with guarding nuclear facilities); theft and sale of weapons, fuel, and other military property are commonplace.⁶ Indeed, the Russian Audit Chamber reportedly concluded that when submarines arrive

⁴In both cases, the terrorists were heavily armed, well-trained, had large quantities of explosives, and were prepared to die. Russian intelligence analysts believe that Chechen terrorists have largely adopted Soviet Spetznatz special forces tactics (some Chechen fighters were trained in Spetznatz units), and should be assumed to have access to weapons, body armor, and night vision equipment comparable to those of elite Russian military units (because they are able to acquire these items from corrupt Russian servicemen). Interview with retired Russian military intelligence (GRU) officer, July 2004. Nor are the numbers of attackers in these cases the upper limit for terrorist attacks in Russia: the Beslan attack, for example, was preceded by an even larger raid on an arms depot, apparently to acquire some of the arms for Beslan. See Mark Deich, "The Ingushetia Knot," *Moskovskii Komsomolets*, 6 August 2004.

⁵One recent survey by a respected Russian non-governmental organization concluded that the cost of bribes in Russia's economy had burgeoned nearly ten-fold from 2001-2005, and was now more than double total federal government expenditures. See Arkady Ostrovsky, "Bribery in Russia up Tenfold to Dollars 316bn in Four Years," *Financial Times*, 22 July 2005.

⁶In a 2005 press conference, Russia's chief military prosecutor reported that property crimes in the military are still increasing—including in the interior ministry forces, which guard Russia's nuclear facilities. See Colonel-General Alexander S. Savenkov, "Press Conference with Chief Military Prosecutor Alexander Savenkov" (Moscow: RIA Novosti, 2005).

at a Murmansk facility to be dismantled, 50% of their electronic components have already been stolen—and a gang war that led to several murders in Murmansk apparently focused on control of the lucrative trade in stolen sub parts.⁷ Even more disturbing, corrupt or ideologically converted law enforcement officers or security officials—again, including some from the interior forces that guard nuclear facilities—are believed to have directly contributed to some of the recent brutal terrorist attacks in Russia.⁸

The corruption case against former Minister of Atomic Energy Yevgeni Adamov is only one of many indicators suggesting that this corruption and insider theft has penetrated Russia's nuclear establishment as well. In April 2006, Russian police arrested a group of conspirators that included a foreman at the Elektrostal nuclear fuel fabrication facility—which processes large quantities of HEU every year—for stealing 22 kilograms of low-enriched uranium.⁹ Several of the mayors of Russia's ten closed nuclear cities have been arrested or forced out either for corruption, or for helping to set up fraudulent tax schemes for Yukos and other businesses.¹⁰ An investigation by a

⁷ "Enormous Damage' from Equipment Theft in Russian Navy", *RTR-TV* (Moscow) (2003).

⁸ See discussion in Simon Saradzhyan and Nabi Abdullaev, "Disrupting Escalation of Terror in Russia to Prevent Catastrophic Attacks," *Connections* (Spring 2005).

⁹ "Foreman Traded Raw Materials for Atom Bomb," trans. World News Connection, *Moskovskiy Komso-molets*, 13 April 2006.

¹⁰ Yevgeny Tkachenko, "Mayor of Russia Nuclear City Arrested on Charge of Bribery," *ITAR-TASS* 2005. Officials in the closed cities of Lesnoy, Trekhgornyy, and Sarov were also caught up in efforts by prosecutors to examine wrong-doing in the oil company Yukos's tax dealings; the governments of the three cities are alleged to have helped Yukos set up shell companies to take advantage of tax-free status that had been given to the closed cities during the

team of American and Russian researchers uncovered extensive corruption, drug use, organized crime activity, and theft of metals and other valuable items at the Mayak plutonium and HEU processing facility in the closed city of Ozersk.¹¹ In short, the threat of insider theft is very real.

Continuing weaknesses. At the same time, neither the personnel nor the equipment for protecting against these threats are yet what they should be. Low pay, poor conditions, and low morale undermine the effectiveness of Russia's nuclear guard forces.¹² Incidents of brutal hazing and suicide remain troublingly common among those guarding Russia's closed nuclear cities.¹³ One recent indicator of the effectiveness of these cities' guard forces would be funny if it were not so serious: in late 2005, a resident of the closed nuclear city of Lesnoy, site of a major nuclear

1990s to foster economic growth. See "Hearing of Tax Ministry Vs. Yukos Case Continues on Tuesday," *Interfax*, 25 May 2004.

¹¹ Robert Orttung and Louise Shelley, *Linkages between Terrorist and Organized Crime Groups in Nuclear Smuggling: A Case Study of Chelyabinsk Oblast*, PO-NARS Policy Memo No. 392 (Washington, D.C.: 2005; available at http://www.csis.org/media/csis/pubs/pm_0392.pdf as of 12 April 2006).

¹² For a remarkable 2003 account of how ineffective some of these guard forces are, by the official who was then the security chief at Seversk, one of Russia's largest plutonium and HEU facilities, see Igor Goloskokov, "Refomirovanie Voisk MVD Po Okhrane Yadernikh Obektov Rossii (Reforming MVD Troops to Guard Russian Nuclear Facilities)," trans. Foreign Broadcast Information Service, *Yadernyy Kontrol* 9, no. 4 (Winter 2003; available at <http://www.pircenter.org/data/publications/yk4-2003.pdf> as of 28 February 2006).

¹³ See, for example, "Analysis: Hazing in Russian Guard Units Threatens Nuclear Cities Security," *Foreign Broadcast Information Service*, 9 June 2005. For a deeply troubling 2003 account of the ineffectiveness of the forces guarding the massive plutonium and HEU stockpiles at Seversk, by the chief of security at the site at the time, see Goloskokov, "Reforming MVD Troops to Guard Russian Nuclear Facilities [Translated]."

weapon assembly and disassembly facility, dressed in combat fatigues and used a forged identification badge with the name and photograph of Chechen terrorist leader Salman Raduev to pass through three guarded checkpoints and gain access to the closed city.¹⁴ Obviously that city's guards were not bothering to check whether people had legitimate passes to the city or not.

In addition, security systems for Russia's nuclear stockpiles remain severely underfunded. Experts from Russian sites continue to describe immense difficulties in getting funding for physical protection or material accounting improvements that the United States will not pay for.¹⁵ Indeed, representatives of two Russian sites recently independently estimated that the upgraded systems the United States is paying to install would only last five years after U.S. assistance is phased out if Russian support does not increase.¹⁶ In May 2005, the head of Eleron, the physical protection firm for the Russian atomic energy agency (known by its Russian name Rosatom), estimated that funding for nuclear security comes to only 30% of the need.¹⁷ In March 2005, the commander of the Ministry of Interior (MVD) troops for the Moscow district said that only seven of the critical guarded facilities in the district had adequately maintained security equipment, while 39 had "serious shortcomings" in

¹⁴ "The Shadow of Salman Raduev Wanders in Lenoynoy," trans. A. Deyanov, Department of Energy, *Uralpolit.ru*, 26 December 2005.

¹⁵ Interviews with Russian experts, May and July 2005.

¹⁶ Discussions in Obninsk, Russia, 16-20 May 2005.

¹⁷ Nikolai N. Shemigon, director-general, Eleron (Rosatom's physical protection firm), remarks to "Third Russian International Conference on Nuclear Material Protection, Control, and Accounting," 16-20 May 2005, Obninsk, Russia.

their physical protection.¹⁸ This lack of funding persists even though the Russian government today, flush with revenues from high international oil prices and Russia's continuing economic recovery, has the resources to finance its nuclear security systems alone—if the Russian government were to assign such security the priority it deserves.

Finally, the centralization of power in the hands of President Putin, and increasing constraints on any public discussion of sensitive topics like nuclear security, have undermined independent oversight by the Russian Duma, the press, and non-government organizations that could otherwise create pressures for additional action to secure nuclear stockpiles—as such independent voices do in the United States.

Limited threats addressed. Nevertheless, there is no doubt that security for Russia's nuclear warheads and materials has in fact improved substantially over the last dozen years. Russia's economy has stabilized, and has been growing steadily since 1998. Nuclear experts and workers are now paid a living wage, on time, reducing the incentives to steal, and the electricity for nuclear security systems is no longer being shut off for non-payment of bills. Moreover, the Russian security services are more pervasive than they were a decade ago, including at nuclear sites. The most egregious nuclear security weaknesses of the early 1990s—gaping holes in fences, buildings with no detector at the door to sound an alarm if someone was carrying out plutonium—have largely been fixed, even at sites where U.S.-funded security upgrades have not

¹⁸ See "Over 4,000 Trespassers Detained at Moscow District Restricted Access Facilities," *Interfax-Agentstvo Voenykh Novostey*, 18 March 2005. The guarded facilities to which he referred include both nuclear and non-nuclear facilities.

been completed. It is unlikely that there are any remaining facilities in Russia that are not adequately protected against the minimal theft threats that succeeded in the mid-1990s—a single outsider walking through a gaping hole in a fence, snapping a padlock on a shed, stealing HEU, and retracing his steps without being noticed for hours, or a single insider with no particular plan repeatedly removing small amounts of HEU and walking out without detection.¹⁹ But the threat of nuclear theft remains substantial, as even the upgraded security systems being installed with U.S. assistance are unlikely to be able to defend against the huge threats terrorists and criminals have shown they can pose in today's Russia.

Much of the improvement in Russia's nuclear security system has come as a result of cooperation between the United States and Russia. As we discuss in greater length in the next chapter, U.S.-funded comprehensive upgrades have been completed for 54% of the buildings with weapons-usable nuclear material in the former Soviet Union (including all of the buildings in the non-Russian states). Rapid upgrades, such as bricking over windows and installing nuclear material detectors at exits, have been completed for a modest number of additional nuclear

¹⁹ A classic case of the simple insider incident was Yuri Smirnov's theft of 1.5 kilograms of 90% enriched HEU from the Luch Production Association in Podolsk. For an interview with Smirnov about his theft, see "Frontline: Loose Nukes: Interviews" (Public Broadcasting System, 1996; available at <http://www.pbs.org/wgbh/pages/frontline/shows/nukes/interviews/> as of 22 April 2006). An equally classic case of simple outsider theft was the theft of over four kilograms of HEU naval fuel from a Russian naval base in 1993, when one individual walked through a hole in the fence, snapped a padlock on a shed, put the HEU in his backpack, and retraced his steps, with no one noticing until hours later. See Oleg Bukharin and William Potter, "Potatoes Were Guarded Better," *Bulletin of the Atomic Scientists* (May-June 1995).

material buildings and a substantial number of additional warhead sites. Upgrades at warhead sites have gotten a slower start, but are catching up: those upgrades the two sides considered to be needed (comprehensive upgrades at most permanent warhead sites, only rapid upgrades at some temporary sites) had been completed for 48 warhead sites, which we estimate represents some 40% of the total number of sites, as of the end of FY 2005.

At the same time, Russia has continued to take steps to strengthen nuclear security on its own—though these appear to be only limited initial steps toward putting in place the security measures that are needed to meet today's threats. Over the past year, the Rosatom continued a series of in-depth inspections of physical protection and nuclear material accounting at Rosatom sites (launched with U.S. funding), uncovering a wide range of problems and weaknesses which the inspection teams then began to help sites address.²⁰ The Russian government completed a new basic regulation on nuclear security, which will take a more graded approach to protecting different types of nuclear materials, and will for the first time require facilities to have defenses adequate to protect against an identified design basis threat (DBT)—though as of the spring of 2006, the new rules were not yet issued.²¹ Russia announced new budget allocations for nuclear safety and security, but little public information on specific spending for security was made available.²² Finally,

²⁰ Alexander Izmailov, "Untitled," in *The Third Russian International Conference on Nuclear Material Protection, Control, and Accounting, Obninsk, Russia, 16-20 May 2005* (Obninsk, Russia: Institute of Physics and Power Engineering, 2005).

²¹ Interviews with Russian nuclear regulatory officials and U.S. Department of Energy officials, May 2005, October 2005, and January 2006.

²² "Rosatom Needs 30 Bln Rubles to Increase Nuclear, Radiation Security in Russia," *Interfax*, 31

a number of sites invested in improved security measures themselves, to comply with Russian regulations.

Progress since Bratislava. The accord on nuclear security reached at the February 2005 summit in Bratislava, Slovakia, between U.S. President George Bush and Russian President Vladimir Putin has led to a significant acceleration of U.S.-Russian nuclear security cooperation, and heightened the dialogue on key subjects such as security culture and plans for sustaining security upgrades. The inter-agency process the summit established, under Secretary of Energy Samuel Bodman and his Russian counterpart (first Alexander Rumiantsev and now Sergei Kirienko) has helped push progress toward completing agreed milestones. Soon after the Bratislava summit, Russian officials provided a list of additional nuclear warhead sites where they would permit security cooperation.²³ By June 2005, in the bilateral group's first progress report to President Bush and President Putin, the two sides had reached agreement on a joint plan to complete agreed sets of nuclear security upgrades at an agreed list of nuclear warhead and nuclear material sites by the end of 2008—though some nuclear material and nuclear warhead sites are not yet on the agreed list.²⁴

Russia also agreed to permit the access the United States believed was needed to implement cooperative security upgrades

January 2006.

²³ For an official discussion of the list Russia provided, see U.S. Department of Defense, *Cooperative Threat Reduction Annual Report to Congress: Fiscal Year 2007* (Washington, D.C.: U.S. Department of Defense, 2006), p. 28.

²⁴ "Statement on Nuclear Security Cooperation with Russia" (Washington, D.C.: The White House, Office of the Press Secretary, 2005; available at <http://www.whitehouse.gov/news/releases/2005/06/20050630-4.html> as of 7 July 2005).

at a wider range of nuclear warhead sites, and similar access has now been worked out for nearly all of the buildings containing weapons-usable nuclear material in Russia. Key exceptions to these access arrangements, however, are Russia's two remaining nuclear weapons assembly and disassembly facilities (known in Russia as the "serial production enterprises"). So far, those two sites remain too sensitive to allow cooperation to move forward, though Rosatom's security chief visited the comparable U.S. facility at Pantex in late 2004. The two sides continue to discuss cooperative approaches to upgrading these facilities without compromising nuclear secrets.²⁵

In September 2005, as called for at Bratislava, the two sides held in-depth workshops on strengthening security culture and on best practices in securing and accounting for nuclear material, bringing the dialogue on those topics to a new level, and discussions of both issues are ongoing. During 2005, the two sides also began drafting a joint plan for sustaining nuclear security after international assistance phases out, with an explicit understanding that Russian funding would have to increase as external funding declines.²⁶ In addition, after Bratislava, Russia and the United States agreed on a joint plan for returning Soviet-supplied HEU to Russia by the end of 2010 (though under current plans, a significant portion of that HEU will be addressed outside of Russia, a job that is expected to extend beyond 2010).

Another key logjam broken after Bratislava was the U.S.-Russian dispute

²⁵ Jim Nesbitt, "Russian Atomic Officials Tour Aiken, S.C.-Area Nuclear Reservation," *The Augusta Chronicle*, 18 November 2004. This information was supplemented by interviews with DOE officials, December 2004 and January 2005.

²⁶ Interviews with DOE officials, September 2005–January 2006.

over legal liability in the event of an accident during threat reduction cooperation, which had led, in 2003, to the expiration of U.S.-Russian agreements on technical cooperation on plutonium disposition and on retooling Russia's nuclear cities. Russia and the United States finalized agreed language on liability for plutonium disposition in mid-2005, though by the spring of 2006, Russia had still not finished an interagency review that would permit the agreement to be signed. DOE expects to use similar language for a new government-to-government agreement on the Nuclear Cities Initiative.²⁷ Prospects are good for an extension of the U.S.-Russian Cooperative Threat Reduction umbrella agreement (which expires in mid-June 2006).

Some important disagreements, unfortunately, are still festering, as they have been for years. The Mayak Fissile Material Storage Facility, a giant fortress built with U.S. funds, was completed in late 2003, and still stands empty, years later²⁸—the result of a combination of disagreements over what transparency rights U.S. monitors will have in return for the funds provided, Russia's failure to train appropriate personnel to operate and guard the facility, and apparently limited Russian funding for converting plutonium into the forms Russia prefers to store there. Similarly, there has been little progress in working with Russia to drastically reduce the number of sites where nuclear weapons and the materials to make them exist, so as to achieve higher security at lower cost.²⁹

²⁷ Interview with DOE official, April 2006, and interview with Department of State official, May 2006.

²⁸ See U.S. Department of Defense, *FY 2007 CTR Annual Report*, pp. 31-32.

²⁹ For discussions of the importance of consolidation as it applies to warheads, see Harold P. Smith, Jr., "Consolidating Threat Reduction," *Arms Control Today* (November 2003; available at http://www.armscontrol.org/act/2003_11/Smith.asp as of 22 March 2006); Gunnar Arbman and Charles Thornton, *Russia's Tactical Nuclear Weapons: Part II: Technical Issues and Policy Recommendations*, FOI-R—1588—SE (Stockholm: Swedish Defense Research Agency, 2005; available at <http://www.foi.se/upload/pdf/FOI-RussiasTacticalNuclearWeapons.pdf> as of 12 April 2006). While there has been limited progress in official channels, Rosatom has given the go-ahead for a study focused on security and consolidation issues in the civil research reactor sector, sponsored by the Nuclear Threat Initiative.

Critical issues remaining. Though the nuclear security improvements in Russia have been substantial, it is essential that policy-makers and the public understand that there remains a dangerous gap between the threat facing nuclear stockpiles in Russia and the current security arrangements for those stockpiles. In fact, the key nuclear security issues in Russia have less and less to do with the specific percentages of buildings or materials covered by the various levels of cooperative security upgrades. Instead, other crucial questions about international assistance for Russia's nuclear security system are now moving into the foreground:

- *Are the security upgrades enough, given the immense scale of corruption and insider theft of everything else in Russia, and the huge scale of the outsider terrorist threat?*
- *Is the human factor that is using these upgrades working, given reports of guards patrolling without ammunition in their guns, and staff propping open security doors for convenience?*³⁰

³⁰ 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*

- *Will the upgrades be sustained after U.S. assistance phases out?*

The upgrades provided by U.S.-Russian cooperation are designed to be sufficient to protect against modest groups of armed outsiders, or one to two insiders, or both together. While greater than the security levels maintained for nuclear stockpiles in some other countries, this security level is less than the threats that terrorists and criminals have shown they can pose in Russia, and less than what the U.S. Department of Energy (DOE) is now requiring its facilities to protect against—even though the threats to nuclear stockpiles are clearly lower in the United States at present. (This is among the reasons why we do not describe sites with initial U.S.-funded upgrades completed as “secured,” as the DOE does).

Moreover, the upgraded security and accounting equipment being installed with U.S. help will only provide high security if coupled with effective security staff and guard forces, which it is Russia’s responsibility to provide (though the United States can and does provide some equipment and training). So far, as already noted, despite high-level statements of priority, Russia does not appear to be assigning remotely sufficient resources to maintain, operate, and eventually replace the modern security equipment now being installed with U.S. assistance. Moreover, although Russia has announced that poorly trained conscripts will no longer be

Needed, GAO-01-312 (Washington, D.C.: GAO, 2001; available at <http://www.gao.gov/new.items/d01312.pdf> as of 16 September 2006), pp. 12-13. In 2003, the head of security at Seversk, one of Russia’s largest plutonium and HEU processing facilities, reported that the facilities’ guard forces were ineffective, repeatedly failing tests of their ability to stop both outsider and insider thefts and often patrolling without ammunition in their guns. See Goloskokov, “Reforming MVD Troops to Guard Russian Nuclear Facilities [Translated].”

used for some key missions, such as the war in Chechnya, no similar commitments have been made for the guards at nuclear or other critical facilities. Until Russia can be convinced to increase the priority assigned to nuclear security, continued U.S. assistance will be crucial to ensuring security for Russia’s nuclear stockpiles, and thus will remain an excellent investment in U.S. homeland security.

Shifting U.S.-Russian relations. Meeting the challenge of securing nuclear stockpiles in Russia in the coming years will require coping with a souring in broader U.S.-Russian relations. Many in the United States have seen a wide range of President Putin’s recent moves as steps to centralize power and disenfranchise the opposition, creating a creeping authoritarianism.³¹ President Putin and some of his security services chiefs have accused the United States and other Western powers of interfering in Russian politics and attempting to foment a revolutionary uprising on the model of that which occurred in Ukraine. The United States and many governments in Europe have protested what they see as crude economic and political pressure by Russia on its neighbors, while Russia has voiced distress that the United States and Europe are interfering in Russia’s historic sphere of influence. Some politicians in the United States and elsewhere have called for Russia to be expelled from the Group of Eight (G8) industrial democracies (which Russia is chairing this year).³² While Russia and the United States have cooperated more

³¹ Peter Baker, “Russian Relations under Scrutiny; U.S. Concerned About G-8 Talks with Putin as Host,” *The Washington Post*, 26 February 2006.

³² For instance, Senator John McCain from Arizona called for the United States not to attend the July 2006 G8 summit in St. Petersburg, Russia. Peter Baker, “Task Force Urges Bush to Be Tougher with Russia; Putin Increasingly Thwarts U.S. Interests,” *The Washington Post*, 5 March 2006.

closely than ever before on confronting Iran's nuclear ambitions, Russia remains deeply concerned that the United States is heading toward another war on its southern borders. While this downward trend in relations has not yet led to any major halts in threat reduction cooperation, the negative atmosphere makes such cooperation more difficult, and makes it almost impossible to build the genuine nuclear security partnership that is needed.

Improving Russian economic conditions. Russia today is not the Russia of the mid-1990s. Russia now has a growing economy, a federal budget in surplus, and a growing "stabilization fund" set aside from surging oil revenues. With Russia's new strength, the Russian government has taken a more assertive line in negotiations over nuclear security cooperation, in many cases making obstacles to cooperation more difficult to overcome. The increasingly heavy hand of the Russian security services, especially in sensitive matters such as nuclear stockpiles, has also made cooperation more difficult.

With these improved economic conditions, if the Russian government could be convinced that nuclear security is a top priority for its own security, Russia could afford to take the needed steps without international assistance. But Russia faces a wide range of other daunting challenges that will inevitably be priorities for government spending, from an ongoing health crisis that has dramatically cut life expectancies to decades-old infrastructure that will require tens of billions of dollars to replace—and repeated statements suggest that many Russian officials simply do not believe that nuclear terrorism is as real and urgent a threat as the United States perceives it to be. Hence, it is still overwhelmingly in the U.S. security interest to invest in nuclear security and other threat reduction activities in Russia—while

working to build Russian commitment to shouldering ever-larger shares of the needed investments and ultimately taking full responsibility for these efforts itself as international assistance phases out. In particular, as discussed in Chapter 5, steps to convince Russia and other countries that nuclear terrorism is a real and urgent threat are extremely important.

Locking Down Nuclear Stockpiles in the Former Soviet States Outside Russia

In those former Soviet states other than Russia that inherited weapons-usable nuclear material, U.S.-funded security and accounting upgrades were completed in the late 1990s, though some further improvements have been made since then.³³ As in Russia, it is unlikely that a single outsider or a single low-level insider could any longer steal nuclear material without detection from any of these facilities. The three questions asked above about Russia, however—are the upgrades enough to meet today's threats, are human operators using the upgraded systems correctly and taking security seriously, and will high security be sustained—all apply here as well. Indeed, the question of the adequacy of upgraded security systems is particularly troubling here, as these facilities have only been upgraded to meet rather vague International Atomic

³³ The initial upgrades put in place at these sites were designed to meet the third revision of the IAEA's physical protection recommendations. In 1999, a fourth revision was completed, and further upgrades were then implemented where necessary to meet the newly revised guidelines. A fifth revision is now being considered, as discussed below. For the text of the fourth revision, see International Atomic Energy Agency, *The Physical Protection of Nuclear Material and Nuclear Facilities*, INFCIRC/225/Rev. 4 (Corrected) (Vienna: IAEA, 1999; available at http://www.iaea.or.at/Publications/Documents/Inf-circs/1999/infcirc225r4c/rev4_content.html as of 22 March 2006).

Energy Agency (IAEA) recommendations—a security standard significantly lower than the upgrades being implemented in Russia are designed to meet (which, in turn, is lower than the new DOE standards, as noted above).³⁴

At the Institute of Nuclear Physics in Uzbekistan, for instance, the DOE declared that it had completed upgrades in 1996.³⁵ It then did so again in 2000, when further upgrades were implemented to meet revised IAEA recommendations. Yet given the presence in Uzbekistan of an armed Islamic movement closely linked to al Qaeda, and the political unrest that resulted in the government's brutal clampdown in Andijon, the capital, in May 2005, this facility remained a top priority for removing the HEU entirely.³⁶ Fresh HEU fuel was in fact removed from the facility in September 2004, and DOE completed sending back to Russia a large stockpile of irradiated HEU fuel from this facility in April 2006.³⁷ The

³⁴ Ambassador Linton Brooks, head of DOE's National Nuclear Security Administration, told Congress that "you would not be very happy" if U.S. facilities were no more protected than required by the IAEA recommendations. See testimony in Armed Services Committee, Subcommittee on Strategic Forces, *Hearing on the Fiscal Year 2007 Defense Department Budget Request for Atomic Energy Defense Activities*, United States House of Representatives, 109th Congress, 2nd Session (1 March 2006).

³⁵ U.S. Department of Energy, *Improving Nuclear Materials Security at the Institute of Nuclear Physics - Tashkent, Uzbekistan* (Washington, D.C.: DOE, 1996; available at http://www.nti.org/e_research/profiles/Uzbekistan/index_6084.html as of 2 June 2006).

³⁶ Information on the remaining priority of removal was confirmed in meeting with DOE Global Threat Reduction Initiative officials, December 2005.

³⁷ On the fresh fuel removal operation, see "Secret Mission to Recover Highly Enriched Uranium in Uzbekistan Successful: Fuel Returned to Secure Facility in Russia" (Washington, D.C.: U.S. Department of Energy, 2004; available at <http://www.energy.gov> as of 16 February 2005). On the spent fuel, see C. J. Chivers, "Uzbeks Ship Bomb-Grade Waste to Russia," *New York Times*, 20 April 2006.

shipment of irradiated HEU from Uzbekistan, in particular, represented a major milestone in the effort to send Soviet-supplied HEU back to Russia, finally getting past the bureaucratic obstacles to implementing such shipments under the terms of Russia's spent fuel import law that had delayed the effort for years.

Also during the past year, a cache of 2.5 kilograms of fresh HEU was returned to Russia from Latvia, and discussions continued with Belarus, Ukraine, and Kazakhstan about returning their HEU stocks to Russia or blending them down.³⁸ Perhaps most impressive, Kazakhstan blended down some 2.9 tons of HEU left over from its closed Aqtau breeder reactor, in a private-government partnership financed in part by the Nuclear Threat Initiative. This operation eliminated the danger that this material could ever be used in bombs without complex re-enrichment.³⁹

Locking Down Nuclear Stockpiles in the Rest of the World

Even if every nuclear warhead and every kilogram of nuclear material in Russia and the former Soviet Union were secured against all plausible threats, an unacceptably high risk of nuclear terrorism would remain, because of the insecurity of nuclear material in other countries around the world.

³⁸ "Highly Enriched Uranium Repatriated from Latvia" (Washington, D.C.: U.S. Department of Energy, National Nuclear Security Administration, 2005; available at http://www.nnsa.doe.gov/docs/PR_2005-05-25_NA-05-13.pdf as of 5/26/2005); "Latvia Returns Russian-Made Highly Enriched Uranium Back to Russia," *RIA Novosti*, 27 May 2005.

³⁹ Kenji Murakami, *Nuclear Threat Initiative-Kazakhstan Project on Elimination of High-Enriched Uranium: Delivered on Behalf of Mohamed ElBaradei* (Washington, D.C.: Nuclear Threat Initiative, 2005; available at http://www.nti.org/c_press/statement_ElBaradei_100805.pdf as of 21 April 2006).

Global vulnerabilities. More than a thousand assembled nuclear weapons are owned by seven countries outside of Russia and the United States. Separated plutonium or HEU exist in hundreds of buildings in more than 40 countries. There are no binding global standards for nuclear security, and in practice the security at sites where the essential ingredients of nuclear weapons are located ranges from excellent to appalling.

Pakistan's nuclear stockpiles are a central focus of concern.⁴⁰ Pakistan's small nuclear arsenal is believed to be heavily guarded, but armed remnants of al Qaeda continue to operate in Pakistan, as do jihadi groups with deep connections to Pakistani intelligence. Moreover, corruption and theft are endemic in Pakistan, including within the military establishment. Indeed, al Qaeda-linked operatives—with cooperation from insiders within the military—have twice almost succeeded in assassinating Pakistani President Pervez Musharraf, suggesting that the threat to other heavily guarded targets (such as nuclear weapons) is real. Senior insiders within Pakistan's nuclear establishment have demonstrated a willingness to sell technology related to nuclear weapons to practically anyone.

Civilian facilities with HEU in countries around the world also pose a major concern, as many have only minimal security measures in place. Many developed countries have tightened their nuclear security rules and practices in the years since the 9/11 attacks. But it remains the case that most civilian research reactors have very modest security—in many

⁴⁰ See the discussion in Matthew Bunn and Anthony Wier, *Securing the Bomb 2005: The New Global Imperatives* (Cambridge, Mass., and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, 2005; available at http://www.nti.org/e_research/report_cnwmupdate2005.pdf as of 6 June 2006), pp. 15-16.

cases, no more than a night watchman and a chain-link fence—even when enough fresh or irradiated HEU for a bomb is present.⁴¹ Unfortunately, complying with the IAEA recommendations on physical protection—as facilities whose material came from the United States or from other members of the Nuclear Suppliers Group are generally required to do—is not sufficient to resolve such problems, because the IAEA recommendations are very general, and not designed to ensure effective protection against any particular threat.

Some 60 metric tons of HEU—enough for over a thousand nuclear weapons—is in civilian use or storage throughout the world, most of it associated with research reactors, and about half of it outside of the United States and Russia.⁴² Today roughly 135 operating research reactors in some 40 countries still use HEU as their fuel, and an unknown number of shut-down or converted research reactors still have HEU fuel on-site.⁴³ Many of these

⁴¹ Author's visits to research reactors in several countries. For a more detailed description of typical security arrangements at research reactors, see George Bunn et al., "Research Reactor Vulnerability to Sabotage by Terrorists," *Science and Global Security* 11 (2003; available at <http://www.princeton.edu/~globsec/publications/pdf/11%202-3%20Bunn%20p85-107.pdf> as of 2 April 2006). For a discussion of security at some Russian facilities, also see Alexander Glaser and Frank N. Von Hippel, "Thwarting Nuclear Terrorism," *Scientific American* 294, no. 2 (February 2006).

⁴² David Albright and Kimberly Kramer, "Civil HEU Watch: Tracking Inventories of Civil Highly Enriched Uranium," in *Global Stocks of Nuclear Explosive Materials* (Washington, D.C.: Institute for Science and International Security, 2005; available at http://www.isis-online.org/global_stocks/end2003/tableofcontents.html as of 21 May 2006).

⁴³ See, for example, the data provided in U.S. Congress, Government Accountability Office, *Nuclear Nonproliferation: DOE Needs to Take Action to Further Reduce the Use of Weapons-Usable Uranium in Civilian Research Reactors*, GAO-04-807 (Washington, D.C.: GAO, 2004; available at <http://www.gao.gov/new.items/d04807.pdf> as of 2 February 2006). GAO

facilities do not have enough HEU on-site for a bomb, but a surprising number of facilities do.⁴⁴ In November 2004, the U.S. Government Accountability Office reported that a DOE study concluded that

notes that as of that time, there were 105 HEU-fueled reactors on DOE's list to convert (of which 29 had already fully converted by the time of GAO's report, leaving 76 still using HEU fuel), and 56 more HEU-fueled reactors for which conversion was not planned, for a total of 132 HEU-fueled reactors as of that time. By late 2005, publicly released data from the GTRI program indicated that three more reactors had completed their conversion, bringing the total fully converted to 32, and the total number of reactors targeted for conversion had increased from 105 to 106. Christopher Landers, "Reactors Identified for Conversion: Reduced Enrichment for Research and Test Reactors (RERTR) Program," in *RERTR 2005: 27th International Meeting on Reduced Enrichment for Research and Test Reactors*, Boston, Mass., 6-10 November 2005 (Argonne, Ill.: Argonne National Laboratory, 2005; available at http://www.rertr.anl.gov/RERTR27/PDF/S9-1_Landers.pdf as of 20 June 2006). That meant that as of the end of 2005, there were 74 reactors remaining that were targeted for conversion but were still using some HEU fuel. But there are also other HEU-fueled reactors which were *not* targeted for conversion, some of which were not on the lists provided by DOE to GAO. Data compiled by Frank von Hippel and Alexander Glaser of Princeton University indicates that there are more than 60 operational HEU-fueled research reactors and critical assemblies around the world not covered by the revised target list for conversion, for a total of roughly 135 HEU-fueled research reactors worldwide. (Personal communication from Frank von Hippel, December 2005.) DOE officials report, however, that additional HEU-fueled reactors are still being identified in ongoing visits to facilities, so the total number of HEU-fueled facilities may turn out to be still higher (Interview with DOE officials, December 2005). DOE has recently asserted that there are 173 operating HEU-fueled reactors in the world (data provided to Rep. Robert Andrews (D-NJ), April 2006), but a close examination of DOE's figures indicates that they are including all of the more than 30 reactors that have converted to LEU; that they are including a number of reactors that have shut down; and that they are including a number of non-research reactor sites with HEU. The von Hippel-Glaser figures appear to be more accurate.

⁴⁴ Moreover, one cannot rule out the possibility of terrorists stealing material from more than one facility, each of which might have less than the amount required for a bomb.

there are 128 nuclear research reactors or associated facilities around the world with 20 kilograms of HEU or more.⁴⁵ Dozens of HEU-fueled research reactors with smaller amounts of material are not on this list of sites with 20 kilograms or more of HEU. Of the list of 128, 87 are reportedly research reactors, and the other 41 are fuel facilities.⁴⁶

Some of these facilities are located on university campuses, where providing serious security against terrorist attack would be very difficult. Many research reactors were built thirty or more years ago; with reduced missions and limited prospects, many now have scant resources to continue safe operation or to pay for substantial security measures. Although DOE generally assumes that facilities in high-income developed countries are already adequately secured, this is often not the case for research reactors. In mid-2005, for example, an investigation by *ABC News* documented inadequate security, ranging from sleeping guards to security doors propped open with books, at most of the 26 university-based research reactors operating in the United States (several of which have HEU on site).⁴⁷ In one high-income non-nuclear-weapon state, there is a research facility with 500 kilograms of weapon-grade HEU metal, in easily portable five-inch squares, which emit so little radioactivity that the researchers at the site handle them by hand. That facility reportedly had no armed guards at all prior to 9/11; today, there are a few armed members of the national police at the site, but they reportedly patrol in vulnerable locations

⁴⁵ U.S. Congress, *DOE Needs to Take Action to Further Reduce the Use of Weapons-Usable Uranium*, p. 28.

⁴⁶ Interviews with Argonne National Laboratory and DOE officials, February 2005.

⁴⁷ "Radioactive Road Trip" in *PrimeTime Live* (ABC News, 2005).

and are poorly integrated into the site's security plan.⁴⁸

Limited cooperation. Because of such threats, the United States has pursued nuclear security cooperation for countries outside the former Soviet Union. For the most part, however, progress has been slow-moving. In China, security at one civilian facility with HEU had been upgraded by the end of fiscal year (FY) 2005, and no agreement is yet in place to upgrade China's remaining facilities.⁴⁹ No cooperative upgrades have been accomplished in India; indeed, the subject of preventing nuclear terrorism was strikingly absent from the U.S.-India nuclear agreement.⁵⁰ Some published accounts suggest that nuclear security cooperation with Pakistan is proceeding, but there has been no official confirmation of this.⁵¹ Though close allies, the United States and Israel neither cooperate on nuclear security nor have discussed doing so, as far

⁴⁸ References available from the authors on request. For obvious reasons, we prefer not to identify the specific location of this site in this report.

⁴⁹ U.S. National Nuclear Security Administration, "U.S. And China Jointly Host Technology Exposition on Nuclear Material Security and International Safeguards: Collaborative Approaches to Enhancing Nuclear Material Security" (Washington, D.C.: NNSA, 2005; available at http://www.nnsa.doe.gov/na-20/docs/china_tech_demo.pdf as of 24 February 2006). For more detail, also see Stephen Wampler, "DOE Helps Chinese Agency to Secure Nuclear Material," *Lawrence Livermore National Laboratory's Weekly Newslines*, 16 December 2005.

⁵⁰ "Joint Statement between President George W. Bush and Prime Minister Manmohan Singh" (Washington, D.C.: The White House, Office of the Press Secretary, 2005; available at <http://www.whitehouse.gov/news/releases/2005/07/20050718-6.html> as of 24 February 2006).

⁵¹ See, for example, Kenneth N. Luongo and Isabelle Williams, "Seizing the Moment: Using the U.S.-Indian Nuclear Deal to Improve Fissile Material Security," *Arms Control Today* (May 2006; available at http://www.armscontrol.org/act/2006_05/usindi-fissilesecurity.asp as of 12 May 2006).

as is publicly known (though given long Israeli experience combating terrorism, Israel's stockpile presumably is highly secure). With North Korea, no nuclear security cooperation is conceivable until there is a dramatic shift in relations between that country and the United States.

For non-nuclear-weapon states beyond the former Soviet Union, by the end of 2005, U.S.-sponsored upgrades (often implemented in coordination with the IAEA Office of Nuclear Security) had been completed for only seven facilities, with six more then in progress.⁵² As with the non-Russian facilities of the former Soviet Union, upgrades for these facilities were designed only to meet rather vague IAEA recommendations, a standard far below the level of security that would be required for the same materials if they were under DOE's control in the United States.

Higher standards in some states. While the United States and other donors have not sponsored security upgrades in developed countries, many states have strengthened their nuclear security measures since the 9/11 attacks. In Japan, which has tons of weapons-usable separated plutonium on its soil, and which was the nation where the Aum Shinrikyo terror cult was working actively to get nuclear weapons and the materials to make them, there were no armed guards at nuclear facilities prior to the 9/11 attacks.⁵³

⁵² Most of the upgrades completed thus far have been in Eastern Europe, though upgrades have also been completed at facilities in Greece and Portugal. Meeting with DOE Global Threat Reduction Initiative officials, December 2005.

⁵³ These countries relied instead on detection and barrier technologies to provide warning and delay any theft until off-site police forces could arrive. Tests in the United States suggest that such an approach would be likely to fail in the face of well-equipped and well-trained attackers, because of the remarkable speed with which various barriers can be breached. The reluctance to have armed units at

Since then, armed units of the national police have been patrolling at nuclear facilities.⁵⁴ In December 2005, a new Japanese law on physical protection did take effect, requiring for the first time that Japanese nuclear facilities have security measures in place able to defeat a specific design basis threat.⁵⁵ Regulations requiring strengthened nuclear security were also proposed in the past year in Canada and Sweden, among others.⁵⁶

nuclear sites reflected a Japanese culture in which possession of firearms by private citizens has been forbidden for centuries and where even policemen are usually not armed. (Britain, which has a similar tradition of tight constraints on the kinds of armament that private guards may have, and of unarmed policemen, set up a separate force—the Atomic Energy Constabulary—to guard nuclear facilities.) For a discussion of the Japanese view on this matter pre-9/11, confirming that “the guards do not carry firearms on duty at any nuclear facility in Japan” (as of 1997), see Hirooyoshi Kurihara, “The Protection of Fissile Materials in Japan,” in *A Comparative Analysis of Approaches to the Protection of Fissile Materials: Proceedings of the Workshop at Stanford University, July 28-30, 1997* (Livermore, Cal.: Lawrence Livermore National Laboratory, 1997). Similarly, in Canada, which has more than a ton of HEU on its soil, the pre-9/11 rules only required enough guards on-site to perform tasks such as checking identification and manning monitors; armed response to possible attack was to rely on forces arriving from off-site. See “Nuclear Security Regulations” in *SOR/2000-209* (Ottawa: Canadian Nuclear Safety Commission, 2000; available at <http://laws.justice.gc.ca/en/n-28.3/sor-2000-209/153978.html> as of 5 December 2005). A number of other countries also do not require armed guards at nuclear facilities.

⁵⁴ Interviews with Japanese experts and a U.S. expert who has visited Japanese nuclear facilities since 9/11. See also, Tatsujiro Suzuki, “Implications of 09/11 Terrorism for Civilian Nuclear Industry and its Response Strategy,” presentation to the Japan Atomic Industrial Forum-Harvard University Nonproliferation Workshop, January 30-31, 2002.

⁵⁵ Text provided by Tatsujiro Suzuki.

⁵⁶ Canadian Nuclear Safety Commission, *Proposed Amendments to Nuclear Security Regulations* (Ottawa, Canada: CNSC, 2005; available at http://www.nuclearsafety.gc.ca/eng/regulatory_information/regulations/NSR_home.cfm as of 21 April 2006); Swedish Nuclear Power Inspectorate, *Proposal*

Progress and gaps in the Global Threat Reduction Initiative (GTRI). As noted above, despite the strengthened nuclear security rules in some countries, many HEU-fueled research reactors around the world remain dangerously insecure.

Like the Bratislava summit, the U.S. creation of GTRI two years ago to address threat posed by civilian nuclear stockpiles was a major step in the right direction. GTRI has succeeded in accelerating removals of HEU from vulnerable sites in several countries. As noted above, in the past year the program completed returns of HEU caches to Russia from Latvia and Uzbekistan.⁵⁷ GTRI marked the first-ever U.S.-funded conversion of a Soviet-supplied research reactor to LEU, with the conversion of the VR-1 Sparrow research reactor at the Czech Technical University on the outskirts of Prague in the Czech Republic (which allowed 14 kilograms of HEU to be returned from there on September 27, 2005).⁵⁸ And in July 2005 GTRI celebrated the announcement by the South African government that it would begin converting the SAFARI-I research reactor from HEU to low-enriched uranium (LEU) in 2006 (though the large stock of HEU at that facility is not likely to be removed

of New Regulations for Physical Protection (Stockholm: Swedish Nuclear Power Inspectorate, 2005; available at http://www.ski.se/extra/news/?module_instance=3&id=371 as of 21 April 2006).

⁵⁷ “Joint Statement by President Bush and President Putin on Nuclear Security Cooperation” (Bratislava, Slovakia: The White House, Office of the Press Secretary, 2005; available at <http://www.whitehouse.gov/news/releases/2005/02/20050224-8.html> as of 25 February 2006).

⁵⁸ U.S. National Nuclear Security Administration, “Highly Enriched Uranium Recovered from Czech Technical University” (Washington, D.C.: NNSA, 2005; available at http://www.nnsa.doe.gov/docs/newsreleases/2005/PR_2005-09-27_NA-05-22.htm as of 4 January 2006); Ann MacLachlan and Daniel Horner, “More Czech HEU Flown to Russia; Small Reactor to Convert to LEU,” *Nuclear Fuel*, no. 21 (10 October 2005).

until the use of HEU targets for medical isotope production there is also converted).⁵⁹ As already noted, the June 2005 post-Bratislava U.S.-Russian progress report included an agreed U.S.-Russian plan for bringing Soviet-supplied HEU back to Russia by the end of 2010. (Implementing that plan, however, will also require the agreement of the states where that material now exists, some of which have not yet agreed to give it up. A substantial portion of this material may be blended down or otherwise destroyed outside Russia, rather than being sent back.)

Despite this good news, GTRI's timelines for converting reactors to use safer LEU and for retrieving the HEU the United States exported around the world stretch out to 2014 and 2019, respectively. Nearly half of the research reactors currently using HEU around the world are not yet on GTRI's target list for conversion. As yet the program has no plan for removing large portions of the civilian HEU and separated plutonium around the world (including two-thirds of the HEU the United States itself exported over the years, which is not covered by the U.S. offer to take back U.S.-exported material). The program is so far offering facilities only very limited incentives to give up their HEU or to convert to LEU, while the policy tool of giving countries incentives to shut down unneeded reactors—an option likely to be far cheaper and easier in many cases than converting to LEU, without requiring any wait for new fuel development—is not yet part of any U.S. or international program to address this problem.

⁵⁹ Ann MacLachlan and Daniel Horner, "Safari-1 Reactor to Use LEU in Landmark Conversion," *Nucleonics Week*, no. 29 (21 July 2005). Despite the important announcement, South African officials also said that they intended to continue to use the fresh HEU fuel on site as targets in the production of medical isotopes.

In short, the United States does not yet have a plan for ensuring that *all* stockpiles of nuclear warheads and weapons-usable nuclear materials worldwide are secure and accounted for.

Limited prospects from the Global Partnership. The Global Partnership Against the Spread of Weapons and Materials of Mass Destruction launched at the 2002 G8 summit has succeeded in highlighting threat reduction issues and convincing additional countries to contribute. Unfortunately, the Gleneagles summit in 2005 again failed to extend the initiative beyond its focus on Russia and Ukraine; there is nothing global about the partnership except its name. The G8 effort is simply not performing as the fast-paced global partnership to lock down nuclear stockpiles that is so urgently needed. As we will discuss in the final chapter, the G8 summit in St. Petersburg in July 2006 will represent another opportunity to launch a fast-paced global effort to secure nuclear stockpiles; that opportunity should not be missed.

So far, the Global Partnership has added only a small amount of money to U.S. spending on programs to improve controls over nuclear warheads, materials, and expertise; most of the non-U.S. Global Partnership funds are going to chemical weapons elimination and submarine dismantlement.⁶⁰ For the specific task of strengthening security and accounting measures for nuclear warheads and materials, the United States invested over \$2 billion in the decade leading up to the announcement of the Global Partnership, over \$200 million per year on average—and since the Global Partner-

⁶⁰ GPWG *Annual Report 2005: Consolidated Report Data (Annex A)* (Gleneagles, United Kingdom: G8 Summit, 2005; available at <http://www.sgpproject.org/resources/Glneagles/AnnualReport2005.pdf> of 23 June 2006).

ship was announced, U.S. budgets for that task have been running at over \$400 million per year.⁶¹ This annual spending is far more than the *total* pledges allocated to this task for the entire decade of the Global Partnership from all other participants combined. As of mid-2005 (when detailed data were last made public), Germany had by far the most substantial non-U.S. program in this area, having pledged some 170 million euros for nuclear security work by 2009 (of which 20.2 million euros had been expended between 2002 and mid-2005); among other projects, Germany is reportedly providing security upgrade assistance at some nuclear warhead sites not covered by U.S. threat reduction programs.⁶² The United Kingdom reports that it expended just over 2 million pounds through 2005 on nuclear material security and accountability projects, with another 4 million pounds anticipated in 2005-2006. The European Union has committed some 25 million euros for 2001 through 2006 for fissile material safeguards in Russia and another 8 million euros for security improvements at Bochvar Institute in Moscow, having expended about 1.6 million euros of that through mid-2005 (before the Global Partnership, the EU

⁶¹ Appropriations for securing nuclear warheads and materials for fiscal years 1993-2002, and for fiscal years 2003-2006, from Anthony Wier, "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, 2006; available at http://www.nti.org/e_research/cnwm/overview/funding.asp as of 15 March 2006).

⁶² Interview with DOE officials, April 2006. Work on nuclear warhead storage security prior to dismantlement is also mentioned in the German report on its Global Partnership work, German Federal Ministry of Economics and Labour, *The G8 Global Partnership: Russian-German Cooperation* (Berlin: Federal Ministry of Economics and Labour, 2004; available at <http://www.sgpproject.org/Donor%20Factsheets/German-Russia%20Report%2015%20May%202004.pdf> as of 23 June 2006).

had expended another 3 million euros in this area). Norway has provided some 5.3 million euros to improve security for the submarines and their spent HEU fuel at Andreyeva Bay in Russia. Sweden has provided approximately \$1.5 million for a variety of physical protection and counter-trafficking projects. Since 2003 Finland has provided 430 thousand euros for safeguards and accounting enhancements in Russia. Canada has also agreed to support physical protection projects, but it has not yet committed to an amount.⁶³ Canada (4 million Canadian dollars) and Germany (1 million euros) also count their extrabudgetary contributions to the IAEA Office of Nuclear Security as part of their Global Partnership contributions (though as noted elsewhere in this report, the IAEA Office of Nuclear Security struggles with a very limited budget).⁶⁴ In total, these contributions amount to just over \$275 million (with currencies converted at average 2005 exchange rates).

Beyond nuclear security, the Global Partnership has also prompted some limited non-U.S. funds for other important tasks to prevent nuclear terrorism. For export control and border security assistance, which in some cases helps prevent nuclear smuggling, the European Union has allocated 78 million euros, with 17.6 million expended through 2005. Several participants are contributing to stabilizing personnel with nuclear, biological, or

⁶³ Figures from *GPWG Annual Report 2005: Consolidated Report Data (Annex A)*; German Federal Ministry of Economics and Labour, *The G8 Global Partnership: Russian-German Cooperation*; United Kingdom Department of Trade and Industry, *The Global Partnership: Progress During 2005 on the UK's Programme to Address Nuclear Chemical and Biological Legacies in the Former Soviet Union* (London: UK DTI, 2005; available at <http://www.dti.gov.uk/files/file14426.pdf?pubpdfload=05%2F373> as of 23 June 2006), p. 26.

⁶⁴ *GPWG Annual Report 2005: Consolidated Report Data (Annex A)*.

chemical weapons or missile expertise: Canada has committed 90 million Canadian dollars, of which 22 million has been expended; the European Union has committed 125 million euros and expended 62.5 million euros since 2002—after providing 173 million from 1994 through 2001; the United Kingdom has launched a Closed Nuclear Cities Partnership with Russia, on which it has expended 6.76 million pounds through 2005, with another 5 million projected in 2005-2006; Japan, continues to support the International Science and Technology Center (ISTC) in Russia, though this is not listed among Japan's Global Partnership projects; and the Republic of Korea has provided some \$2.3 million to the ISTC.⁶⁵ (Only a fraction of these totals are going to nuclear personnel, as opposed to people in the biological, chemical, or missile complexes; most of these funds are being funneled through the ISTC, which has invested heavily in biological projects in recent years.) For eliminating the production of weapons-grade plutonium, DOE reports that it has received commitments of \$29.43 million from other contributors (roughly 3% of the estimated total project cost of \$1 billion, the rest of which will be paid by the United States), including \$20 million from the United Kingdom, \$7.3 million from Canada, \$1.3 million from the Netherlands, \$0.58 million from Finland, and \$0.25 million from South Korea.⁶⁶

Total non-U.S. pledges for disposition

⁶⁵ Figures from International Science and Technology Center, *Annual Report: 2004* (Moscow: ISTC, 2005; available at <http://istc.ru/ISTC/sc.nsf/AR-2004-en.pdf> as of 23 June 2006); *GPWG Annual Report 2005: Consolidated Report Data (Annex A)*; United Kingdom Department of Trade and Industry, *The Global Partnership: UK Progress During 2005*, p. 26.

⁶⁶ U.S. Department of Energy, *FY 2007 Congressional Budget Request: National Nuclear Security Administration--Defense Nuclear Nonproliferation*, vol. 1, DOE/CF-002 (Washington, D.C.: DOE, 2006; available at http://www.cfo.doe.gov/budget/07budget/Content/Volumes/Vol_1_NNSA.pdf as of 24 February 2006), p. 529.

of excess weapons plutonium come to roughly \$440 million (depending on currency fluctuations):⁶⁷ Japan has pledged \$100 million dollars; France has committed 73 million euros, along with up to 70 million euros previously contributed for bilateral French-Russian cooperation on plutonium disposition; Italy has pledged 80 million euros; the United Kingdom has pledged 70 million pounds; the European Union has provided 4.8 million euros of a pledged 6 million for regulatory work on mixed oxide fuel; and Canada has committed 65 million Canadian dollars.⁶⁸ Planned non-U.S. expenditures for stabilizing employment for weapons scientists and for plutonium disposition are substantially higher than those for the urgent task of improving nuclear security—but planned non-U.S. expenditures for chemical weapons demilitarization and general purpose submarine dismantlement are larger still.

Because these programs sponsored by other donors total to only a small fraction of the expenditures in U.S. programs in the areas discussed in this report, and because very few data have been released about the actual progress that has been made by these other threat reduction programs, this report focuses primarily on the progress of programs funded by the United States.

⁶⁷ The U.S. pledged contribution is \$400 million; DOE reported the total amount pledged as \$844 million in Armed Services Committee, Subcommittee on Emerging Threats and Capabilities, *Hearing on the U.S. Nonproliferation Strategy and the Roles and Missions of the Department of Defense and the Department of Energy in Nonproliferation*, United States Senate, 109th Congress, 2nd Session (29 March 2006).

⁶⁸ Figures from Strengthening the Global Partnership Project, "Donor Factsheets" (Washington, D.C.: Center for Strategic and International Studies, 2005; available at <http://www.sgppproject.org/Donor%20Factsheets/ProjectAreas/SciEmploy.html> as of 2 April 2006); *GPWG Annual Report 2005: Consolidated Report Data (Annex A)*.

UNSCR 1540: an important but so far little-used tool. A potential breakthrough in the effort to create binding global standards for nuclear security was created by the unanimous April 2004 passage of United Nations Security Council Resolution 1540, which created a legal requirement that all countries provide “appropriate effective” security for their nuclear stockpiles. But two years later, no one has defined what the essential elements of an appropriate effective system are. Nor has any country, including the United States, seriously begun to cajole, help, and pressure countries to meet the UNSCR 1540 obligation to put those essential elements in place.

The United Nations committee created to implement UNSCR 1540 has labored to compile both initial reports from countries on their current response to the resolution’s obligations (as of April 2006, 129 states had responded) and clarifications of those initial reports (requested of all 129 states, with 79 states responding by April 2006). But those reports simply do not provide the information needed to understand how effective states’ nuclear security efforts are, and the committee has not had the resources to actually visit states to review the security measures in place.⁶⁹ In April 2006 the Security Council voted to extend the committee’s life for another two years.

New international agreements. In the past year both an amendment to strengthen the physical protection convention and a new nuclear terrorism convention were also approved. Both

⁶⁹ For the text of the original resolution, the texts of the several reports the committee has produced, and the texts of the national reports that have been submitted, see United Nations, “1540 Committee” (New York: UN, 2005; available at <http://disarmament2.un.org/Committee1540/index.html> as of 25 February 2006).

include useful provisions that will make a contribution, but neither includes any specific, binding standards for nuclear security that would, if met, provide confidence that nuclear warheads and materials were not likely to be stolen. (Indeed, while the agreed amendment will broaden the scope of the physical protection convention, it still excludes all military material, which represents more than four-fifths of the global stockpiles of separated plutonium and HEU.) Discussions of a revision of current IAEA recommendations on nuclear security are getting underway, and could be important—but if past is prologue, it is unlikely that, left to their own, these talks will be able to overcome the resistance to calling for tough (and expensive) security measures that would be effective against substantial outsider and insider threats.

The IAEA Office of Nuclear Security. Finally, during the past year, the IAEA Office of Nuclear Security, which was created in the aftermath of the 9/11 attacks, detailed a four-year plan for helping countries improve nuclear security and block nuclear smuggling. But this group continues to struggle forward with a small staff, meager resources, and limited authority. Over the period 2006–2009, the IAEA expects it will only be able to spend about \$15.5 million each year, plus any in-kind donations of equipment and cost-free experts member states might make.⁷⁰ In other words, the key office in the United Nations system responsible for assisting countries in securing their nuclear material expects to operate on an annual budget slightly smaller than the budget for trash collection in Washington,

⁷⁰ International Atomic Energy Agency, *Nuclear Security: Measures to Protect against Nuclear Terrorism: Progress Report and Nuclear Security Plan for 2006–2009*, GC(49)/17 (Vienna: IAEA, 2005; available at <http://www.iaea.org/About/Policy/GC/GC49/Documents/gc49-17.pdf> as of 10 May 2006), pp. 11–13.

D.C.⁷¹ The IAEA will never be more than a supporting actor to states cooperating bilaterally and multilaterally, but given appropriate resources and authority, the Office of Nuclear Security can play a key role in identifying and promoting best practices, drafting standards, organizing international discussions, and highlighting dangerous shortfalls in countries' nuclear security practices.

WHAT IMPROVED NUCLEAR SECURITY CAN AND CANNOT DO

Beefing up security at the world's most vulnerable nuclear sites, or removing the nuclear weapons or weapons-usable nuclear material from them entirely, has the potential to dramatically reduce the risk that terrorists might be able to get their hands on nuclear weapons or their essential ingredients. But it cannot eliminate this risk, for several reasons.

First, some nuclear materials may already have been stolen and not recovered. The CIA assesses that undetected thefts of nuclear material have probably occurred—but no one knows how much might already have been stolen.⁷² (Given that there is no convincing evidence that al Qaeda succeeded in acquiring stolen nuclear material despite attempting to do so for many years before the 9/11 attacks, however, there is reason to hope that al-

⁷¹ Government of the District of Columbia, Office of the Chief Financial Officer, *FY 2006 Budget and Financial Plan: Public Works* (Washington, D.C.: DC OCFO, 2005; available at <http://cfo.dc.gov/cfo/cwp/view,a,1321,q,629443.asp> as of 15 May 2006), pp. F-9.

⁷² 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, 2004; available at http://www.dni.gov/nic/special_russiannuke04.html as of 5 June 2006).

ready-stolen material represents only a small portion of the threat of nuclear terrorism.)

Second, some threats are bigger than plausible security systems will be able to handle. If the government of a state where nuclear stockpiles exist collapses, if a site is attacked by a rogue military unit or other group of scores or hundreds of well-armed outsiders, or if senior managers of the site decide to sell off nuclear material, improved fences and intrusion detectors at the site simply will not solve the problem. Hence, improved security and accounting measures can only reduce, never eliminate, the risk that a particular cache of nuclear weapons or materials will be stolen; only removing the material from a site entirely can eliminate the threat of theft from that site.

Finally, reducing the danger of nuclear theft will not address the possibility of a state providing nuclear weapons or materials to terrorists. As discussed below, however, the danger that a state such as North Korea or Iran would intentionally provide nuclear material to terrorists is probably far smaller than the danger of nuclear theft.

POTENTIAL STATE TRANSFER TO TERRORISTS

No amount of work on security upgrades will prevent a state from willfully deciding to provide nuclear weapons or materials to terrorists. President George W. Bush is among those who see this path of terrorist nuclear acquisition as the dominant danger: "Rogue states," he has said, "are clearly the most likely sources of chemical and biological and

nuclear weapons for terrorists.”⁷³ This belief determines the policy prescription: if the principal danger of terrorists acquiring weapons of mass destruction is that hostile states might provide them, then the key element of the solution is to take on those hostile states and make sure that they do not provide them. This is the idea animating the preemptive doctrine laid out in the 2002 and 2006 editions of the administration’s *National Security Strategy*, which in turn underpinned the argument for going to war with Iraq. Since the overthrow of Saddam Hussein, concern about regimes sharing nuclear technology has centered primarily on two countries: North Korea and Iran.

North Korea

In the past year, six party negotiations between the United States, North Korea, China, Japan, South Korea, and Russia reached what many regarded as a hopeful crescendo with a joint statement in September 2005 that committed North Korea to verifiably eliminate all of its nuclear programs. But the United States and North Korea quickly began trading more and more acrimonious language about who should take what actions first, and tensions between the two countries rose over U.S. efforts to curb alleged counterfeiting and illicit trafficking by the North Korean government. Through the spring of 2006 the downward diplomatic spiral prevented any resumption of the six-party talks. All the while, North Korea continues to produce even more plutonium that could be used in more weapons, with no international inspectors in the country—and whatever enrichment work it may be

able to accomplish with the technology provided by the A.Q. Khan network continues to proceed in secret.

Iran

Meanwhile, the last months of 2005 and the first several months of 2006 have witnessed a dangerous deterioration in efforts to prevent Iran from developing a capability to build nuclear weapons. Iran had agreed in the fall of 2004 to suspend all known uranium enrichment-related activities while it negotiated with France, Germany, and the United Kingdom (the so-called EU-3)—renewing an earlier suspension deal that had begun to unravel. In August 2005, Iran resumed uranium conversion work, citing frustration with the pace of progress in the talks. In September 2005 the IAEA’s Board of Governors found Iran to be in violation of its safeguards agreement. In January 2006 Iran announced that it was resuming “research and development” on uranium enrichment, and removed the inspectors’ seals from its enrichment centrifuges. That move precipitated a February 2006 IAEA Board of Governors decision to demand that Iran renew its suspension and to have Director-General ElBaradei report the matter to the United Nations Security Council. That in turn caused Iran to end its voluntary adherence to the Additional Protocol to the IAEA safeguards agreement. In late March, Russia failed to win Iranian agreement to a Russian proposal for a joint venture to enrich uranium on Russian soil, and the Security Council adopted a presidential statement calling on Iran to suspend its enrichment and reprocessing activities and resolve the IAEA’s questions.

In April, Iranian President Mohamed Ahmadinejad announced that Iran had successfully enriched uranium in its 164-centrifuge cascade to 3.5% LEU, prompting the five permanent members

⁷³President George W. Bush, “President Speaks on War Effort to Citadel Cadets: Remarks by the President at the Citadel” (Washington, D.C.: The White House, Office of the Press Secretary, 2001; available at <http://www.whitehouse.gov/news/releases/2001/12/20011211-6.html> as of 5 March 2006).

of the Security Council to meet to discuss their response. As of mid-2006, continued efforts to find a negotiated solution were underway—but Iran was working to expand its enrichment capability beyond its experimental 164-centrifuge cascade, international inspectors were limited to observing Iran’s activities at the small number of declared sites, and serious questions remained about possible covert Iranian activities.

Limited Risk of States Providing Bomb Material to Terrorists

Despite these troubling developments, conscious state decisions to provide nuclear material or nuclear weapons to terrorists remain a modest part of the nuclear terrorism risk. It is certainly *not* correct, as is sometimes argued, that only terrorists with help from a state could possibly put together the capability to get and use a nuclear bomb.⁷⁴ Indeed, under all but a few circumstances, states—even states like Kim Jong Il’s North Korea—are unlikely to consciously decide to transfer a nuclear weapon or weapons-usable nuclear materials in their possession to a terrorist group. Such a decision would mean transferring the most awesome military power the state had ever acquired to a group over which it had little control. If the terrorists actually used the transferred capability against the United States or one of its allies, there would be a substantial chance that the source of the weapon or material would be traced back to the state that provided it, and that the resulting retaliation would be overwhelming, almost

⁷⁴ 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; available at http://www.nti.org/e_research/cnwm/overview/2004report.asp as of 1 February 2006), pp. 17-26.

certainly removing the government that decided on such a transfer.

Hence, prior to the 2003 U.S.-led invasion of Iraq, U.S. intelligence agencies reportedly concluded that it was unlikely Saddam would attempt any form of unconventional attack on the United States except if “ongoing military operations risked the imminent demise of his regime” or if he intended to “extract revenge” for such an assault; the only qualification was from the State Department, who thought Saddam Hussein would not attempt such an attack even then.⁷⁵

Thus, while a North Korean transfer of bomb materials to terrorists cannot be ruled out, such a decision appears quite unlikely given the importance Pyongyang appears to attach to regime survival, unless the regime concludes that U.S. overthrow of the regime is inevitable or becomes so desperate that the revenue from a nuclear sale comes to be seen as crucial to regime survival. A decision by the Iranian government to provide nuclear weapons or materials to al Qaeda terrorists (in the future, when the Iranian government might have such items to provide) also appears extraordinarily unlikely, particularly as the Sunni al Qaeda has been sponsoring widespread attacks on Shiites in Iraq, Pakistan, and elsewhere. In short, the danger that a state such as North Korea or Iran would provide nuclear material to terrorists is probably substantially smaller than the danger of nuclear theft, for to provide the key ingredients for an act of nuclear terror would be to run an incredible risk of being found out and facing overwhelming retaliation.

⁷⁵ Murray Waas, “Intel Reports Cast Doubt on Iraq War Justifications,” *Global Security Newswire*, 9 March 2006.

Nevertheless, an international effort to provide packages of credible carrots and sticks sufficient to convince the North Korean and Iranian governments that it is in their interests to verifiably end their nuclear weapons programs would be a key contribution to reducing the danger of nuclear terrorism—and the impasse in talks with both countries over the last year, with North Korea continuing to churn out weapons plutonium and Iran moving ever closer to the day when it has the capability to produce HEU, contributes to the danger.

INTERDICTING NUCLEAR SMUGGLING

Once a nuclear weapon or the material needed to make one has been stolen from the facility where it is supposed to be, that weapon or material could be anywhere, and the problem of finding and recovering it multiplies a thousandfold. Enough plutonium or HEU for a nuclear bomb would fit easily in a suitcase—indeed, could be carried in one hand—and while these materials are radioactive, their radioactivity is weak and difficult to detect at any substantial range, particularly in the case of HEU. Nevertheless, efforts to interdict nuclear smuggling both globally and at the United States' borders are worth some investment, for they hold the hope of closing off some of the easiest routes for smuggling nuclear weapons or materials, thus making the smuggler's job more complicated and uncertain.

Border Detection

Major programs are now underway to install radiation detectors at key border crossings and ports around the world. To date, approximately 40% of the border crossings around the world targeted by the United States as posing the highest risks for nuclear smuggling have been

given equipment and training to detect smuggled bomb material—as will be described in more detail in the next chapter.⁷⁶ As of the spring of 2006, DOE reported that U.S.-installed radiation detection equipment was in place and in use at only six of the dozens of megaports that send millions of shipping containers to the United States every year—though equipment installation was underway at eight other sites, and it appears that some other ports (such as Hong Kong) had installed some radiation detection equipment without U.S. help.⁷⁷ Virtually no capabilities are in place to prevent nuclear smuggling across wild, unguarded stretches of the border, or to prevent a fishing boat from bringing in nuclear material at an unmonitored cove.

In late 2005, the Domestic Nuclear Detection Office (DNDO) completed the development of a “global detection architecture” for radiation detection.⁷⁸ An interagency discussion of which agencies will implement which parts of this pro-

⁷⁶ See our discussion in the following chapter on “Key Border Posts Trained and Equipped to Detect Nuclear Smuggling.”

⁷⁷ U.S. Department of Energy, *National Nuclear Security Administration, Fact Sheet on NNSA's Second Line of Defense Program* (Washington, D.C.: DOE, 2006; available at <http://www.nnsa.doe.gov/docs/factsheets/2006/NA-06-FS01.pdf> as of 7 March 2006). See also testimony of David Huizenga, assistant deputy administrator of the National Nuclear Security Administration, in Homeland Security and Governmental Affairs Committee, Permanent Subcommittee on Investigations, *Hearing on Nuclear and Radiological Threats*, U.S. Senate, 109th Congress, 2nd Session (28 March 2006; available at <http://hs-gac.senate.gov/index.cfm?Fuseaction=Hearings.Detail&HearingID=335> as of 30 March 2006). An early public account of the Hong Kong project can be found in Alex Ortolani and Robert Block, “Keeping Cargo Safe from Terror; Hong Kong Port Project Scans All Containers; U.S. Doesn't See the Need,” *Wall Street Journal*, 29 July 2005.

⁷⁸ See testimony of Vayl Oxford, director of the Domestic Nuclear Detection Office, in *Hearing on Nuclear and Radiological Threats*.

posed architecture, with what resources, on what schedules, was still underway as of early 2006.⁷⁹ DNDO also conducted a series of realistic tests of available radiation detection equipment at the Nevada Test Site, and accelerated development of new, more capable radiation detectors.

Other major efforts are underway to install radiation detection capabilities at key border crossings and ports within the United States. As of late March 2006, U.S. Customs and Border Protection can screen approximately 67% of the containerized cargo entering the United States (including only about 44% of sea-borne containers) and roughly 80% of passenger vehicles with radiation portal monitors that would have some chance of detecting both plutonium and highly enriched uranium.⁸⁰

But domestic deployment has fallen behind schedule, making it unlikely a 2009 goal for full deployment will be met.⁸¹ Nor is there a detection capability in place at the many unofficial crossings or on the open stretches of border or coastline. There is widespread agreement that the generation of radiation portal monitoring equipment now being put in place in the United States and around the world would probably not be able to detect HEU for a bomb if the smugglers used shielding.⁸²

⁷⁹ Interview with DOE official, April 2006.

⁸⁰ See the testimony of CBP Assistant Commissioner Jayson Ahern in *Hearing on Nuclear and Radiological Threats*.

⁸¹ U.S. Congress, Government Accountability Office, *Combating Nuclear Smuggling: DHS Has Made Progress Deploying Radiation Detection Equipment at U.S. Ports-of-Entry, but Concerns Remain*, GAO-06-389 (Washington, D.C.: GAO, 2006; available at http://hsgac.senate.gov/_files/GAOREPORTInternational.pdf as of 30 March 2006).

⁸² See the discussion in *Hearing on Nuclear and Radiological Threats*. Also, this is implied by the research

Proliferation Security Initiative

Beyond radiation detection, the United States is cooperating with multiple other countries through the Proliferation Security Initiative (PSI) to interdict illicit trafficking of technologies related to missiles or nuclear, chemical, or biological weapons. PSI, however, is much more likely to be able to interdict large and observable shipments such as missiles or uranium enrichment equipment than to be able to detect and stop a suitcase of nuclear material.

In the past year, countries participating in PSI continued to carry out training exercises and experts' meetings. In 2005, the United States signed ship boarding agreements—gaining authority to board sea vessels with that country's flag that are suspected of carrying illicit shipments of weapons of mass destruction, their delivery systems, or related materials—with Belize, Croatia, and Cyprus.⁸³ Some eight multilateral exercises on various interdiction scenarios were carried out in 2005 and the first several months of 2006. Despite these exercises and meetings, in the past year there were no published reports of significant interdictions under this initiative.

Law Enforcement and Intelligence Cooperation

Radiation detection is by no means the only step that should be taken to address nuclear smuggling. A redoubled intelligence and law enforcement focus on tracking and breaking criminal networks

agenda outlined in U.S. Congress, *Combating Nuclear Smuggling: DHS Has Made Progress*, pp. 34-37.

⁸³ U.S. Department of State, "Proliferation Security Initiative" (Washington, D.C.: U.S. Department of State, no date; available at <http://www.state.gov/t/np/c10390.htm> as of 1 March 2006).

and smuggling groups potentially linking possible source states to areas of possible demand—which terrorists or nuclear smugglers might make use of for a nuclear shipment—is clearly needed.⁸⁴ For that focus to be successful, greatly expanded police and intelligence sharing across the world will be required, to help connect the dots that different agencies in different countries have in their hands in dealing with such transnational networks. Measures should be taken to make the barriers to successful transactions between buyer and seller even higher than they already are. Intelligence and law enforcement agencies could run additional stings and scams, posing as either buyers or sellers of nuclear material, to catch participants in this market, collect intelligence on market participants, and increase the fears of real buyers and sellers that their interlocutors may be government agents. As most of the confirmed cases in which stolen weapons-usable nuclear material was successfully seized involved one of the conspirators or some one they tried to involve in the effort informing on the others, additional measures to make such informing more likely—including anonymous tip hotlines that were well-publicized in the nuclear community, rewards, and the like—could also have substantial benefit.⁸⁵ All potential source states and likely transit states should have units of their national police force trained and equipped to deal with nuclear smuggling cases, and other law enforcement personnel should be trained to call in those units as needed.⁸⁶

⁸⁴Orttung and Shelley, *Linkages between Terrorist and Organized Crime Groups in Nuclear Smuggling*.

⁸⁵Such measures require considerable care in how they are set up and how the reports that come in are evaluated, if they are not to distract officials with large quantities of nonsense reporting.

⁸⁶For a discussion of measures in this area and their strengths and weaknesses, see Anthony Wier, “Interdicting Nuclear Smuggling,” in *Nuclear Threat Initiative Research Library: Securing the Bomb*

In all, the potential impact of efforts to interdict nuclear smuggling in reducing the risk of nuclear terrorism should not be exaggerated. The length of international borders, the millions of people and vehicles which cross them every year, the problem of unguarded “green borders,” the existence of successful smuggling routes and networks across most of the borders of the world, and the small size of and low signal from nuclear weapons or materials all conspire to make the smuggler’s job simpler and law enforcement’s job more difficult. Nevertheless, to increase the chances of stopping terrorists at some point on their pathway to the bomb, it is important to build and maintain a layered defense against nuclear terrorism.

OTHER ELEMENTS OF CONTROLLING NUCLEAR STOCKPILES

There are a number of other tasks that are important to improving controls over nuclear stockpiles and preventing nuclear terrorism.

Stabilizing Employment for Nuclear Personnel

Because even the best security system is only as good as the people who run it, it is important to stabilize the economic situations of nuclear personnel, in order to ensure that nuclear scientists, workers, and guards are not desperate enough to want to steal nuclear weapons and materi-

(Cambridge, Mass., and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, 2002; available at http://www.nti.org/e_research/cnwm/interdicting/index.asp as of 1 March 2006). See also Rensselaer Lee, “Nuclear Smuggling: Patterns and Responses,” *Parameters: U.S. Army War College Quarterly* (Spring 2003; available at <http://carlisle-www.army.mil/usawc/Parameters/03spring/lee.pdf> as of 5 January 2006).

als or sell nuclear knowledge. It is also wise to close unsustainable and unnecessary nuclear facilities, so that stronger and more sustainable security can be achieved at the remaining facilities.

Over the past year, progress continued in all of the key programs focused on stabilizing employment for nuclear weapons scientists. As already noted, the liability dispute that led to the 2003 expiration of the Nuclear Cities Initiative agreement was resolved (in the context of talks on plutonium disposition), and DOE received approval to begin negotiations, using similar language, on a new U.S.-Russian agreement for the Nuclear Cities Initiative.

Other challenges remain for the question of stabilizing the economic situation for nuclear personnel. To date, most U.S. programs continue to leave key categories of personnel with potentially dangerous knowledge or access to potential bomb materials unaddressed—from members of the guard forces, to production workers, to scientists who no longer have an association with a particular institute or facility. On the Russian side, there continues to be only modest apparent planning for the future of the closed nuclear cities—where many of the key Russian nuclear scientists and engineers live and work. Over the past year, the Russian government shifted subsidies for the closed nuclear cities from the federal budget to regional budgets. This shift creates substantial uncertainties over financing for these concentrations of nuclear materials and know-how. Meanwhile, in the past year several mayors, former mayors, and facility directors from these cities were either fired or charged with criminal offenses or both, with allegations ranging from creation of tax havens to benefit the former oil giant Yukos, to accepting bribes, to illegal dumping of radioactive waste. There

seems little doubt that anti-corruption initiatives need to be added to the portfolio of steps being taken to address the potential leakage of nuclear materials and expertise from Russia's nuclear complex.

Monitoring Stockpiles and Reductions

While the direct purpose of most proposed measures aimed at monitoring stockpiles and reductions is to confirm that agreed nuclear reductions are being implemented, such measures can also have substantial indirect benefits, by reducing the risk of theft of nuclear weapons and materials, by easing the access that facilitates cooperation, by highlighting weaknesses in security and accounting, and by providing an incentive to fix potentially embarrassing problems before they are revealed. Overall, the goal here should be to put in place sufficient monitoring and data exchanges to build confidence that nuclear stockpiles are secure and accounted for, agreed reductions are being implemented, and assistance funds are being spent appropriately.

Today, however, the reality is that the U.S. government is not pursuing broad-based nuclear transparency measures, either bilaterally with Russia or on a multilateral basis; only transparency measures related to specific agreements that are now being implemented—sometimes called “islands of transparency” in an opaque sea—are being pursued.

During 2005, transparency measures for the U.S.-Russian HEU Purchase Agreement continued to be implemented successfully.⁸⁷ Limited transparency measures for the plutonium production reactor shutdown agreement continued to

⁸⁷ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 499.

be implemented.⁸⁸ Ongoing talks during the past year still failed to reach agreement on transparency measures for the Mayak Fissile Material Storage Facility.⁸⁹

The United States and Russia did make substantial progress toward reaching an agreed approach for monitoring disposition of excess weapons plutonium (for which an agreement is required before construction of disposition facilities can begin). The two sides made no major progress, however, toward transparency in stockpiles of either strategic or tactical nuclear warheads.⁹⁰ The United States continued to permit IAEA monitoring of a small portion of its excess plutonium and HEU (along with the ongoing blending of HEU to low-enriched uranium).⁹¹ In February 2006, in response to a Freedom of Information Act lawsuit, the Department of Energy released (with some details removed) a detailed declaration concerning the U.S. HEU stockpile as of 1996, and the history of U.S. HEU production.⁹²

⁸⁸ U.S. Department of State, *FY 2005 Performance and Accountability Report* (Washington, D.C.: U.S. Department of State, 2005; available at <http://www.state.gov/documents/organization/58043.pdf> as of 16 May 2006).

⁸⁹ U.S. Department of Defense, *FY 2007 CTR Annual Report*, pp. 31-32.

⁹⁰ On plutonium disposition monitoring, interview with DOE officials, April 2006. For information on the transparency agreements, see U.S. Department of State, *FY 2005 Performance and Accountability Report*, p. 162.

⁹¹ For a discussion of this monitoring, see Matthew Bunn, "IAEA Monitoring of Excess Nuclear Material," 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, 2003; available at http://www.nti.org/e_research/cnwm/monitoring/trilateral.asp as of 23 May 2006).

⁹² U.S. Department of Energy, *Highly Enriched Uranium: Striking a Balance (Revision 1)* (Washington, D.C.: DOE, 2001; available at <http://www.fas.org/sgp/othergov/doe/heu/striking.pdf> as of 23 May 2006).

Ending Further Production

Clearly, the most important part of the objective of ending further production of nuclear weapons or weapons-usable material is ending (or preventing) production in countries where that production may be used to build a new nuclear arsenal—such as North Korea and Iran, as discussed above. Beyond efforts to deal with those countries' nuclear programs, there were other important developments in the past year related to this goal.

Perhaps surprisingly, there are no current efforts to put an end to further production of nuclear warheads in the United States and Russia. Both the United States and Russia are decreasing, rather than increasing, their nuclear warhead stockpiles, but both retain the right to manufacture new warheads if needed to replace existing warheads. Similarly, there are no current efforts to reach agreements to end nuclear weapon manufacture in the other nuclear weapon states.

Shutting plutonium production reactors. During the past year, progress was made in U.S.-Russian cooperation to build alternative power sources to replace Russia's last three plutonium production reactors, in the cities of Seversk and Zheleznogorsk, allowing them to be shut down without leaving the nearby towns in the cold and the dark. Between them, the three reactors produce approximately 1.2 tons of weapon-grade plutonium per year, adding to Russia's already large stockpile of excess plutonium. Under current plans, the \$387 million project to refurbish a coal plant in Seversk, allowing the two reactors there to shut down, is expected to be completed in 2008, and the \$570.5 million project to build a new coal plant at Zheleznogorsk to shut down the single reactor there has been accelerated from 2011

to 2010.⁹³ DOE has received some \$29.4 million in international commitments to support the Zheleznogorsk shut-down project (some 5% of the estimated total project cost).⁹⁴

The purpose of these shut-down projects is to avoid the production of the weapons-grade plutonium these reactors would otherwise produce during the remainder of their lives—and to reduce the safety risks these aging, pre-Chernobyl-design reactors would otherwise pose. If judged by the cost per ton of plutonium avoided, the cost of these projects appears quite high, particularly in the case of the Zheleznogorsk effort, which will cost more to shut down half as much annual plutonium production at a later date.⁹⁵

⁹³U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 525. For the cost figure for Zheleznogorsk, see U.S. National Nuclear Security Administration, *Elimination of Weapons-Grade Plutonium Production* (Washington, D.C.: NNSA, no date; available at <http://www.nnsa.doe.gov/na-20/ewgpp.shtml> as of 17 February 2006).

⁹⁴U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 529.

⁹⁵How much plutonium production would be avoided by shutting these reactors down depends on how long the reactors would otherwise keep running. The reactors have been operating for more than 40 years, and eventually it will no longer be possible to keep refurbishing and operating them. Estimates of the time when they would no longer be able to operate have ranged over the years from 2012 (only two years past the planned shut-down date for the Zheleznogorsk project) to 2025. Even if the 2025 date is correct—by which time the reactors would have been operating for some 60 years—the Zheleznogorsk project will avoid the production of only 6 tons of plutonium (added to a stockpile that already includes over 180 tons of separated plutonium), for a cost of some \$95 million per ton of plutonium avoided. Allowing this plutonium to be produced, and then adding it to the stock slated for disposition, would be much cheaper. But terminating the Zheleznogorsk effort and leaving Russia to find its own funds to replace this reactor could have impacts on other threat reduction cooperation, and it would mean

In the course of implementation, the Bush administration should significantly increase efforts to work with Russia to provide alternative employment for the thousands of nuclear experts and staff in Seversk and Zheleznogorsk who will be thrown out of work when these reactors and their associated reprocessing plants shut down, to avoid having the effort's success itself create new proliferation risks.

Fissile cutoff talks stalled. Globally, efforts to negotiate a Fissile Material Cutoff Treaty (FMCT) remained stalled in 2005, following the Bush administration's 2004 decision that it would not support verification of such an accord.⁹⁶ The May 2006 introduction by the United States of a draft treaty appears unlikely to move matters very much.⁹⁷ While a negotiated agreement is not moving forward, all five of the NPT nuclear-weapon states have in fact stopped producing plutonium and HEU for weapons (though China has not made any public pledge not to do so in the future).

India, Pakistan, Israel, and North Korea, however, are still producing plutonium, HEU, or both for weapons use. In the U.S.-India nuclear deal negotiated over

that large-scale processing of weapons-grade plutonium—a stage in the life-cycle that is especially vulnerable to insider theft—would continue at Zheleznogorsk for many years to come.

⁹⁶Matthew Bunn, "Fissile Material Cutoff Treaty," in *Nuclear Threat Initiative Research Library: Securing the Bomb*, ed. Matthew Bunn and Anthony Wier (Cambridge, Mass., and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, 2004; available at http://www.nti.org/e_research/cnwm/ending/fmct.asp as of 15 February 2006).

⁹⁷U.S. Department of State, *Texts of the Draft Mandate for Negotiations and the Draft Treaty -- Conference on Disarmament* (Geneva: U.S. Mission to the United Nations, 2006; available at <http://www.state.gov/t/isn/rls/other/66902.htm> as of 26 May 2006).

the past year, India agreed to support negotiation of an FMCT (a promise without much bite, since such negotiations are going nowhere and India did not promise to sign or ratify such an agreement if it was ever completed). But India was unwilling to stop producing additional weapons material, either immediately or at any specified time in the future; indeed, India insisted on leaving so many of its reactors outside of international safeguards that it would have the option, if it so chose, to drastically increase production of weapons plutonium.⁹⁸

Civilian plutonium and HEU

production. As currently envisioned, an FMCT would only ban production of weapons-usable nuclear materials for use in nuclear weapons—production of such materials for civilian purposes, or permitted military purposes (such as naval fuel) would be permitted. This does not affect HEU significantly, as there is little if any current production of HEU for non-weapons purposes around the world. But civilian separation and use of weapons-usable plutonium continues on a massive scale. Each year, some 20 tons of civilian plutonium is reprocessed from spent fuel, and only 10 tons of that is fabricated into fuel and used in reactors, adding some 10 tons to the global stockpile every year.⁹⁹

⁹⁸ The list of reactors to be placed under safeguards is listed under section 14 in Embassy of India to the United States, *Text of the Document Titled "Implementation of the India-United States Joint Statement of July 18, 2005: India's Separation Plan" Tabled in Parliament on March 7, 2006* (Washington, D.C.: Embassy of India, 2006; available at http://www.indianembassy.org/newsite/press_release/2006/Mar/29.asp as of 26 May 2006).

⁹⁹ See David Albright, "Separated Civil Plutonium Inventories: Current Status and Future Directions," in *Global Fissile Material Inventories*, ed. David Albright and Kimberly Kramer (Washington, D.C.: Institute for Science and International Security, 2004; available at http://www.isis-online.org/global_stocks/separated_civil_pu.html as of 15 February 2006).

Already, over 240 tons of weapons-usable civilian plutonium has built up in civilian stores around the world. Within a few years, these stocks of civilian separated plutonium will exceed the total amount of plutonium in all the world's military stockpiles.¹⁰⁰

Indeed, the Bush administration acknowledges that, as Secretary of Energy Samuel Bodman has put it, "the stores of plutonium that have built up as a consequence of conventional reprocessing technologies pose a growing proliferation risk that requires vigilant attention" and "simply must be dealt with."¹⁰¹ Yet as of today, there are no U.S. programs in place specifically designed to slow or stop this civilian plutonium production. A U.S.-Russian agreement on a 20-year moratorium on plutonium separation in both countries was almost complete at the end of the Clinton administration; the Bush administration should restart the effort to negotiate such an agreement, which would end the production of roughly a ton of reactor-grade (but weapons-usable) plutonium each year, roughly comparable to the amount of plutonium production to be stopped by shutting down the Seversk and Zheleznogorsk plutonium production reactors.

The Bush administration hopes that the new spent fuel treatment technologies to be developed in its proposed Global

¹⁰⁰ David Albright and Kimberly Kramer, "Separated Civil Plutonium Inventories: Current Status and Future Directions," in *Global Stocks of Nuclear Explosive Materials* (Washington, D.C.: Institute for Science and International Security, 2005; available at http://www.isis-online.org/global_stocks/end2003/tableofcontents.html as of 27 June 2006).

¹⁰¹ Samuel Bodman, *Carnegie Endowment for International Peace Moscow Center: Remarks as Prepared for Secretary Bodman* (Moscow: U.S. Department of Energy, 2006; available at <http://energy.gov/news/3348.htm> as of 17 March 2006).

Nuclear Energy Partnership (GNEP) will be more proliferation-resistant than traditional reprocessing, and will eventually replace traditional technologies. Moreover, Secretary Bodman and others argue that the advanced burner reactors (ABRs) to be developed as part of GNEP could help burn up the large existing civilian stockpiles.

Critics, by contrast, argue that the proposed new spent fuel treatment technologies will have only marginally better proliferation resistance than traditional reprocessing and that the initiative will encourage additional reliance on reprocessing while doing little to convince other states to switch over to the newer fuel processing technologies the United States proposes.¹⁰²

Either way, the administration's concept is a rather long-term approach to what it describes as an urgent problem: even if the administration's aggressive schedule goes according to plan, construction of a U.S. plant using the new recycling technologies (which is likely to take a substantial period), would not begin until after a demonstration of them was launched in 2011, and the first full-scale ABR would not be built until 2023.¹⁰³ Without pro-

¹⁰² Jungmin Kang and Frank Von Hippel, "Limited Proliferation-Resistance Benefits from Recycling Unseparated Transuranics and Lanthanides from Light-Water Reactor Spent Fuel," *Science and Global Security* 13, no. 3 (2005). Also, Steve Fetter and Frank von Hippel, "Is U.S. Reprocessing Worth the Risk?" *Arms Control Today* 35, no. 7 (1 September 2005; available at http://www.armscontrol.org/act/2005_09/Fetter-VonHippel.asp as of 26 May 2006).

¹⁰³ U.S. Department of Energy, *GNEP Element: Demonstrate Proliferation-Resistant Recycling* (Washington, D.C.: DOE, 2006; available at <http://www.gnep.gov/gnepProliferationResistantRecycling.html> as of 25 May 2006); U.S. Department of Energy, *GNEP Element: Develop Advanced Burner Reactors* (Washington, D.C.: DOE, 2006; available at [grams focused more directly on phasing out plutonium separation, it would likely take decades thereafter to phase out traditional plutonium reprocessing operations in other countries and burn the vast stockpiles of separated civilian plutonium that have accumulated.](http://</p></div><div data-bbox=)

Reducing Stockpiles

In addition to ending new production of material, actually reducing the massive stockpiles of nuclear weapons and weapons-usable nuclear material built up over the decades of the Cold War could have benefits both for reducing the risk of nuclear theft and for making reversal of ongoing nuclear arms reductions more difficult, observable, and costly. This is true for excess stockpiles of nuclear warheads, HEU, and plutonium.

The United States, Russia, France, and the United Kingdom have all reduced their nuclear forces since the collapse of the Soviet Union, dismantling thousands of nuclear weapons. In 2004, the Bush administration announced that the U.S. nuclear stockpile would be further reduced; non-government analysts estimate that some 6,000 weapons will remain in the U.S. weapons stockpile by 2012, the lowest level in decades.¹⁰⁴ Currently, however, there are no international negotiations or initiatives focused on achieving deeper reductions in nuclear weapons stockpiles. U.S. threat reduction assistance programs are not providing direct assistance for dismantlement of nuclear weapons in other countries (though as

www.gnep.gov/gnepAdvancedBurnerReactors.html as of 25 May 2006).

¹⁰⁴ Robert S. Norris and Hans M. Kristensen, "NRDC Nuclear Notebook: U.S. Nuclear Reductions," *Bulletin of the Atomic Scientists* (September/October 2004; available at http://www.thebulletin.org/article_nn.php?art_ofn=so04norris as of 21 June 2006).

discussed in Chapter 3, some programs provide indirect help, such as assistance in transporting warheads to dismantlement sites).

During 2005, implementation of the HEU Purchase Agreement continued, with another 30 tons of HEU blended to LEU and shipped to the United States. No decisions were announced, however, concerning whether the purchase would be extended beyond the original 500 tons of HEU. Disposition of U.S. excess HEU also continued, with another 17 tons of U.S. excess HEU either blended down or shipped for down-blending.¹⁰⁵

In September 2005, Secretary Bodman announced that the United States would provide LEU blended from 17 tons of U.S. excess HEU as the first contribution to an international fuel bank of last resort.¹⁰⁶ Russia's nuclear agency chief then pledged to support the fuel bank idea.¹⁰⁷ Two months later, Secretary Bodman announced that another 200 tons of the U.S. HEU stockpile would be removed from the stock available for weapons use.¹⁰⁸ But 160 tons of this material is being held in reserve for naval use, so the total amount added to the 174.5 tons previously declared as excess to all military needs was only 40 tons. Moreover, of that 40 tons, only 20 tons (10% of the total announce-

ment) would be blended to LEU under current plans, with the remaining 20 tons used as fuel for HEU-fueled reactors before they can convert to LEU.¹⁰⁹

Plutonium disposition efforts overcame some obstacles in 2005, but progress on the ground remained slow, some key obstacles remained, and these efforts' future remained in doubt. As noted above, by July 2005, U.S. and Russian negotiators had agreed on language resolving the long-standing liability dispute that had been blocking progress.¹¹⁰ But as of the spring of 2006, the agreed language remained mired in Russian interagency review and had not yet been signed, a delay that continued to cast doubt on Russian commitment to the effort. Russia has nearly completed site preparation activities at the location in Seversk where a plutonium-uranium mixed oxide (MOX) fuel fabrication facility is slated to be built.¹¹¹ In March 2005, the U.S. Nuclear Regulatory Commission (NRC) approved a license amendment allowing Duke Power to irradiate four MOX lead test assemblies that had been fabricated in France (which are now generating power in Duke reactors), and also approved construction of a MOX fabrication plant for plutonium disposition at Savannah River.¹¹² DOE held a ground-breaking ceremony for the Savannah River MOX plant in October 2005.

Major obstacles to progress remained, however, not least of which is Russia's reluctance to embrace the MOX approach.

¹⁰⁵ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 535.

¹⁰⁶ Samuel Bodman, *International Atomic Energy Agency 49th Session of the General Conference: Remarks Prepared for Energy Secretary Samuel Bodman* (Vienna: U.S. Department of Energy, 2005; available at <http://energy.gov/news/1948.htm> as of 25 May 2006).

¹⁰⁷ "Russia Ready to Join US-Led Uranium Fuel Bank," *Agence France Presse*, 27 September 2005.

¹⁰⁸ U.S. Department of Energy, *DOE to Remove 200 Metric Tons of Highly Enriched Uranium from U.S. Nuclear Weapons Stockpile* (Washington, D.C.: DOE, 2005; available at <http://www.energy.gov/news/2617.htm> as of 25 May 2006).

¹⁰⁹ U.S. Department of Energy, *DOE to Remove 200 Metric Tons of Highly Enriched Uranium from U.S. Nuclear Weapons Stockpile*.

¹¹⁰ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 461.

¹¹¹ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 461.

¹¹² U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 461.

In early 2006, Russia made clear that it would prefer to abandon the previously agreed approach of using MOX in its existing light-water reactors (LWRs), proposing instead to use its excess plutonium instead as fuel for the BN-800 fast neutron reactor now under construction and for other fast-neutron reactors not yet begun.¹¹³ Russian negotiators have indicated that because, in their view, the use of plutonium in LWRs is inefficient, they would not choose to do this in the absence of the need to reduce stockpiles of weapons plutonium, and hence are unwilling to move forward unless the international community pays 100% of their costs to do so. In the case of using plutonium in the BN-800 reactor, however, Russia would be prepared to pay a substantial part of the costs itself.¹¹⁴ The total capital cost of this option would be higher, however, as there is still \$1.5 billion yet to spend on building the BN-800 reactor, in addition to the costs of a plutonium fuel fabrication plant.¹¹⁵ Recent history suggests there may be substantial delays in building the BN-800 (construction of which started in 1987, only to be put on hold for many years for lack of funds). In 2005, for instance, the Russian government requested some \$200 million for construction, but the Duma provided just over \$30 million.¹¹⁶

In response to this Russian shift, U.S. negotiators have taken a two-pronged approach: the United States and Russia are close to agreement to move forward

¹¹³ Daniel Horner, "US Appears Ready to Drop Objections to Russian Fast-Reactor Pu Disposition," *Nuclear Fuel* (10 April 2006).

¹¹⁴ Interview with DOE officials, April 2006; discussion with former First Deputy Minister of Atomic Energy Valentin Ivanov (now a leading member of the Russian Duma), October 2005.

¹¹⁵ Interview with DOE officials, April 2006.

¹¹⁶ Interview with DOE officials, April 2006.

with "early disposition" of approximately a third of a ton of plutonium per year in the existing BN-600 fast reactor (as envisaged in the 2000 plutonium disposition agreement), and are establishing a joint working group to consider a wide range of reactor options for disposition of the remainder.¹¹⁷

Other cost and management concerns trouble the effort. First, not enough money is available to fund disposition of Russia's excess plutonium. To date, the United States and other international partners have pledged \$844 million toward the estimated \$2 billion cost of disposition of the 34 tons of excess weapons plutonium covered by the U.S.-Russian plutonium disposition agreement.¹¹⁸ But these are pledges rather than contracts; if the shifting discussion of what reactors to use delays construction, some participants may decide to spend their money elsewhere. Second, despite years of discussions, a multilateral agreement on financing and managing Russian plutonium disposition has not been completed—in part because it has been awaiting resolution of the liability dispute. Third, the U.S.-Russian plutonium disposition agreement specifies that construction of a MOX plant in Russia will not begin until agreement has been reached on monitoring and transparency measures; that agreement is not yet complete, though the two sides made substantial progress toward an agreed approach in the past year.¹¹⁹ Fourth, on the U.S. side, the costs of the projected plutonium disposition are skyrocketing, as documented in a recent DOE Inspector

¹¹⁷ Interview with DOE officials, April 2006.

¹¹⁸ *Hearing on U.S. Nonproliferation Strategy*.

¹¹⁹ Interview with DOE officials, April 2006. U.S. Department of State, *FY 2005 Performance and Accountability Report*, p. 159.

General report.¹²⁰ Fifth, the combination of huge cost growth and doubts over the Russian program's future is undermining support for the effort in Congress and in some quarters of the administration. As of the spring of 2006, Congress was moving to break the link between construction of U.S. and Russian disposition facilities, and, on the House side, to cut funding for the disposition effort. In short, the long-term political sustainability of the effort remains uncertain, both in Russia and in the United States.

Part of the wavering support for plutonium disposition comes from doubts about whether the effort as currently conceived really would have large security benefits. As we have argued before, disposition of 34 tons of excess plutonium could bring substantial security benefits only if (a) the initial 34 tons becomes only a first step toward disposition of a much larger fraction of the U.S. and Russian plutonium stockpiles; and (b) stringent standards of security and accounting are maintained throughout, so that the process of removing the material from guarded vaults, processing it into fuel, and shipping it from place to place does not substantially increase, rather than decrease, proliferation risks.¹²¹ To date,

¹²⁰ U.S. Department of Energy, Office of the Inspector General, *Audit Report: Status of the Mixed Oxide Fuel Fabrication Facility*, DOE/IG-0713 (Washington, D.C.: 2005; available at <http://www.ig.doe.gov/pdf/ig-0713.pdf> as of 26 May 2006).

¹²¹ See discussion in 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/overview/report.asp as of 1 February 2006), pp. 156-161. For a detailed analysis of the security benefits and issues from disposition of excess plutonium, see U.S. National Academy of Sciences, Committee on International Security and Arms Control, *Management and Disposition of Excess Weapons Plutonium* (Washington, D.C.: National Academy

however, there seems to be little focus on moving beyond the first 34 tons, and the U.S. government is not pursuing deep and irreversible nuclear arms reductions as a near-term objective. Moreover, there appears to have been little focus on ensuring stringent security measures throughout the process in both Russia and the United States; indeed, Duke Power has sought and received waivers from some NRC security rules going in the opposite direction.¹²² If the approach for disposition in Russia ultimately becomes using the BN-800 as originally designed—an approach in which the reactor produces more weapon-grade plutonium than it consumes—continued U.S. support would be more likely to undermine than to promote U.S. nonproliferation objectives.

Press, 1994; available at <http://books.nap.edu/html/plutonium/0309050421.pdf> as of 20 March 2006).

¹²² For the decision making the remarkable statement that there is “no rational reason” why a MOX-fueled reactor should have increased security, see 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; available at <http://www.nrc.gov/reading-rm/doc-collections/commission/orders/2004/2004-29cli.pdf> as of 29 March 2006). By contrast, a committee of the National Academy of Sciences concluded that plutonium in all of the stages of the disposition process before it became spent fuel (including in fabricated MOX fuel) posed a sufficient hazard that, to the extent practicable, it should be secured to the same degree that stored nuclear weapons are—the so-called “stored weapon standard.” See U.S. National Academy of Sciences, *Management and Disposition of Excess Weapons Plutonium*. While the risk of theft of fabricated MOX fuel may be low in the United States, if the United States is to convince Russia and other countries around the world to apply high security standards to all plutonium and HEU without substantial radiation barriers to inhibit theft and processing, it will have to take a similar approach itself. For the announcement of the authorization to load MOX lead test assemblies into the Catawba reactors, see U.S. Nuclear Regulatory Commission, *NRC Authorizes Use of Mixed Oxide Fuel Assemblies at Catawba Nuclear Power Plant* (Washington, D.C.: NRC, 2005; available at <http://www.nrc.gov/reading-rm/doc-collections/news/2005/05-043.html> as of 28 March 2006).

THE NEED FOR LEADERSHIP

Urgent action is needed to overcome all of these daunting challenges and significantly reduce the threat of nuclear terrorism. While the technology is available to accomplish that task, the obstacles are great. Success in a host of difficult tasks is required: building the needed spirit of partnership; forging a common sense of the urgency of the threat; finding means to cooperate without compromising nuclear secrets; structuring incentives that will convince states and facilities to invest in high security and consolidate nuclear stockpiles into fewer, more secure locations; gaining agreement on effective global standards for nuclear security; and overcoming the myriad bureaucratic and political obstacles to rapid implementation of security upgrades. No one person has the power to simply order that these tasks be accomplished, and then expect them to be done. Executing these tasks will require sustained, creative leadership from the highest levels of government—in the United States, in Russia, and in other leading nuclear states.

The results from the Bratislava summit have demonstrated what presidential leadership can do. With their joint statement, President Bush and President Putin set goals they expected their subordinates to meet, established a process to follow through, and communicated to their governments that they viewed security cooperation as a priority not to be delayed by bureaucratic obstacles. The result was a significant improvement in cooperation between the two governments, breaking the logjam on securing a substantial number of warhead sites, notably accelerating progress in securing materials, and elevating the dialogue on critical matters such as steps to forge strong security cultures and best practices in achieving and sustaining high levels of nuclear security.

But since Bratislava, presidential intervention to move the process forward has not been sustained, either in Washington or in Moscow. While President Bush and Vice President Cheney speak often of the need to keep weapons of mass destruction out of terrorist hands, they then focus almost exclusively on proliferation by states such as North Korea and Iran rather than the crucial task of securing global nuclear stockpiles from theft.¹²³ Virtually no public discussions of the topics for meetings with foreign leaders by the president, the secretary of state, the secretary of defense, or even the deputy secretary of state or the relevant undersecretary of state even mention the subject of securing nuclear stockpiles.

For example, there was no public mention of nuclear security in any of the statements or briefings surrounding President Bush's 2006 meeting with Chinese president Hu Jintao, although lower-level officials have been working for years to gain Chinese agreement to allow cooperation on security upgrades beyond the one civilian facility that has been upgraded so far. Similarly, as noted above, no initiative on nuclear security was included in the negotiation of the U.S.-India nuclear deal, though lower-level officials had been trying to convince India to cooperate on nuclear security improvements for years.

¹²³ For typical speeches where the president and vice president discuss the link between terror and weapons of mass destruction, but then fail to address the need to secure nuclear stockpiles, see Vice President Dick Cheney, "Vice President's Remarks to the American Israel Public Affairs Committee 2006 Policy Conference" (Washington, D.C.: The White House, Office of the Press Secretary, 2006; available at <http://www.whitehouse.gov/news/releases/2006/03/20060307-1.html> as of 26 May 2006); President George W. Bush, "President Addresses American Legion, Discusses Global War on Terror" (Washington, D.C.: The White House, Office of the Press Secretary, 2006; available at <http://www.whitehouse.gov/news/releases/2006/02/20060224.html> as of 26 May 2006).

Despite numerous recommendations from blue-ribbon panels, the administration has still not appointed a senior White House official with the full-time responsibility of overseeing and coordinating U.S. efforts to control nuclear warheads, materials, and expertise.¹²⁴ Instead, the agenda has largely been left to Secretary of Energy Samuel Bodman and lower-ranking officials of other departments to push forward. While Secretary Bodman has pursued it with considerable energy, the reality is that DOE is not among the lead national security agencies of the U.S. government, and many of the steps that need to be taken require high-level leadership from the White House or the State

¹²⁴ Such an appointment has been recommended in numerous previous reports. For instance, see John P. Holdren's testimony in Committee on Foreign Relations, Subcommittee on Europe, *The Threat from Surplus Nuclear-Bomb Materials*, U.S. Senate, 104th Congress, 1st Session (23 August 1995). In his testimony, Holdren summarizes the results of a secret study by a panel of the President's Committee of Advisers on Science and Technology. See also Title XIV in U.S. Senate, *The Defense against Weapons of Mass Destruction Act of 1996*, 104th Congress, 2nd Session, Public Law 201 (1996). This bill is commonly referred to as Nunn-Lugar-Domenici, which attempted to direct that such an official be appointed. Also see other high-level panels recommending this course of action: Commission to Assess the Organization of the Federal Government to Combat the Proliferation of Weapons of Mass Destruction, *Combating Proliferation of Weapons of Mass Destruction* (Washington, D.C.: Deutch Commission, 1999; available at http://www.mipt.org/pdf/combattprolifwmd_senate.pdf as of 26 May 2006); Secretary of Energy Advisory Board, Russia Task Force, *A Report Card on the Department of Energy's Nonproliferation Programs with Russia* (Washington, D.C.: U.S. Department of Energy, 2001; available at <http://www.ceip.org/files/projects/npp/pdf/DOERussiaTaskForceReport011001.pdf> as of 26 May 2006); John P. Holdren and Nikolai P. Laverov, "Letter Report from the Co-Chairs of the Russian Academy of Sciences / U.S. National Academies Joint Committee on U.S.-Russian Cooperation on Nuclear Non-Proliferation" (Washington, D.C.: National Academies Press, 2002; available at <http://www4.nationalacademies.org/news.nsf/isbn/s02052003?OpenDocument> as of 26 May 2006).

Department. There is scant public information to suggest that the White House is focusing daily on the task of securing all nuclear weapons and weapons-usable nuclear material around the world—that is, little daily focus on the task the 9/11 Commission recommended be a "top national security priority."¹²⁵

Unfortunately, leaders of other countries around the world are doing even less to reduce this danger. While some might think that nuclear terrorism is something only Americans need worry about, UN Secretary-General Kofi Annan has been eloquent in pointing out the global impact of a nuclear terrorist attack:

Were such an attack to occur, it would not only cause widespread death and destruction, but would stagger the world economy and thrust tens of millions of people into dire poverty. Given what we know of the relationship between poverty and infant mortality, any nuclear terrorist attack would have a second death toll throughout the developing world.¹²⁶

¹²⁵ 9/11 Public Discourse Project, "Report on the Status of 9/11 Commission Recommendations: Part III: Foreign Policy, Public Diplomacy, and Nonproliferation" (Washington, D.C.: 9/11 Public Discourse Project, 2005; available at http://www.9-11pdp.org/press/2005-11-14_report.pdf as of 26 May 2006). Also, "9/11 Public Discourse Project Holds a News Conference on Government Implementation of the 9/11 Commission's Recommendations on Foreign Policy, Public Diplomacy and Nonproliferation - News Conference" (Washington, D.C.: Political Transcripts by CQ Transcriptions, 2005; available at http://www.9-11pdp.org/press/2005-11-14_remarks.pdf as of 24 April 2006).

¹²⁶ 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; available at <http://english.safe-democracy.org/keynotes/a-global-strategy-for-fighting-terrorism.html> as of 10 March 2006).

Others appear to believe that the probability of nuclear terrorism is so small that the danger can effectively be ignored. Pakistani President Musharraf has publicly argued that terrorists could not make nuclear weapons, even if they got nuclear material, and that the “the West is overly concerned” about the threat of nuclear terrorism.¹²⁷ Similarly, the security chief for Russia’s nuclear agency has dismissed terrorist bomb construction as “absolutely impossible.”¹²⁸

¹²⁷ David Brunnstrom, “Interview-Dirty Bomb a Fear, Not Nuclear Terrorism-Musharraf,” *Reuters News*, 14 April 2005.

¹²⁸ Aleksandr Khinshteyn, “Secret Materials” in *Russian Central TV* (2002).

Despite the creation of the G8 Global Partnership Against the Spread of Weapons and Materials of Mass Destruction in 2002, the reality today is that most countries do not share the United States’ sense of urgency about the threat of nuclear terrorism and the need to secure nuclear stockpiles, and no global coalition genuinely focused on rapidly improving nuclear security around the world yet exists.

In short, there continues to be a substantial gap between the urgency of the nuclear terrorism threat and the pace and scope of the global response.

3 TRACKING PROGRESS IN CONTROLLING NUCLEAR WARHEADS, MATERIALS, AND EXPERTISE

The United States, other countries, and the International Atomic Energy Agency (IAEA) have a wide range of efforts under way to secure, monitor, and reduce stockpiles of nuclear weapons and materials in the former Soviet Union and around the world. In this chapter we use a series of specific metrics to assess in detail the progress U.S.-funded programs are making in each of six areas: securing nuclear warheads and materials; interdicting nuclear smuggling; stabilizing employment for nuclear personnel; monitoring nuclear stockpiles; ending further production; and reducing nuclear stockpiles.

This review demonstrates that the efforts by the United States and its global partners to reduce the threat of nuclear terrorism have had real, demonstrable successes, representing an excellent investment in American and world security. Enough nuclear material for thousands of nuclear weapons has been permanently destroyed. (Indeed, nearly half of the nuclear-generated electricity in the United States comes from blended-down highly enriched uranium (HEU) from dismantled Russian nuclear weapons, as part of the U.S.-Russian HEU Purchase Agreement, sometimes known as “Megatons to Megawatts.”) Security for scores of vulnerable nuclear sites has been demonstrably improved, and the United States and Russia have now set a joint objective of completing security and accounting upgrades for most nuclear warhead and weapons-usable nuclear material sites in Russia by the end of 2008. At least temporary civilian employment has been provided for thousands of nuclear weapons scientists and workers who might otherwise have been driven by desperation to seek to sell their

knowledge or the materials to which they had access.

But as we rightly celebrate this important progress—and the hard work by hundreds of U.S., Russian, and international officials and experts that brought it about—it is important to remain focused on the parts of the job yet to be done. As we discuss in detail below, by the end of fiscal year (FY) 2005, U.S.-funded security upgrades had been completed for roughly 54% of the buildings containing weapons-usable nuclear material in the former Soviet Union.¹ Less than a quarter of Russia’s stockpile of bomb uranium has been destroyed, and it will still be years before destruction of substantial quantities of U.S. and Russian excess bomb plutonium even begins. Much less than half of Russia’s excess nuclear weapons experts have yet received self-supporting civilian jobs (as opposed to short-term subsidized grants). Beyond the former Soviet Union, cooperative security upgrades are only just beginning, leaving many sites dangerously vulnerable, and no effective, binding global nuclear security standards have yet been put in place.

Moreover, some of the most important issues to be addressed are difficult to reflect in quantifiable metrics. As discussed in the previous chapter, in Russia, even as the agreed upgrades near completion, important questions remain about whether the security levels being achieved by those upgrades are enough to meet the threats that exist in Russia; whether those

¹ The U.S. federal fiscal year runs from 1 October to 30 September of the year named, so FY 2005 is the fiscal year that ended on 30 September 2005.

security levels will be sustained after U.S. assistance phases out; and whether strong security cultures are being built. Similar issues are sure to arise in other countries as cooperation beyond the former Soviet Union expands. In short, the goal of ensuring that every stockpile of nuclear warheads and materials worldwide is sustainably secured and accounted for to stringent standards remains a long way away—unacceptably far away, given the urgency of the threat.

It is impossible to directly measure the risk of nuclear theft and terrorism, and whether it is increasing or decreasing. Hence, all the measures of progress the U.S. government uses to track these efforts, and all the measures we discuss in this chapter, are intended only as partial substitutes for such a direct measure, reflecting progress in implementing some particular approach to addressing one part of this multi-faceted problem. The metrics used here are inevitably rough summaries of a more complex story.

We have relied on official government measures and data where possible, but in some cases these are not available. The administration, led by the Department of Energy (DOE), has improved the availability and transparency of measures of performance for its programs to control nuclear warheads, materials, and expertise worldwide.² But the fact remains

²The detailed justifications of their budget proposal supplied by the agencies to Congress contain performance information and targets for each major activity; for instance, see U.S. Department of Energy, *FY 2007 Congressional Budget Request: National Nuclear Security Administration--Defense Nuclear Nonproliferation*, vol. 1, DOE/CF-002 (Washington, D.C.: DOE, 2006; available at http://www.cfo.doe.gov/budget/07budget/Content/Volumes/Vol_1_NNSA.pdf as of 24 February 2006). See also the performance assessments of the Energy and State Departments: U.S. Department of Energy, *Performance and Accountability Report: FY*

that the U.S. government has no comprehensive plan for ensuring that *all* nuclear weapons and weapons-usable materials worldwide are secure and accounted for, or for the other elements of this agenda, and has not put forward a comprehensive set of milestones that would allow Congress and the public to fully understand both how much progress is being made and where prolonged delays suggest the need for a change in approach.³ Until that occurs, we will continue to provide the best measurable assessments we can from outside the government.

Such measures to track progress are crucial to the effectiveness of almost any government program. Only by understanding which efforts are showing real results and which efforts are not can mid-course corrections be made, and ineffective efforts be improved. But such measures are inevitably imperfect. Undue reliance on particular progress metrics can be misleading. Progress on sustainability and security culture, for example, is fundamental to the long-term success of nuclear security efforts, but such prog-

2005 (Washington, D.C.: DOE, 2006; available at <http://www.cfo.doe.gov/progliaison/2005pr.pdf> as of 4 April 2006); U.S. Department of State and U.S. Agency for International Development, "Strategic Goal 4: Weapons of Mass Destruction" in *FY 2007 Performance Summary* (Washington, D.C.: U.S. Department of State, 2006; available at <http://www.state.gov/documents/organization/59174.pdf> as of 14 April 2006). A handful of relevant programs have been examined using the White House Office of Management and Budget's Program Assessment Rating Tool (PART): see U.S. Office of Management and Budget, *Program Assessment Rating Tool* (Washington, D.C.: OMB, 2006; available at <http://www.whitehouse.gov/omb/expectmore/> as of 27 March 2006)

³For a discussion on the absence of a government-wide strategic plan, see U.S. Congress, Government Accountability Office, *Weapons of Mass Destruction: Nonproliferation Programs Need Better Integration*, GAO-05-157 (Washington, D.C.: GAO, 2005; available at <http://www.gao.gov/new.items/d05157.pdf> as of 31 January 2006), pp. 8-17.

ress is very difficult to quantify, and is not reflected at all in the measures presented in this chapter. Any particular measure of progress reflects one definition of the problem to be addressed, and one idea of the best method for solving that problem, excluding others. A manager focused exclusively on racking up more progress by that measure is likely to miss opportunities for different approaches to taking on the problem—and thus managing to a particular metric can breed complacency.

TRACKING PROGRESS: SECURING NUCLEAR WARHEADS AND MATERIALS

The overall goal in this category is simple: every nuclear weapon and every kilogram of nuclear material anywhere in the world must be sustainably secured and accounted for, to standards sufficient to defeat the threats that terrorists and criminals have shown they can pose. As noted in the last chapter, this is a global problem, with weapons-usable nuclear materials in some 40 countries under widely varying levels of security.

Assessing how close the world is to meeting the goal of effective security for these stockpiles is more difficult than it might seem. Within the former Soviet Union, the U.S. government has made available reasonably detailed estimates of the number of sites and buildings with weapons-usable nuclear materials and the quantity of these materials, along with estimates of the percentages of these sites, buildings, and materials covered by various levels of upgrades; data on warhead sites and upgrades are numerous, though far less complete. But for the rest of the world, there are very few publicly available data on the number of sites where nuclear warheads and the materials needed to make them exist, the current security levels at those sites compared to

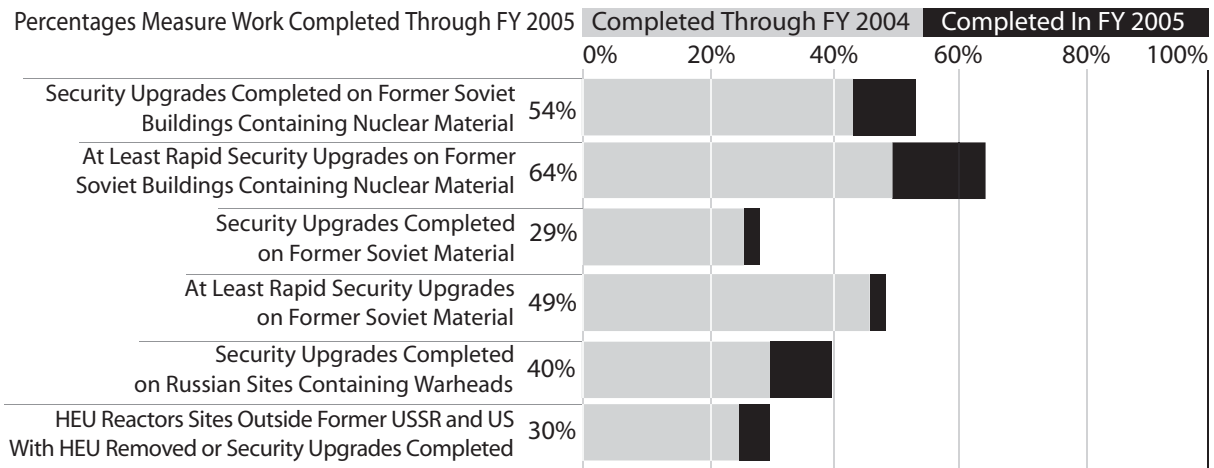
the threats that terrorists and criminals have shown they can pose in the regions of those facilities, or the quantity and quality of weapons-usable material that exists at those sites. Data have simply not been collected—in classified form or not—on important matters such as pay, morale, and corruption among the staff at nuclear sites around the world, or what procedures are used at different facilities to assess and test the security of sites and what the results of those assessments may have been.

In particular, the answer to the basic policy questions “how many buildings around the world need security upgrades, how extensive are the upgrades they need, how much will that cost, and how long will that take?” depend a great deal on what standards of nuclear security are set as the objective of the effort. Currently, the standards being pursued vary widely from one program to another, for reasons that are more the result of historical accident than rational calculation. The United States is spending roughly \$1.5 billion annually on safeguards and security for DOE facilities and activities,⁴ most of which goes to protecting sites against a very substantial post-9/11 design basis threat (DBT) that reportedly includes squad-sized teams of well-trained outside attackers equipped with sophisticated armaments and equipment, along with multiple well-placed insiders.⁵

⁴ See the “Safeguards and Security Crosscut” in U.S. Department of Energy, *FY 2007 Congressional Budget Request: Other Defense Activities*, vol. 2, DOE/CF-003 (Washington, D.C.: DOE, 2006; available at http://www.cfo.doe.gov/budget/07budget/Content/Volumes/Vol_2_ODA.pdf as of 5 May 2006).

⁵ For a discussion of the kinds of armament and equipment included in the new DOE DBT, see Ronald E. Timm, *Security Assessment Report for Plutonium Transport in France* (Paris: Greenpeace International, 2005; available at <http://greenpeace.datapps.com/stop-plutonium/en/TimmReportV5.pdf> as of 6 February 2006). For non-government

Figure 3-1
How Much Securing Work Have U.S.-Funded Programs Completed?



U.S.-sponsored upgrades being installed in Russia are intended to defend against more modest threats (though apparently the threats U.S. teams are directed to help Russian facilities defend against have been increased since 9/11). In principle Russian sites should be defended against higher threats than U.S. sites, rather than the other way around, as both the outsider and insider threats in Russia appear to be substantially higher than they are in the United States, given the ongoing terrorist conflict there and the huge problem of insider theft and corruption bedeviling Russian society. For HEU-fueled research reactors in other countries, the United States is only helping with upgrades to meet very general and vague IAEA recommendations, which do not include *any* particular threat to be defended against; in

most cases, sites “completed” under this effort could probably only defend against a very small number of outside attackers and perhaps one insider.

Clearly, how many sites are below the bar of effective nuclear security, by how far, depends on where the bar is set. If the objective was to ensure that all nuclear weapons and weapons-usable nuclear material worldwide were secured to DOE standards, a very large fraction of all the world’s nuclear facilities would probably require upgrades, and the upgrades needed would likely be extensive, costly, and time-consuming (as they are expected to be at DOE’s own facilities, which are still putting in place the measures needed to defeat the post-9/11 threats DOE regulations require them to be prepared for). On the other hand, DOE’s Global Threat Reduction Initiative (GTRI) program believes that the vast majority of the world’s HEU-fueled research reactors already have security in place that meets International Atomic Energy Agency (IAEA) recommendations, leaving only about 10 HEU-fueled research reactors worldwide where security upgrades are still underway or planned, and 17 more where the

summaries of the size of the potential attacking forces included in the threat, see, for example, Project on Government Oversight, “Energy Ups Their DBT, NRC Still Making Excuses” (Washington, D.C.: POGO, 2004; available at http://pogoblog.typepad.com/pogo/2004/09/energy_ups_thei.html as of 5 February 2006); Peter Stockton, “Vulnerability of Spent Fuel Pools and the Design Basis Threat” (Washington, D.C.: Project on Government Oversight, 2004; available at <http://pogo.org/m/ep/ep-spentfuelpools-NAS-5102004.pdf> as of 1 February 2006).

U.S. government is still assessing the need for upgrades.⁶

We believe that the bar should be set at a level that will provide security able to defeat the kinds of overt attacks and covert thefts that terrorists and criminals have shown they can carry out in different regions of the world. United Nations Security Council Resolution 1540 legally requires all states to have “appropriate effective” security for whatever stockpiles of nuclear weapons and weapons-usable nuclear materials they may have. If the word “effective” is taken literally, it suggests that these security measures must be able to effectively defeat the threats that have been shown to exist. This suggests a security standard that would probably be well above the minimum measures needed to meet current IAEA recommendations, though perhaps below the standard now required of DOE facilities. We do not yet have good measures of how many facilities worldwide would require what level of upgrade to meet such an objective. We believe Congress should consider asking the administration to prepare estimates of how many facilities worldwide would require upgrades, and how extensive those upgrades would be, for various possible standards of nuclear security, and to make a recommendation to Congress as to what nuclear security standards should be pursued. In the absence of such specific measures of the total amount of global work to be done, we use, in this chapter, a number of measures focused on Russia, followed by a very partial measure of the global picture.

In the absence of hard data on the real effectiveness of nuclear security systems in the former Soviet Union and around the world, we rely, in this section, on metrics

⁶ DOE statement provided to Rep. Robert Andrews (D-NJ), April 2006.

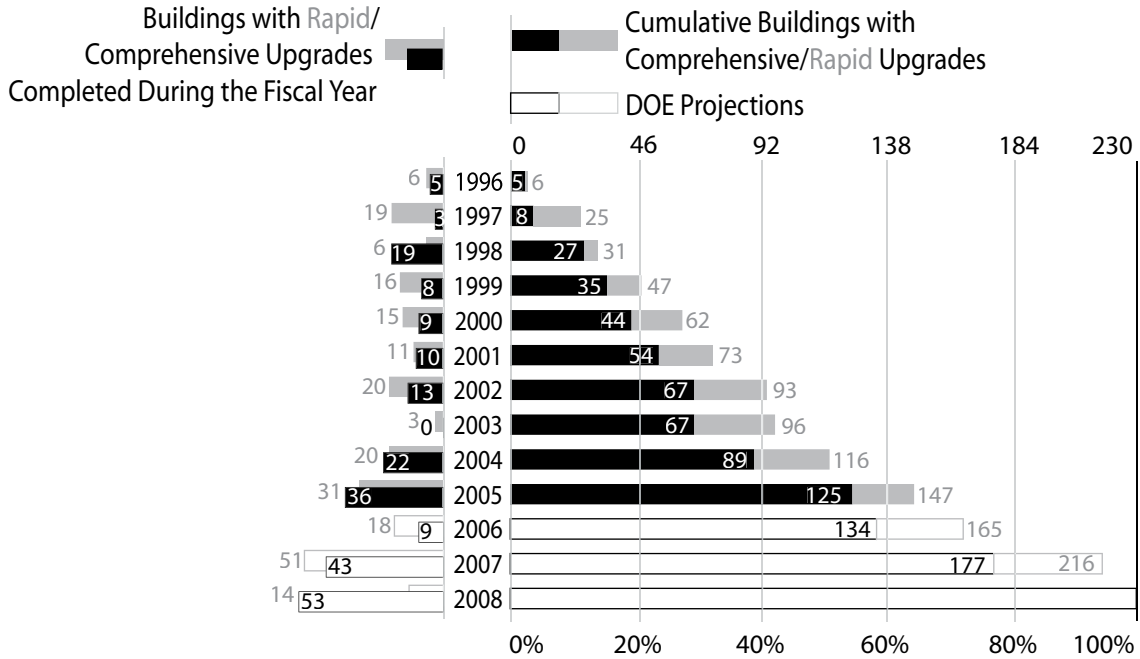
very similar (in most cases) to those the U.S. government uses to report the progress of its efforts in these areas. These focus, in particular, on (a) materials or buildings that have two defined levels of security and accounting equipment upgrades installed with U.S. assistance—“rapid” upgrades and “comprehensive” upgrades—and (b) buildings or sites where the potential nuclear bomb material has been removed entirely, eliminating the theft risk from that location.⁷

By its nature, however, the first category of measure does not include the progress Russia or other partner states have made in upgrading security on their own, without U.S. or other foreign assistance. Nor does it include harder-to-measure but crucial progress in areas such as providing training or strengthening independent regulation of nuclear security and accounting, areas which presumably have benefits for securing and accounting for *all* nuclear materials in recipient countries, not just those for which U.S.-funded equipment is being installed. Another key issue is that it measures, essentially, the installation of modern security and accounting equipment, but does not capture whether the *people* at these sites are following effective security procedures and using the equipment in a way that in fact provides high levels of security.⁸ Hence,

⁷ Rapid upgrades include items such as: installing nuclear material detectors at the doors, putting material in steel cages that would take a considerable time to cut through, bricking over windows, and counting how many items of nuclear material are present. “Comprehensive” upgrades represent the installation of complete modern security and accounting systems, designed to be able to protect the facility against at least modest insider and outsider theft threats.

⁸ For an extensive recent discussion of the importance of the “human factor” in security, in Russia in particular, 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;

Figure 3-2
Annual and Cumulative Number of Buildings
with Rapid and Comprehensive Cooperative
Security Upgrades Completed



it is quite possible for some material counted as “completed” by this measure to be insecure. It is equally possible for material counted as “not completed” to be secure, because the partner state has already taken action to secure it effectively.

Securing Metric 1: Security Upgrades on Former Soviet Buildings Containing Nuclear Material

The best available measure—though still a rough one—of both the fraction of the needed security upgrade work that has been finished and of the fraction of the threat that has been reduced is the fraction of the buildings where weapons-usable nuclear material is located whose secu-

rity has been upgraded.⁹ The fraction of buildings covered is a better measure of risk reduction than the fraction of materials covered because, as DOE puts it, “a building with 1 ton of nuclear material in storage is as great a threat as a building with 10 tons.”¹⁰ Improving security at a building with a massive amount of nuclear material involves more work, but not dramatically more, so the total amount of work completed is also more closely related to the number of buildings covered than to the amount of material covered. Building-level data are also better than site-level data, because a large site with dozens of buildings containing nuclear material may have dozens of different groups that

⁹We have relied primarily on measures focusing on materials in the past only because these were the only data DOE made publicly available.

¹⁰U.S. Department of Energy, *FY 2007 Congressional Budget Request: National Nuclear Security Administration--Defense Nuclear Nonproliferation*, p. 514.

available at <http://www.uga.edu/cits/documents/pdf/Security%20Culture%20Report%2020041118.pdf> as of 18 February 2006).

have access to that material, and because the work of improving security at such a huge and multifaceted site is much more time-consuming, complex, and expensive than the work of improving security at a small site with only one building.

DOE has now adopted the buildings measure as its primary metric of how much has been accomplished in the cooperative security upgrades program. For a building to be listed as “completed” means that either comprehensive upgrades have been finished there, or DOE has determined that only rapid upgrades were needed at that building (if, for example, the material in the building was of low attractiveness for use in a nuclear weapon). DOE also frequently uses the term “secured,” which is used to mean buildings with at least rapid upgrades put in place, regardless of whether DOE still plans to install comprehensive upgrades.

As of the end of FY 2005, just over 54% of the 230 buildings in the former Soviet Union containing weapons-usable nuclear material have had comprehensive security upgrades.¹¹ By that time, at least rapid security upgrades had been put in place on 64% of the buildings.¹² Figure 3-1 shows the number of buildings with comprehensive or rapid upgrades completed as a fraction of the total amount of buildings requiring upgrades.

Rate of progress. During FY 2005, comprehensive upgrades were completed for an additional 36 buildings, almost twice

the highest number that had been completed in any previous year, bringing the total completed to 125.¹³ Rapid upgrades were completed for an additional 31 buildings, bringing the total from 116 (50%) to 147 (64%)—again the fastest pace of any year since the effort’s inception.¹⁴ Figure 3-2 shows the year-by-year progress of comprehensive and rapid security upgrades in the former Soviet Union, and DOE’s projections for the remaining years until the effort is complete.¹⁵

¹³ Data provided by DOE, May 2006.

¹⁴ Data provided by DOE, May 2006. These data appear to represent updates to the estimates presented in U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 514. There, DOE bases its estimates on 195 buildings to be completed by the end of 2008, rather than the more recent 230-building figure, and reports that 150 of these had at least rapid upgrades completed by the end of FY 2005, rather than the more recent 147 figure provided here. The increased number of total buildings in the more recent data significantly reduces the figures for the percentage completed; the figure is 77% of the buildings with at least rapid upgrades for the earlier data in the budget justifications, but 64% here.

Last year, we estimated that 56% of the buildings had at least rapid upgrades completed, compared to the 50% DOE now reports for the end of FY 2004. We built our estimate using data that at the time commingled buildings containing only material with those containing warheads. In those data, there were 205 buildings with weapons-usable material, as opposed to 230 such buildings in the more recent DOE data, or 195 reported in the budget justifications. Such re-estimates are normal as a program gains more data about the scope of work it faces. We should have also been more explicit in last year’s report in describing our 56% figure as being the buildings where at least rapid upgrades had been completed, rather than suggesting that all upgrades had been finished at those buildings. For last year’s full discussion, see Matthew Bunn and Anthony Wier, *Securing the Bomb 2005: The New Global Imperatives* (Cambridge, Mass., and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, 2005; available at http://www.nti.org/e_research/report_cnmupdate2005.pdf as of 6 June 2006), pp. 32-34.

¹⁵ Data provided by DOE, May 2006.

¹¹ In some cases, upgrades are being performed on buildings without nuclear material, but which are essential to ensuring that nuclear material is secured, such as central alarm stations. The figures in the text are from unpublished data provided by DOE, May 2006.

¹² U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 514.

DOE plans to complete comprehensive upgrades on the buildings with weapons-usable material in Russia by the end of 2008. DOE then expects a four-year period of cooperation to ensure sustainability, during which U.S. assistance will phase down, and Russia's investments, DOE hopes, will increase. Congress has mandated that DOE attempt to put in place a security system in Russia that is sustained with only Russian resources by January 1, 2013.¹⁶

If the FY 2005 pace of completing buildings could be sustained, the target of completing the planned upgrades by the end of 2008 would be met.¹⁷ Meeting that target, however, will be challenging, and is likely to require sustained leadership on both sides to overcome obstacles to progress as they arise.

In particular, meeting the 2008 target would require rapidly resolving the impasse over access at sensitive sites (or other measures to assure that U.S. taxpayer funds would be spent appropriately) that has so far blocked work on upgrades at Russia's two remaining nuclear warhead assembly and disassembly facilities (known in Russia as the "serial production enterprises"), where a quarter or more of the nuclear material in Russia is thought to reside. These facilities are the most sensitive sites in Russia's nuclear weapons complex, and presumably are

already among the most secure sites in Russia. On the other hand, at every site U.S. experts have visited so far, they have quickly reached agreement with Russian security experts that a wide range of security and accounting improvements were needed. Following the 2005 Bush-Putin summit in Bratislava, DOE and Rosatom agreed on a comprehensive joint action plan for completing security upgrades by the end of 2008.¹⁸ But that agreed plan does not yet include these two facilities. Some Russian officials have publicly said that Russia will never agree to implement U.S.-funded upgrades at these sites, but U.S.-Russian discussions of the issue are still ongoing.¹⁹ If DOE's full target for the end of 2008 is to be met, agreement on these sites will have to be reached very quickly, and the work will have to be carried out extremely efficiently. Alternatively, if it proves impossible to work out arrangements with Russia to perform cooperative upgrades at the last two facilities, DOE may choose to declare the job complete when the facilities that have been agreed are finished.

It is important to understand what else the 2008 target does and does not include. Beyond the two serial production enterprises just discussed, there are a very small number of other facilities in Russia which may have weapons-usable nuclear material, but where this has not been confirmed.²⁰ Until recently, in most

¹⁶ U.S. House of Representatives, *National Defense Authorization Act for Fiscal Year 2003*, 108th Congress, 2nd Session, Public Law 107-314 (2002; available at <http://thomas.loc.gov/cgi-bin/query/z?c107:H.R.4546.ENR>; as of 16 May 2006).

¹⁷ Completing comprehensive upgrades for the remaining 105 buildings where they have not been completed in three years would require completing 35 per year, compared to the 36 completed in FY 2005. DOE projects a significantly slower pace for FY 2006, followed by 43 buildings in FY 2007 and 53 in FY 2008. Data provided by DOE, May 2006.

¹⁸ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 511.

¹⁹ Carla Anne Robbins and Alan Cullison, "Closed Doors: In Russia, Securing Its Nuclear Arsenal Is an Uphill Battle," *The Wall Street Journal*, 26 September 2005.

²⁰ Committee on Indigenization of Programs to Prevent Leakage of Plutonium and Highly Enriched Uranium from Russian Facilities, Office for Central Europe and Eurasia, National Research Council, *Strengthening Long-Term Nuclear Security: Protecting Weapon-Usable Material in Russia* (Washington,

cases U.S.-funded programs were not sponsoring security upgrades for irradiated HEU, which in many cases still poses a serious proliferation threat, as it is often still highly enriched and not radioactive enough to pose a serious barrier to theft;²¹ DOE is now reassessing what upgrades may be needed for some of this material, but those upgrades are not likely to be completed by the end of 2008.²² Finally, at several sites new or greatly modified storage facilities are being built, and the plan is to move material from other buildings into these facilities; in some of these cases, the building will be finished by the end of 2008, but it will take a substantial period thereafter to move the material—so that material will not yet have improved security as of the end of 2008.²³

Securing Metric 2: Security Upgrades on Former Soviet Nuclear Material

Fraction accomplished. U.S.-funded cooperative nuclear security upgrade efforts concentrated first on upgrading particularly vulnerable sites with small quantities of nuclear material—though still enough for a bomb, if stolen. While completing security upgrades at these sites reduced proliferation risks substantially, it had little effect on the fraction of the total nuclear material covered by upgrades. As a result, the fraction of material covered by different levels of upgrades remains

D.C.: National Academy Press, 2005; available at <http://fermat.nap.edu/catalog/11377.html> as of 4 April 2006).

²¹ See discussion of this point in 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; available at http://www.nti.org/e_research/cnwm/overview/2004report.asp as of 1 February 2006), p. 37.

²² Interview with DOE officials, October 2005.

²³ Interview with DOE official, July 2004.

substantially lower than the fraction of buildings with those upgrade levels.

Within the former Soviet Union, as of the end of FY 2005, an estimated 29% of the potentially vulnerable weapons-usable nuclear material outside of nuclear weapons—estimated to amount to roughly 600 tons—had U.S.-funded comprehensive security and accounting upgrades installed.²⁴ An additional 20% of the material had initial “rapid” upgrades installed, for a total of 49% with either rapid or comprehensive U.S.-funded upgrades completed.²⁵ Upgrades are underway on a significant additional amount of material. Figure 3-1 shows the amount of material with comprehensive or rapid upgrades completed as a fraction of the total amount of potentially vulnerable nuclear material.

The apparent precision in these figures is illusory. DOE knows exactly which buildings have had what types of security upgrades installed. But in most cases Russia does not provide data on exactly how much material is in each building, for security reasons, and DOE is forced to estimate how much material has been covered by the upgrades at the various buildings where it has worked. (The amount of material in a particular building can fluctuate substantially, as work with this material leads it to be moved around within a site or shipped to other sites.) Indeed, the DOE estimate of 600 tons of material outside of warheads is itself extremely uncertain. Russia has never formally declared how much HEU or separated plutonium it has, how much of those stockpiles are in warheads, or how much material is in each of its many dif-

²⁴ Data provided by DOE, October 2005. This is confirmed in U.S. Department of Energy, *Performance and Accountability Report: FY 2005*, p. 95.

²⁵ Data provided by DOE, October 2005.

ferent facilities. Most of that information is still considered a state secret in Russia.

Comprehensive upgrades have been completed for all of the nuclear material in Russia's naval nuclear complex, all of the nuclear material in the non-Russian states of the former Soviet Union, and nearly all of the nuclear material at Russia's civilian sites. Nearly all of the material for which comprehensive upgrades have not yet been completed is located at a small number of massive sites in Russia's nuclear weapons complex, for which the access issue has taken the most time to resolve.

Rate of progress. During FY 2005, comprehensive upgrades were completed on an additional 3% of the weapons-usable nuclear material outside of nuclear weapons in the former Soviet Union (roughly 18 tons of additional material), increasing the fraction with comprehensive upgrades from 26% to 29%.²⁶ The year before, DOE completed security upgrades on some 4% of material.²⁷ Rapid upgrades were also completed on an additional 3% of the material, bringing the total with at least rapid upgrades completed from 46% to 49%.

DOE had hoped to complete comprehensive upgrades for 11% of the potentially vulnerable nuclear material in Russia during FY 2005, rather than 3%; the gap between performance and intention is attributable to the failure to gain access to the serial production enterprises.²⁸

DOE hopes to complete comprehensive upgrades on the remaining 71% of the

²⁶ The FY 2004 figure is at U.S. Department of Energy, *FY 2006 Defense Nuclear Nonproliferation Budget Request*, p. 485.

²⁷ Bunn and Wier, *Securing the Bomb 2005*, p. 31.

²⁸ U.S. Department of Energy, *FY 2006 Defense Nuclear Nonproliferation Budget Request*, p. 485.

material in Russia by the end of 2008, assuming, as described above, that they rapidly reach agreement with Russia on approaches to carrying out upgrades at the serial production enterprises without compromising secrets. This will clearly require a dramatic acceleration of the past pace, as measured by the fraction of material upgraded each year. But because the program has completed upgrades at the buildings with small amounts of material, and is now implementing upgrades at buildings with huge quantities of material, such acceleration may well be in prospect. The joint action plan agreed with Russia specifies what upgrades will be installed where and when, to meet the agreed-upon target of completing all of the agreed work by the end of 2008. Even so, meeting that target will likely require sustained leadership from all levels of government to overcome obstacles to progress as they arise.

Securing Metric 3: Security Upgrades on Russian Sites Containing Warheads

Fraction accomplished. The U.S. Department of Defense (DOD) and DOE are both working with Russian counterparts to install modern security systems at many Russian nuclear warhead storage sites. Measuring progress in aiding security at warhead storage sites is inevitably murkier, as neither the U.S. nor Russian government has published current, detailed estimates of how many nuclear warheads exist in Russia, at how many sites. Even the basic question of what fraction of Russia's warhead sites are covered by current U.S. plans for warhead security upgrades can only be partially answered from publicly available data.²⁹

²⁹ We are grateful to Charles L. Thornton of the University of Maryland, and to several U.S. govern-

It is also important to note that the number of sites to be secured is not necessarily fixed from year to year. Russia appears to be reducing the number of sites where its warheads are stored.³⁰ At a June 2005 press conference, General Igor Valynkin, head of the organization charged with the nuclear warhead management and security in Russia, the 12th Main Directorate of the Ministry of Defense (known by its Russian acronym as the 12th GUMO), stated, "Earlier, we had about 120 such [nuclear warhead] storage facilities, now we have reduced them more than two times and will reduce further as necessary."³¹ It is not clear whether General Valynkin was referring to sites with permanent storage bunkers or including temporary facilities as well, or when the consolidation he described occurred; much of it may have been associated with the pull-back of Soviet weapons from Eastern Europe and the non-Russian republics. (Russia still appears to have the world's largest nuclear warhead storage and handling infrastructure, however, and major further reductions in the *number* of warhead sites are very important, in order to provide higher security at lower cost for the remaining sites.³² Current

ment officials, for helping us better understand the limited publicly available information.

³⁰ For analyses calling for consolidating warheads in Russia to a much smaller number of sites, see Harold P. Smith, Jr., "Consolidating Threat Reduction," *Arms Control Today* (November 2003; available at http://www.armscontrol.org/act/2003_11/Smith.asp as of 22 March 2006); Gunnar Arbman and Charles Thornton, *Russia's Tactical Nuclear Weapons: Part II: Technical Issues and Policy Recommendations*, FOI-R-1588-SE (Stockholm: Swedish Defense Research Agency, 2005; available at <http://www.foi.se/upload/pdf/FOI-RussiasTacticalNuclearWeapons.pdf> as of 12 April 2006).

³¹ Alexander Konovalov and Vladislav Kuznetsov, "Russia Reduces Nuclear Warheads by 75 Percent under START I," *ITAR-TASS*, 22 June 2005.

³² For discussions, see, for example, Smith, "Consolidating Threat Reduction"; Gunnar Arbman and Charles Thornton, *Russia's Tactical Nuclear Weapons*:

U.S.-funded programs, however, have not focused on assistance in reducing the number of Russian warhead sites, though assistance with warhead transports has presumably helped in removing warheads from some sites Russia had decided to close down.)

After President Bush and President Putin agreed at their February 2005 summit in Bratislava, Slovakia, to develop a joint plan for security improvements, the Russian Ministry of Defense transmitted a list of some 42 sites for further cooperation on upgrades.³³ Of those 42 sites, 18 were reportedly new sites where cooperative upgrade work had not previously been agreed;³⁴ an interagency process assigned 8 of those new sites to DOD and 7 to DOE.³⁵ The U.S. government declined to cooperate at a few sites for various policy reasons, such as not wanting to improve Russian operational capability (a January 2003 interagency decision prohibited most upgrades for warhead handling areas at operational bases for that reason).³⁶

Part I: Background and Policy Issues, FOI-R-1057-SE (Stockholm: Swedish Defense Research Agency, 2003). Similarly, Colonel-General Yevgeny Maslin, retired commander of the 12th GUMO emphasized the need to reduce the number of sites as a key element of improving the sustainability of the upgrades now being installed. Personal communication, October 2005.

³³ U.S. Department of Defense, *Cooperative Threat Reduction Annual Report to Congress: Fiscal Year 2007* (Washington, D.C.: U.S. Department of Defense, 2006), p. 28.

³⁴ Carla Anne Robbins and Cullison, "Closed Doors: In Russia, Securing Its Nuclear Arsenal Is an Uphill Battle."

³⁵ U.S. Department of Defense, *FY 2007 CTR Annual Report*, p. 28.

³⁶ U.S. Congress, Government Accountability Office, *Weapons of Mass Destruction: Additional Russian Cooperation Needed to Facilitate U.S. Efforts to Improve Security at Russian Sites*, GAO-03-482 (Washington, D.C.: GAO, 2003; available at <http://www.gao.gov>).

With the post-Bratislava agreement for enhanced cooperation, DOE now plans to perform some level of upgrade on 39 Navy sites, 25 Strategic Rocket Forces (SRF) sites, and 9 sites managed by the 12th GUMO, for a total of 73 sites.³⁷ Of the 39 Navy sites, 6 are long-term storage sites.³⁸ DOD now states that it plans to provide upgrades for 24 warhead sites under the control of, or supporting, the 12th GUMO, the SRF, and the Russian Air Force.³⁹ Thus in total, U.S.-sponsored upgrade work is planned at 97 Russian warhead sites.⁴⁰

gov/new.items/d03482.pdf as of 4 March 2006), pp. 33-34. In the past DOE has also declined to offer assistance for three naval sites, apparently because there should not be warheads there if Russia is fulfilling its pledges under the 1991-1992 Presidential Nuclear Initiatives. Russian requests for assistance at these three Navy sites provoked considerable concern and suspicion within the U.S. government. Interviews with DOE, DOD, and national laboratory officials, 2003 and February-March 2004. The U.S. government has apparently also declined to support upgrades at a site in the Russian enclave of Kaliningrad, a site near the Black Sea, and possibly others.

³⁷ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 515. The previous year, DOE had projected carrying out upgrades on 39 Navy sites, 19 SRF sites, and 12 12th GUMO sites. Of the 39 Navy warhead sites, most are sites where DOE completed initial upgrades, but will not provide additional upgrades or site-level maintenance after the interagency decision that in most cases support would not be provided for upgrading warhead-handling sites.

³⁸ U.S. Department of Defense, *FY 2007 CTR Annual Report*, p. 28.

³⁹ U.S. Department of Defense, *Fiscal Year (FY) 2007 Budget Estimates: Former Soviet Union Threat Reduction* (Washington, D.C.: U.S. Department of Defense, 2006; available at http://www.dod.mil/comptroller/defbudget/fy2007/budget_justification/index.html as of 12 April 2006), p. 762.

⁴⁰ In the past, DOD and DOE published numbers of warhead sites appear not to have been carefully coordinated, and it appears that some sites were included on both lists in the past. In last year's report we did not realize this, and estimated that 112 total sites were targeted by the U.S. government, citing a DOD goal of completing upgrades at 42 sites, and

It is difficult to assess the total number of warhead sites in Russia, in order to assess what fraction of that total is covered by the 97 sites where cooperation has now been agreed. While DOD has made clear that the list now agreed includes all the sites where it plans to offer security upgrades,⁴¹ it is clear that there are a small number of permanent warhead storage sites and a larger number of temporary warhead locations (such as warhead handling areas at bases or rail transfer points) where the two sides have not agreed to cooperate on security upgrades. Upgrades at a few of the sites not yet covered by U.S. programs, however, may be being sponsored by other Global Partnership donor countries. In some cases, sites are not on the agreed list because the U.S. government has policy concerns about cooperation at those sites; in others, it is because Russia has not included them on the lists available for cooperation. The number of temporary sites that exist in Russia is substantial. Indeed, prior to the January 2003 decision, DOD had considered providing a package of security upgrades for dozens of temporary warhead facilities, of which only a fraction are covered by the current agreed list of sites for upgrades.⁴² There is also the entire category of front-line tactical warhead sites, which are not covered in current plans. If Russia has fully implemented the 1991-1992 U.S.-Russian nuclear initiatives, these in general should no longer

a DOE goal of upgrades at 70 sites; Bunn and Wier, *Securing the Bomb 2005*, pp. 34-35. This year, DOD uses the same number to describe the sites where DOE is working that DOE does, suggesting that the numbers are now coordinated and overlap has been eliminated, making it possible to add the two departments' numbers to arrive at a total.

⁴¹ DOD says that "the current list for site security upgrades represents the plan for completing all U.S.-Russia cooperative work in this assistance area." U.S. Department of Defense, *FY 2007 CTR Annual Report*, p. 28.

⁴² Personal communication, May 2005.

have warheads in them, but a number of them continue to exist, some of the units continue to train for nuclear missions, and U.S. officials have occasionally asserted that Russia has not fully implemented its side of these initiatives.⁴³ It thus appears that the total number of warhead sites, including both permanent and temporary sites but not counting the front-line tactical sites that may no longer have warheads, is likely to be in the range of 110-130, leaving roughly 10-30 sites not yet subject to cooperation.⁴⁴

⁴³ Wade Boese, "U.S., Russia Debate Tactical Nuclear Arms," *Arms Control Today* (November 2004; available at http://www.armscontrol.org/act/2004_11/Tactical_Nukes.asp as of 22 March 2006). We are grateful to Charles L. Thornton for making this point to us.

⁴⁴ In previous years' reports, we compared official U.S. government estimates of the sites targeted for upgrades to an unclassified estimate of warhead storage and handling areas, counting each individually secured perimeter. Bunn and Wier, *Securing the Bomb 2005*, pp. 34-37; Bunn and Wier, *Securing the Bomb: An Agenda for Action*, pp. 51-56. We used an estimate that warheads were stored at some 150-210 individually secured locations, whether they were fixed bunkers or locations where warheads are temporarily stored. This total assumed 50-70 national stockpile sites, 60-80 deployed, service-level storage sites, and 40-60 temporary sites (such as rail transfer points and warhead handling areas at operational bases). The numbers were from Charles Thornton, presentation, Harvard University, October 24, 2003. We were mistaken in assuming that each "site" designated by DOD or DOE corresponded to one such separately fenced area. Rather, the DOD or DOE "sites" come from designations provided by the Russian Ministry of Defense, some of which include several storage bunkers at a single "site." Both types of estimates are correct on their own terms, but the numbers they generate cannot be compared to each other; any error in applying these numbers from different publicly available sources was entirely our own. The shift this year to numbers based on DOD and DOE approach is the reason why our estimates of the total fraction of the warhead work accomplished have substantially increased.

Most of the estimated 20-30 uncovered sites are temporary sites. Some temporary warhead sites might not require permanent, fixed security equip-

By the end of FY 2005, DOE had completed security upgrades for 37 Russian Navy sites and 10 SRF sites, while DOD had completed security upgrades at 1 storage site (it is not clear whether the storage site is controlled directly by the 12th GUMO or one of the services).⁴⁵ These 48 sites represent just under 50% of the 97 sites targeted by DOD and DOE, and roughly 40% of our estimate of the total number of sites.⁴⁶

By the end of FY 2004, DOE had already completed at least rapid upgrades on all 39 of the Navy sites where DOE is working.⁴⁷ As of February 2005, DOE was hoping to have completed at least rapid upgrades on 17 SRF sites by the end of FY 2005, but DOE has not released subsequent data to confirm whether this target was met.⁴⁸ Upgrades at 12th GUMO sites where DOE is working are expected to

ment equivalent to the equipment provided in rapid upgrades, much less more elaborate comprehensive upgrades; other, rapidly deployable but temporary security measures may be appropriate for such sites, though there is currently no publicly available information suggesting that such temporary security measures have been provided for these types of temporary sites.

⁴⁵ For DOE numbers, see U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, pp. 514-515. For DOD numbers, see U.S. Department of Defense, *FY 2007 CTR Annual Report*, p. 28. The U.S. government has concluded that at 23 of the 39 targeted Navy sites further support is not permitted, and upgrades are completed, so DOE counts these sites under its total of 37 completed Navy warhead sites even though they will not receive comprehensive upgrades. Personal communication from DOE program official, February 2004.

⁴⁶ This estimate uses 120 sites, the midpoint of the 110-130 range, as the baseline, and is rounded to the nearest 5%, to avoid giving a false sense of precision.

⁴⁷ Calculations based on unpublished data provided by DOE, February 2005.

⁴⁸ Calculations based on unpublished data provided by DOE, February 2005.

commence in FY 2006.⁴⁹ In the DOD program, site designs have been completed, and equipment has been ordered, for 11 sites, and contracts are in place to work on 16 sites.⁵⁰

Rate of progress. During FY 2005, DOE completed upgrades on 3 additional Navy sites and 8 SRF sites, meeting its target of 11 sites.⁵¹ DOD completed upgrades at 1 site, and completed designs for 2 additional sites.⁵² Using the baselines

⁴⁹U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 515.

⁵⁰U.S. Department of Defense, *FY 2007 CTR Annual Report*, p. 28. In the past, DOD also provided 123 sets of “quick fix” sets of security equipment—similar in some respects to what DOE calls “rapid upgrades”—to Russia’s Ministry of Defense (MOD), but because of earlier disagreements about site access, the MOD was slow to use its own funds to install the equipment; see “Warhead Security: The Saga of the Slow ‘Quick Fix,’” in Bunn and Wier, *Securing the Bomb: An Agenda for Action*, pp. 53-54. As of late 2003, MOD had officially certified that 47 quick fix sets were installed, but had informally indicated that roughly half of them had been installed. After discussions of U.S. support for installations of these sets began, MOD largely stopped providing its own funds to install them. (Personal communication with DTRA official, February 2004.) Any additional sets that have been installed since then have been installed by the teams funded by the DOE and DOD programs. Given that there appears to be much less gap between the total number of sites and the number of sites where the United States is planning to offer assistance, it appears likely that much of this installed equipment will serve as initial upgrades upon which some U.S.-provided upgrades will improve. See the discussion in U.S. Department of Defense, *Cooperative Threat Reduction Annual Report to Congress: Fiscal Year 2006* (Washington, D.C.: U.S. Department of Defense, 2005), p. 41.

⁵¹Calculations from comparing the following: U.S. Department of Energy, *Performance and Accountability Report: FY 2005*, and U.S. Department of Energy, *Performance and Accountability Report: FY 2004*.

⁵²Calculations from comparing the following: U.S. Department of Defense, *Cooperative Threat Reduction Annual Report to Congress: Fiscal Year 2006*, p. 41, and U.S. Department of Defense, *FY 2007 CTR Annual Report*, p. 28.

discussed above, our estimate of the work completed in FY 2005 is approximately 10%, rising from approximately 30% to approximately 40%.⁵³

In last year’s report, we argued that a substantial acceleration would be needed to complete upgrades at warhead storage sites by the end of 2008, as seemed to be envisioned in the Bratislava summit statement. With the U.S.-Russian agreement following the Bratislava summit, it appears such acceleration is now the official plan: the United States has now committed to complete all planned upgrades in Russia by calendar year 2008.⁵⁴

For FY 2006 DOE expects to complete the final 2 Navy sites and 2 more SRF sites; it wants to complete 5 more sites in FY 2007, 6 in FY 2008, and 9 presumably in the first three months of FY 2009, before calendar year 2008 comes to an end.⁵⁵

DOD did not explicitly state how much it plans to accomplish in FY 2006, but in February 2006 DOD requested \$44.5 in FY 2006 supplemental funding to accelerate the pace of upgrades, suggesting a rapid planned pace during FY 2006. By the end of calendar year 2007, DOD expects to have completed the 16 sites for which contracts are already in place; DOD wants to complete upgrades for the 8 additional sites by the end of 2008.⁵⁶

⁵³Again, this figure rounds to the nearest 5%.

⁵⁴U.S. Department of Defense, *FY 2007 CTR Annual Report*, p. 28. Similarly, DOE has specified December 2008 as the target for completing upgrades at all the sites where it is working. See U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 514.

⁵⁵U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 515.

⁵⁶U.S. Department of Defense, *FY 2007 CTR Annual Report*, p. 3.

Securing Metric 4: HEU Reactor Sites Outside the Former USSR and the United States With HEU Removed or Security Upgrades Completed

Neither the United States government nor any other government or organization has a comprehensive picture of nuclear security around the world, or what work would have to be done, at which sites, to improve nuclear security enough to reduce the risk of nuclear theft and terrorism to a minimal level. Since the size of the job is not yet well defined, it is difficult to assess what fraction of the job is done.

It is possible, however, to lay out the different pieces of the global job that needs to be done, and discuss in general terms which of them are covered by current U.S. programs, and how much those programs have accomplished. To ensure that every cache of nuclear weapons or weapons-usable nuclear materials worldwide is effectively and sustainably secured and accounted for, it would be important to put in place strengthened security measures in each of the types of countries where these stockpiles exist and to remove the weapons or materials entirely from as many sites as possible (addressing those sites whose nuclear holdings cannot be effectively defended where they are, and achieving higher security at lower cost at the remaining sites).

This would include improved nuclear security in states with nuclear weapons, in high-income non-nuclear-weapon states, and in lower income non-nuclear-weapon states, along with forging global standards for nuclear security that would help ensure that *all* nuclear weapons and weapons-usable materials were effectively secured. Efforts to reduce the number of locations with dangerous nuclear stockpiles would include consolidating nuclear weapons, military

stockpiles of nuclear material, civilian HEU, and civilian separated plutonium. Consolidating civilian HEU would include: converting research reactors and other civilian reactors to use low-enriched uranium (LEU) instead of HEU; shutting down research reactors that were no longer needed; removing the stocks of HEU (both fresh and irradiated) formerly used at these facilities; removing HEU from as many of the non-research-reactor civilian sites where it exists (such as fuel processing facilities) as possible; and avoiding the use of HEU in new research or power reactors. Below, we briefly review the current status in each of these categories.

Improved security in states with nuclear weapons: modest progress outside the United States and Russia. In addition to 100% of the world's nuclear weapons, states with nuclear weapons own more than 95% of the world's HEU and separated plutonium; their share of the buildings where such materials exist is only modestly lower. Hence, the state of nuclear security in the states with nuclear weapons, and of progress in improving it, is a particularly important first area to examine in elucidating the global picture of nuclear security.

The U.S. government has chosen to upgrade nuclear security in the United States substantially since the 9/11 attacks. Although the terrorist threat within the United States appears to be substantially lower than in many other countries—as reflected by the complete absence of further terrorist attacks on U.S. soil since the 9/11 attacks—DOE facilities with weapons-usable nuclear material are reportedly now required to be able to defend against a squad-sized force of well-trained attackers with sophisticated armaments and equipment, along

with multiple insiders.⁵⁷ The Nuclear Regulatory Commission (NRC) has also increased security requirements for the large HEU fuel facilities it regulates. U.S. HEU-fueled research reactors regulated by the NRC, however, continue to have minimal security measures in place.⁵⁸

⁵⁷ Project on Government Oversight, "Energy Ups Their DBT, NRC Still Making Excuses." For a discussion of security improvements at DOE since the 9/11 attacks, see, for example, Committee on Energy and Commerce, Subcommittee on Oversight and Investigations, *A Review of Security Initiatives at DOE Nuclear Facilities*, U.S. House of Representatives, 109th Congress, 1st Session (18 March 2005; available at <http://energycommerce.house.gov/108/Hearings/03182005hearing1457/hearing.htm> as of 15 April 2006). While little information is publicly available about the measures DOD is taking to protect nuclear warheads and HEU fuel in its custody, they are thought to be generally comparable to DOE's measures. Requirements for the two major privately owned HEU processing facilities regulated by the U.S. Nuclear Regulatory Commission (NRC) have also increased since 9/11, but are reportedly less than the requirements at DOE facilities. See Project on Government Oversight, *U.S. Nuclear Weapons Complex: Homeland Security Opportunities* (Washington, D.C.: POGO, 2005; available at <http://pogo.org/p/homeland/ho-050301-consolidation.html> as of 4 April 2006). For a discussion of the new measures NRC has required (focusing more on power plant security against sabotage than on nuclear material security against theft, which has received less public attention in the case of NRC facilities), see, for example Committee on Government Reform, Subcommittee on National Security, Emerging Threats, and International Relations, *Nuclear Security: Has the NRC Strengthened Facility Standards since 9/11?* U.S. House of Representatives, 109th Congress, 2nd Session (4 April 2006; available at <http://reform.house.gov/NSETIR/Hearings/EventSingle.aspx?EventID=41937> as of 6 May 2006). Unfortunately, HEU-fueled research reactors regulated by the NRC still have very modest security measures in place—often not even including a fence around the building or a night watchman on duty. See "Radioactive Road Trip" in *PrimeTime Live* (ABC News, 2005).

⁵⁸ See, for example, "Radioactive Road Trip." HEU located at research reactors is exempted from most NRC requirements for Category I nuclear material. 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; available at

Similarly, as just discussed, U.S.-funded programs, programs funded by other donor states, and Russia's own efforts have, between them, significantly improved nuclear security in Russia in recent years—though the measures being put in place are not likely to provide effective defenses against the scale of threats that DOE is requiring its facilities to defend against.

France and the United Kingdom have each reportedly strengthened nuclear security measures since the 9/11 attacks, but nuclear security in these countries has not been the focus of either U.S.-funded programs or U.S. diplomacy. Publicly available information is sparse, but suggests that security measures for some categories of weapons-usable material are significantly less than those that would apply in the United States.⁵⁹

As noted in Chapter 2, DOE has been working to build cooperation with China on improving security for nuclear stockpiles there, but as of the end of FY 2005, upgrades had been completed for only one civilian facility with weapons-usable nuclear material, and there was as yet no agreement on implementing a broader program of upgrades. In India, no cooperation to upgrade nuclear security is yet underway, and hence no upgrades have been completed. Public reports suggest that nuclear security cooperation with Pakistan may be under way,⁶⁰ but no official information has been publicly

<http://www.nrc.gov/reading-rm/doc-collections/cfr/part073/full-text.html> as of 28 March 2006).

⁵⁹ See, for example, Timm, *Security Assessment Report for Plutonium Transport in France*.

⁶⁰ Kenneth N. Luongo and Isabelle Williams, "Seizing the Moment: Using the U.S.-Indian Nuclear Deal to Improve Fissile Material Security," *Arms Control Today* (May 2006; available at http://www.armscontrol.org/act/2006_05/usindiafissilesecurity as of 12 May 2006).

released. No nuclear security cooperation is currently planned with Israel (whose stockpiles are believed to be highly secure, given Israel's long experience with protecting against terrorist threats) or with North Korea. In short, outside of Russia and the United States, there appears to be both slow progress and important gaps in U.S. programs to work with states with nuclear weapons to ensure that effective nuclear security measures are put in place.

Improved security in high-income non-nuclear-weapon states: not covered by U.S. programs. Most of the weapons-usable nuclear material outside of the states with nuclear weapons is in developed, high-income countries such as Germany and Japan. Nuclear security in high-income countries has not been the focus of U.S.-funded programs. DOE has indicated that it assumes that security in high-income countries is already sufficient.⁶¹ As discussed in the previous chapter, however, this assumption is not correct in some cases, particularly when it comes to civilian research reactors fueled with HEU, most of which have only minimal security measures in place (including in the United States itself), even in the aftermath of post-9/11 steps to tighten nuclear security rules that several of these countries have taken. The security measures at HEU-fueled research reactors in many of these countries (as with the United States) would have little chance of defending against a determined and well-armed terrorist attack even of relatively limited size—and might not be sufficient to prevent determined insiders from removing HEU.

In general, these countries do have physical protection measures in place that comply with IAEA recommendations, and

in the case of countries that received their nuclear material from the United States, there are occasional reviews required by U.S. law to confirm that this is the case. But as noted earlier, the IAEA recommendations are quite vague. Complying with them does not in itself ensure that facilities are effectively protected against the outsider and insider threats that exist where they are located—and the U.S. visits assess only whether the facilities are following the recommendations, not whether their security measures seem likely to be effective in defeating credible threats. While there have been some efforts to work with these countries to ensure that they put in place effective nuclear security measures, much more remains to be done. Of course, in wealthy countries such measures would not necessarily have to be paid for by the United States (though to the extent improvements are pursued in partnership-based cooperation, with ideas and expertise flowing in both directions, the United States should pay for its share of that work).

Improved security in lower-income non-nuclear-weapon states: limited progress outside the former Soviet Union. Because of the assumption that nuclear security in high-income countries is already sufficient, DOE has focused its nuclear security upgrade work in countries with lower incomes—developing countries, countries in transition from communist rule, and a few of the less wealthy developed countries (such as Greece and Portugal). Most of the upgrades that have been done, however, have been in the former Soviet Union, and therefore are already included in the metrics discussed above. To date, the U.S. Research Reactor Security effort (a sub-program of GTRI) and its predecessors have completed U.S.-funded security upgrades for only seven facilities in non-nuclear-weapon states outside the former Soviet Union: one each in the Czech Republic,

⁶¹Data provided by DOE to Rep. Robert Andrews (D-NJ), April 2006.

Greece, Hungary, Poland, and Portugal, and two in Romania).⁶² All of these upgrades were intended only to meet the IAEA recommendations, not to provide defense against a substantial design basis threat. Hence, security at these sites after the upgrades were completed is probably comparable to security at many other HEU-fueled research reactors in developed and developing countries—and, like those other facilities, is not sufficient to protect against the threats that terrorists and criminals have shown they can pose.

DOE has presented a very different approach to assessing how much of the job of securing civilian nuclear materials is done. First, their measure focuses only on HEU-fueled research reactors, rather than on weapons-usable nuclear materials more generally. Second, DOE counts all of the research-reactor-related HEU facilities in the former Soviet Union that have received security upgrades in its measure of the work completed; since those sites are already covered in the metrics above, we do not count them here. Third, DOE excludes all HEU-fueled research reactors in high-income countries from the total to be addressed, assuming that all of those facilities have adequate security already (which is not an accurate assumption, as discussed above). With those assumptions, they conclude that there are 103 sites to be addressed (the HEU-fueled research reactor sites outside of high-income countries), of which the United States has already provided security upgrades for 76, some 74% of the total.⁶³ All but seven of these 76, however, appear to be former Soviet sites. The sites addressed outside the former Soviet Union are a very, very small fraction of the total.

⁶²Data provided by DOE, December 2005.

⁶³Data provided to Rep. Robert Andrews (D-NJ), April 2006.

Creating effective global nuclear security standards: very limited progress. The U.S. government has not been actively pressing to create effective global nuclear security standards, and hence there has been little progress in this direction. As noted in Chapter 2, the recently approved amendment to the physical protection convention and the nuclear terrorism convention both include useful provisions, but neither establishes any clear global standard for security. UNSCR 1540 legally requires all states to provide “appropriate effective” security and accounting for whatever nuclear stockpiles they may have, but no one as yet has defined what the essential elements of an “appropriate effective” system are. The purely voluntary IAEA recommendations are the closest thing to a global nuclear security standard that now exists, and a fifth revision of these recommendations is now being considered. It is highly unlikely, however, that this revision will result in standards that would ensure that all facilities that complied were effectively protected against demonstrated terrorist and criminal threats.

Consolidating nuclear weapons: not covered by U.S. programs. As noted above, current U.S.-funded programs have generally not focused on assistance in reducing the number of Russian warhead sites, though U.S.-funded assistance for secure warhead transports has presumably helped Russia to remove warheads from some sites.

The number of sites where U.S. nuclear weapons exist has also been reduced substantially in recent years. Nuclear weapons have been removed entirely from the U.S. Army, from naval surface vessels, and from all but a few overseas locations, largely as part of the Presidential Nuclear Initiatives of 1991-1992. It appears that the United Kingdom and

France have also reduced the number of sites where nuclear weapons exist with the consolidation of the British nuclear deterrent in its submarine fleet and the consolidation of the French nuclear forces in the submarine fleet and a limited number of bombers. No U.S. initiatives have focused on warhead consolidation in these countries, however. Similarly, there have been no U.S. initiatives focused on warhead consolidation in China, India, Pakistan, or Israel. Proposals now being discussed in the six-party talks would eliminate all nuclear weapons in North Korea—the ultimate in consolidation—but it remains to be seen whether those discussions will succeed.

Consolidating military stocks of nuclear material: limited progress, major gaps.

Most of the world's weapons-usable nuclear material is in stockpiles designated for defense purposes; the defense sector accounts for most of the global total of buildings where such material exists as well. With the end of the Cold War, much of this material and many of these buildings are no longer realistically needed. Both the U.S. Nuclear Cities Initiative and the materials protection, control, and accounting (MPC&A) program have been working with Russia to consolidate these materials into a smaller number of buildings and sites. Successes include the substantial reduction in the number of Russian Navy sites with HEU, the closure of the two smallest of the four Russian nuclear weapons assembly/disassembly facilities (though only one of these involved U.S. assistance), and Russia's decision (without U.S. help or prodding) to close one of its two facilities for producing plutonium and HEU weapons components. But overall, progress has been limited: there are still thought to be more than 200 buildings in Russia with weapons-usable nuclear material, most of which are at naval or nuclear-weapons-complex sites.

Similarly, the United States has made some progress in consolidating the nuclear material in DOE's defense complex, with steps such as the closure of the Rocky Flats plutonium facility, the removal of weapons-usable nuclear material from Technical Area 18 (TA-18) at Los Alamos, and a substantial reduction of the number of buildings with nuclear material at Hanford. But there is still a long way to go.⁶⁴ DOE is now planning to eliminate major caches of nuclear material from both the Sandia and Livermore national laboratories, in part to reduce safeguards and security costs, but it may be years before this is accomplished.⁶⁵ There do not appear to be any U.S. government initiatives focused on working with other states with weapons-usable nuclear materials for defense purposes to consolidate them into fewer locations. Indeed, GTRI has largely defined its scope as focusing only on civilian nuclear materials, largely excluding even those research reactors used for defense purposes.

Converting HEU-fueled reactors: some progress, many not covered by U.S. programs. Both separated plutonium and HEU have civil uses, making it important to consolidate civil stockpiles as well. Consolidation of civil plutonium is discussed below. The most common civil use of HEU around the world is in research reactors, and these are some of the locations where HEU is potentially most vulnerable to theft. Hence, removing the HEU from as many of these sites as possible is a key part of the consolidation agenda.

⁶⁴ Project on Government Oversight, *U.S. Nuclear Weapons Complex: Homeland Security Opportunities*.

⁶⁵ See, for example, discussion in Committee on Armed Services, Strategic Forces Subcommittee, *Plans for Transforming the Department of Energy's Nuclear Weapons Complex*, U.S. House of Representatives, 109th Congress, 2nd Session (5 April 2006).

As noted in the last chapter, approximately 135 research reactors in nearly 40 countries worldwide still use HEU fuels (representing roughly half of the over 270 research reactors worldwide),⁶⁶ and a surprising number of these (and of their associated fuel facilities) have enough material on-site for a nuclear bomb. The reactors still operating with HEU use an estimated 1,000 kilograms of HEU each year, of various enrichments.⁶⁷

As part of GTRI, DOE is seeking, where possible, to convert HEU-fueled research reactors to use LEU fuel, which cannot be used in nuclear weapons without complex re-enrichment. GTRI hopes to complete conversion of 106 HEU-fueled reactors by 2014.⁶⁸ Of these, 32 had been fully converted to LEU by the end of FY 2005, with eight more partly converted (and therefore still using some HEU fuel

in their cores).⁶⁹ The 40 converted or partially converted to date (stretching back to the origins of the conversion program in 1978) represent some 38% of the target group. The 32 fully converted reactors represent 30% of the targeted group.

With 32 of the 106 reactors already fully converted, there were 74 reactors in the targeted group that still use HEU fuel as of the end of FY 2005, and hence these 74 are on the global list of approximately 135 HEU-fueled reactors. That leaves some 61 reactors, roughly 45% of the world's current HEU-fueled research reactors, that are *not* covered by DOE's conversion effort (although GTRI is examining what would be required to expand the list to cover a portion of these additional reactors).⁷⁰

There are a variety of reasons why particular reactors are not included on the list slated for conversion. Virtually no critical assemblies—research facilities designed to be just barely critical, generating almost no power, used to measure key nuclear cross-sections or to simulate the cores of new power reactor designs—are targeted for conversion. In many cases these assemblies would be difficult to convert, though a recent IAEA consultation recommended that opportunities for reducing enrichment at critical assemblies

⁶⁶Data compiled by Frank von Hippel and Alexander Glasser, Princeton University, personal communication, December 2005. DOE officials report, however, that additional HEU reactors continue to be identified in discussions with foreign experts, especially in Russia (interview with DOE officials, December 2005).

⁶⁷Alexander Glaser and Frank N. von Hippel, "Global Cleanout: Reducing the Threat of HEU-Fueled Nuclear Terrorism," *Arms Control Today* (January/February 2006; available at http://www.armscontrol.org/act/2006_01-02/JANFEB-heuFeature.asp as of 8 June 2006).

⁶⁸DOE modified its list of reactors targeted for conversion in the past year, removing some reactors that had been mistakenly included even though no fuel suitable for converting them was in development, and adding some reactors that now appear possible to convert. For the latest list, see Christopher Landers, "Reactors Identified for Conversion: Reduced Enrichment for Research and Test Reactors (RERTR) Program," in *RERTR 2005: 27th International Meeting on Reduced Enrichment for Research and Test Reactors*, Boston, Mass., 6-10 November 2005 (Argonne, Ill.: Argonne National Laboratory, 2005; available at http://www.rertr.anl.gov/RERTR27/PDF/S9-1_Landers.pdf as of 20 June 2006).

⁶⁹For 40 reactors converted, see U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 562. For a more detailed account, listing all the reactors targeted for conversion and their status (including the statement that only 32 reactors were fully converted), see Landers, "Reactors Identified for Conversion." There is a modest discrepancy in these sources, both from GTRI, in that Landers refers to 42 reactors fully or partially converted at that time; we rely here on the budget justifications as the more authoritative figure.

⁷⁰Data compiled by Frank von Hippel and Alexander Glasser, Princeton University, personal communication, December 2005. Consideration of adding additional reactors is from interview with DOE officials, December 2005.

around the world be examined, and it appears that some of those that now use 90% enriched material could get by with 30% enriched material posing much less risk.⁷¹ Critical assemblies are a very important gap in the conversion effort, as some critical assemblies have hundreds of kilograms or even tons of HEU or plutonium; at critical assemblies, this material is hardly radioactive at all, and would be quite easy to steal. (Indeed, at some assemblies, the researchers handle the fuel by hand.)

Similarly, most pulse reactors—reactors that generate short but intense bursts of power—are not covered by current conversion efforts (in part because the conversion efforts are focused on civilian reactors, and most pulse reactors are used for defense research), and some of these reactors also have very large quantities of high-grade nuclear material.

Reactors with unique specialty fuels, fast-neutron reactors, and research reactors that operate at high temperatures are also generally not covered by current conversion efforts because they could not use the LEU fuels developed to date or the denser fuels still in development.

Moreover, current conversion efforts have made little progress in Russia, which has the world's largest number of HEU-fueled reactors. Although some Russian reactors are on DOE's list of 106 reactors targeted for conversion, no Russian research reactors have yet converted to LEU, and Russia has resisted moving forward on conversion in formal govern-

⁷¹ Frank N. von Hippel, "Future Needs for Critical Assemblies," in *RERTR 2005: 27th International Meeting on Reduced Enrichment for Research and Test Reactors*, Boston, Mass., 6-10 November 2005 (Argonne, Ill.: Argonne National Laboratory, 2005; available at http://www.rertr.anl.gov/RERTR27/PDF/S9-3_vonHippel.pdf as of 20 June 2006).

ment-to-government channels, insisting in the Bratislava summit statement that the endorsement of conversion apply only to "third countries." In an informal private initiative, however, a non-governmental organization in Russia has proposed to undertake a detailed study of conversion and shut-down possibilities for Russia's research reactors (as well as other issues related to nuclear materials at these sites) in cooperation with the Nuclear Threat Initiative. Similarly, in private conversations with non-government U.S. experts, representatives from a number of Russian sites have expressed interest in studying conversion of some major facilities to LEU, or shut-down of some unneeded critical assemblies.

In addition to using HEU as fuel, some research reactors use HEU as targets to be irradiated in order to produce medical isotopes. Roughly 85 kilograms of HEU per year are used for this purpose.⁷² GTRI is also hoping to convert this production to the use of LEU, and has developed promising processes for doing so which have been adopted by smaller isotope suppliers (for example in Argentina and Australia). To date, however, the largest suppliers of medical isotopes have resisted conversion. Indeed, in 2005 these suppliers succeeded in convincing Congress to modify U.S. laws to ease restrictions on export of HEU to medical isotope suppliers not participating in efforts to convert to LEU.⁷³

⁷² U.S. Congress, Government Accountability Office, *Nuclear Nonproliferation: DOE Needs to Take Action to Further Reduce the Use of Weapons-Usable Uranium in Civilian Research Reactors*, GAO-04-807 (Washington, D.C.: GAO, 2004; available at <http://www.gao.gov/new.items/d04807.pdf> as of 2 February 2006), p. 2.

⁷³ For a critical account, see Alan J. Kuperman, "Bomb-Grade Bazaar," *Bulletin of the Atomic Scientists* (March/April 2006; available at http://www.thebulletin.org/article.php?art_ofn=ma06kuperman as of 20 June 2006).

In addition to research reactors, there are also icebreaker reactors, tritium and plutonium production reactors, and naval reactors that use substantial quantities of HEU fuel each year. HEU has also been used for space nuclear reactors in the past, and the United States recently set aside a portion of its excess HEU stockpile for possible future use in space reactors.⁷⁴ The U.S. government has not yet targeted these reactor types for conversion.⁷⁵ Russian experts have proposed a project to develop LEU fuels for the icebreaker fleet, however, and the Nuclear Threat Initiative is negotiating with them to provide initial funding for that effort.

The GTRI program estimates that, beyond the 40 research reactors already fully or partially converted, 43 more could convert to LEU fuels that have already been developed.⁷⁶ They have not done so because they have had only modest incentives to convert to LEU, which many reactor operators believe (generally incorrectly) will lead to lower reactor performance. While U.S. law limits export of new HEU fuel to reactors that could convert to LEU and have not done so, and the U.S. take-back offer is limited to fuel from reactors that have converted or agreed to do so, many of the reactors that have not yet converted already have HEU fuel for their lifetime, or at least for many years to come. DOE has not spelled out what additional incentives will be offered to convince reactor

⁷⁴ U.S. Department of Energy, *DOE to Remove 200 Metric Tons of Highly Enriched Uranium from U.S. Nuclear Weapons Stockpile* (Washington, D.C.: DOE, 2005; available at <http://www.energy.gov/news/2617.htm> as of 25 May 2006).

⁷⁵ For useful discussions, see Frank von Hippel, "A Comprehensive Approach to Elimination of Highly-Enriched Uranium from All Nuclear Reactor-Reactor Fuel Cycles," *Science and Global Security* 12, no. 3 (November 2004); Glaser and von Hippel, "Global Cleanout."

⁷⁶ Landers, "Reactors Identified for Conversion."

operators to convert to LEU; to date, DOE has offered assistance in some cases to help ensure that conversion would not be a major cost to the reactor operator, but has declined to offer incentives that would make reactors better off than they would be if they did not bother to convert.⁷⁷

Another 23 of the reactors on the target list for conversion require new, higher-density fuels to be developed before they can convert to LEU without major losses in performance. High-density fuels based on uranium-molybdenum alloys (both solid and as dispersed powders) are in development; assuming that the solid alloy is as successful as it has been in early tests, and that cost-effective manufacturing processes for this fuel can be developed, this class of fuels could be used to convert all of these 23 reactors.

The 2014 date for completing the conversion of the targeted list of reactors has been criticized as being too far in the future. It is based on current expectations that high-density fuels will be qualified and become available in 2010, after which several years will be needed to convert all the reactors that will use those fuels. Unfortunately, accelerating that date would probably be difficult, and there is a substantial risk that the date will continue to slip.

As a metric of progress, DOE tracks the number of reactors converted. This metric provides a useful indicator of the progress of the particular policy tool of conversion. But undue reliance on this metric tends to divert attention from the reactors not covered on the targeted list, from encouraging reactors to shut down rather than convert (discussed below), from reactors that have already shut down or converted

⁷⁷ Interview with DOE officials, December 2005.

but may still have HEU on-site, and from HEU stored at non-reactor facilities.

Shutting down unneeded HEU-fueled research reactors: not covered by U.S. programs. Many of the world's research reactors are aging and no longer offer research and testing benefits commensurate with their costs and risks. The IAEA has estimated that out of more than 270 operating research reactors in the world today, perhaps 30-40 are needed for the long term,⁷⁸ suggesting that 80-90% of the world's research reactor fleet should be shuttered. In many cases, it makes far more sense to shut down HEU-fueled reactors than to pay to convert them to LEU. Indeed, more HEU-fueled reactors have shut down since the RERTR program began in 1978 than have converted to LEU.

In particular, a recent IAEA consultation recommended a detailed examination of which of the world's critical assemblies (which, again, have particularly dangerous nuclear material and are generally not covered by current conversion efforts) are no longer needed, given the data that have already been collected and the ever-increasing possibilities of computer simulation.⁷⁹ The United States recently shut down the critical assemblies at TA-18 at Los Alamos, which, like many of the critical assemblies around the world, was a site that was very difficult to defend, and shipped the nuclear material to the secure Device Assembly Facility at the Nevada Test Site (where additional critical experiments will be done). Similarly, the United States is planning to shut down the pulse reactor at Sandia National Labo-

⁷⁸ Iain Ritchie, "IAEA Presentation on Threat Reduction Activities," paper presented at The Global Threat Reduction Initiative International Partners' Conference, Vienna, Austria, 18-19 September 2004.

⁷⁹ Von Hippel, "Future Needs for Critical Assemblies."

ratories, and remove the weapon-grade material from that site.⁸⁰

Unfortunately, however, neither the U.S. government nor any other government or international organization has any program in place to encourage governments to phase out support for unneeded research reactors, or to provide incentives to research reactor operators to shut down. This represents an important gap in current efforts to minimize and ultimately eliminate the civilian use of HEU.

Removing stocks of HEU at research reactors: some progress, substantial stocks not yet covered by U.S. programs. Of course, simply converting or shutting down research reactors is not enough. The HEU at these sites must be physically removed if the number of sites with HEU is to be reduced. The United States and the Soviet Union supplied more than 90% of the HEU for research reactors around the world, and as part of GTRI, DOE has programs in place to take U.S.-supplied HEU back to the United States, and to ship Soviet-supplied HEU back to Russia or blend it to LEU in the countries where it now exists.

In the case of Soviet-supplied HEU, it appears that as of the early 1990s when threat reduction efforts began, there were approximately 22-24 Soviet-supplied sites with HEU outside of Russia.⁸¹ Since

⁸⁰ See, for example, discussion in *Transforming DOE's Nuclear Weapons Complex*.

⁸¹ These include four sites at that time in Kazakhstan, three in Ukraine, two each in Uzbekistan and the Czech Republic, and one each in Belarus, Bulgaria, Georgia, Germany, Hungary, Latvia, Libya, North Korea, Poland, Romania, Vietnam, and Yugoslavia. (We are not counting, here, the Sukhumi I. Vekhva Institute of Physics and Technology in Sukhumi, Abkhazia, from which HEU was apparently stolen some time after the Georgian civil war broke out in the 1990s. Since HEU

Table 3-1
U.S.-Assisted Removals of Russian-Origin
Highly Enriched Uranium (HEU) Fuel

Location	Date	Material Removed
Ulba, Kazakhstan [Project Sapphire]	Nov 1994	581 kg HEU (fresh)
Tbilisi, Georgia [Auburn Endeavor]	Apr 1998	~5 kg HEU (fresh)
Vinca Institute, Yugoslavia	Aug 2002	48 kg HEU (fresh)
Pitesti Institute, Romania	Sep 2003	14 kg HEU (fresh)
Sofia, Bulgaria	Dec 2003	~17 kg HEU (fresh)
Tajura, Libya	Mar 2004	16 kg HEU (fresh)
Institute of Nuclear Physics, Uzbekistan	Sep 2004	~3 kg HEU (fresh)
Rez, Czech Republic	Dec 2004	6 kg HEU (fresh)
Salaspils, Latvia	May 2005	~3 kg HEU (fresh)
Czech Technical University, Czech Republic	Sep 2005	14 kg HEU (fresh)
Institute of Nuclear Physics, Uzbekistan	Apr 2006	63 kg HEU (irradiated)

then, by just after the end of FY 2005, U.S.-funded efforts had removed *all* the HEU from three of these facilities (the Ulba facility in Kazakhstan, from which nearly 600 kilograms of HEU was airlifted in 1994; a facility in Tbilisi, Georgia, whose HEU was airlifted to the United Kingdom in 1998; and the “Sparrow” research reactor in the Czech Republic, whose HEU was removed in October 2005). All the fresh, unirradiated HEU has been removed from seven more sites (Vinca, in Serbia, in 2002; Romania and Bulgaria in 2003; Libya, another site in the Czech Republic, and Uzbekistan in 2004; and Latvia in 2005),⁸² but in these

is no longer located at that facility, it should not be counted against the total number for judging the fraction of facilities that have been addressed.) Some variations in figures may result from differing definitions of “sites” or “facilities” (in Libya, for example, there is both a research reactor and a critical assembly fueled with HEU at a single research institute, so they are counted by some as two facilities and by others as one site); other variations in figures may be caused by differing cutoff times for data.

⁸² See discussion of these cases in Matthew Bunn and Anthony Wier, “Removing Material from Vulnerable Sites,” in *Nuclear Threat Initiative Research Library: Controlling Nuclear Warheads and Materials* (2004; available at http://www.nti.org/e_research/cnwm/securing/vulnerable.asp as of 2 February 2006).

cases significant quantities of irradiated HEU, also posing a proliferation hazard, still remained. Table 3-1 lists the removals of Soviet-supplied HEU from various countries since threat reduction efforts began. In addition, the private Nuclear Threat Initiative partnered with Kazatomprom, the Kazakhstan nuclear company, to remove all the HEU from a fourth location, at Aqtau in Kazakhstan, and have it blended to LEU at the Ulba facility there (though some three tons of weapon-grade plutonium in irradiated fuel remains at Aqtau).⁸³ If, over-generously, all seven of the recent sites are considered to have been fully addressed (along with the NTI project at Aqtau), then, by just after the end of FY 2005, material had been removed from 11 of the original 22-24 sites, or 45-50% of the total. If, on the other hand, only those sites are counted where all HEU that poses a significant proliferation threat has been removed, by just after the end of FY 2005 only four sites had been

⁸³ “Government of Kazakhstan and NTI Mark Success of HEU Blend-Down Project: Material Could Have Been Used to Make up to Two Dozen Nuclear Bombs” (Ust-Kamenogorsk, Kazakhstan: Nuclear Threat Initiative, 2005; available at http://www.nti.org/c_press/release_Kaz_100805.pdf as of 17 January 2006).

completed, roughly 16-18% of the original total.

DOE tracks its progress in returning Soviet-supplied HEU to Russia by the number of kilograms of HEU returned. By the end of FY 2005, 122 kilograms of HEU fuel had been returned to Russia. This represents 6% of the 1,959 kilograms of Soviet-supplied HEU that DOE believes exist outside of Russia.⁸⁴ It represents 18%, however, of the fresh, unirradiated Soviet-supplied HEU outside of Russia, and some 60% of the fresh HEU that DOE now expects to be returned to Russia.⁸⁵ (DOE now expects that a substantial amount of the fresh HEU in the former Soviet states will be downblended outside of Russia or used as reactor fuel in those states.⁸⁶) The number of kilograms of HEU returned provides a rough measure of the fraction of the work done so far (though irradiated HEU will involve far more costs and difficulties per kilogram than fresh HEU). But it does not provide any insight into whether, for example, particular sites have had all the HEU that could readily be used for a bomb removed, or only a part of it, leaving enough behind to pose a serious proliferation risk. That is why we focus here primarily on the number of sites whose HEU has been entirely removed.

In April 2006, there was a substantial breakthrough in dealing with the irradiated HEU at these sites when DOE announced that the shipment of the irradi-

⁸⁴ The 1,959 kilogram figure is from data provided by DOE, December 2005. This appears to have been updated from the estimate of 1,781 kilograms reported in DOE's budget justifications, prepared earlier. See U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 562.

⁸⁵ Calculated from data provided by DOE, December 2005.

⁸⁶ Interviews with DOE officials, December 2005.

ated HEU from the Institute for Nuclear Physics in Uzbekistan back to Russia had been completed. This operation demonstrated that the obstacles to returning spent fuel to Russia can be overcome.⁸⁷ Moreover, given the political unrest in Uzbekistan and the presence of the Islamic Movement of Uzbekistan, a well-armed terrorist organization linked to al Qaeda, the removal of the HEU from this Uzbek site was particularly important.

There remain significant obstacles to completing the cleanout of Soviet-supplied HEU outside of Russia. Some facilities have not yet agreed to convert to LEU, or to give up the HEU they have on-site. Some countries are willing to give up their HEU stocks, but not to see their HEU sent to Russia; options for blending HEU outside of Russia are being examined (one possibility being to make use of the blending operation at Ulba that blended the Aqtau HEU).

Numbers on how many sites have had all of their U.S.-supplied HEU entirely removed are somewhat fuzzy, as DOE tracks other metrics for its fuel return programs. But it appears that by the end of 2005, all HEU had been removed from something in the range of 10-15 U.S.-supplied sites since 1996 (when the U.S. fuel take-back program resumed).⁸⁸

⁸⁷ U.S. National Nuclear Security Administration, "Secret Mission to Remove Highly Enriched Uranium Spent Nuclear Fuel from Uzbekistan Successfully Completed: Four Shipments Have Been Sent to a Secure Facility in Russia" (Washington, D.C.: NNSA, 2006; available at http://www.nnsa.doe.gov/docs/newsreleases/2006/PR_2006-04-20_NA-06-10.htm as of 16 May 2006).

⁸⁸ The Government Accountability Office lists 11 countries which have returned all U.S.-origin HEU. U.S. Congress, Government Accountability Office, *Nuclear Nonproliferation: DOE Needs to Consider Options to Accelerate the Return of Weapons-Usable Uranium from Other Countries to the United States and Russia*, GAO-05-57 (Washington, D.C.: GAO, 2004;

Another way of assessing progress is by the fraction of the HEU that has been returned. As of the end of FY 2005, the assemblies that had been returned, after nine years of the take-back program, contained approximately 1.2 tons of HEU. This represents some 23% of the 5.2 tons of HEU eligible for the program, but only 7% of the 17.5 tons of U.S.-supplied HEU that was abroad when the take-back effort restarted in 1996.⁸⁹ In the year since our last report, DOE extended the take-back offer until 2019, and it is therefore not expecting to complete the return of eligible U.S.-supplied HEU until then.

DOE tracks the progress of the effort to take back U.S.-supplied HEU by the total

available at <http://www.gao.gov/new.items/d0557.pdf> as of 2 February 2006), p. 9. Some of these countries, however, have HEU from other sources, and some (such as Italy) have U.S.-origin HEU that was not returned because it is not eligible for the current take-back offer. At the same time, however, there are some facilities in other countries that have had all HEU removed from that specific facility, without all HEU having been removed from the country. Additional sources for the estimates here include von Hippel and Glaser data on reactor conversions (personal communication, December 2005), and David Albright and Kimberly Kramer, "Civil HEU Watch: Tracking Inventories of Civil Highly Enriched Uranium," in *Global Stocks of Nuclear Explosive Materials* (Washington, D.C.: Institute for Science and International Security, 2005; available at http://www.isis-online.org/global_stocks/end2003/tableof-contents.html as of 21 May 2006).

⁸⁹Data provided by DOE, December 2005. For the 17.5 tons figure, see, for example, U.S. Department of Energy, Office of the Inspector General, *Audit Report: Recovery of Highly Enriched Uranium Provided to Foreign Countries*, DOE/IG-0638 (Washington, D.C.: DOE OIG, 2004; available at <http://www.ig.doe.gov/pdf/ig-0638.pdf> as of 3 March 2006). See also U.S. Congress, *Nuclear Nonproliferation: DOE Needs to Consider Options to Accelerate the Return of Weapons-Usable Uranium*. These figures on tons of HEU refer to the tons of HEU the fuel contained when it was originally shipped from the United States; after irradiation, the number of tons of HEU remaining is significantly less. In addition, a modest portion of the total has been reprocessed in Europe and no longer exists as HEU.

number of fuel assemblies returned to the United States. By the end of FY 2005, this figure stood at 6,783 assemblies returned since the take-back program was restarted in 1996, some 30% of the 22,743 assemblies DOE hopes to return to the United States.⁹⁰ These include both LEU assemblies (from reactors that agreed to convert to HEU in the past or were designed from the outset to avoid the use of HEU) and HEU assemblies; indeed, most are LEU assemblies. This metric provides a reasonable rough guide to the fraction of the work accomplished. But by not distinguishing between HEU and LEU, this metric makes it difficult to discern how much of the proliferation threat has been reduced. Like the metric for the Russian take-back effort, it also obscures the issue of how many sites have had all of their HEU removed.

Two-thirds of the 17.5 tons of U.S. HEU that was abroad when the United States renewed its take-back offer in 1996 is not even covered by the U.S. offer to take the HEU back. (The offer was limited at the time to aluminum-based fuels and TRIGA fuels the United States was planning to manage in any case.⁹¹) This material poses important proliferation risks that are not currently being addressed effectively. The U.S. take-back offer was intended to apply to HEU fuel after it had been used: fresh, unused U.S.-supplied HEU is also a gap material, as is the small amount of HEU supplied by countries other than the United States and Russia, and the research quantities of plutonium that exist at several sites around the world (see discussion of consolidating

⁹⁰U.S. Department of Energy, *FY 2006 Defense Nuclear Nonproliferation Budget Request*, p. 544.

⁹¹Aluminum-based fuels are being sent to Savannah River, and uranium-zirconium-hydride TRIGA fuels (Training, Research, Isotopes, General Atomics—a common reactor design) are being sent to the Idaho National Laboratory.

civil plutonium stocks below). DOE is currently considering expanding the U.S. take-back program to cover some or all of these “gap materials,” in DOE’s phrase—meaning materials in the gaps between current programs—but more than two years after the establishment of GTRI, no decision on such an expansion has yet been announced. Nevertheless, GTRI has begun to address some of these gap materials in a small way: by the spring of 2006, for example, 35 kilograms of fresh U.S.-supplied HEU had been returned from Canada and Belgium.⁹²

Even the material eligible for the take-back offer is not necessarily fully addressed by current programs. Independent studies have concluded that unless DOE offers greater incentives for facilities to return their HEU to the United States, roughly half the material covered by the take-back offer is not likely to be returned.⁹³ DOE has not yet spelled out what additional incentives it may be prepared to offer.

Removing stocks from HEU fuel facilities and other non-research reactor facilities: not yet covered by U.S. programs, in most cases. Not all civil HEU is at research reactors. As noted above, 41 of the 128 civil sites around the world estimated to possess 20 kilograms or more of HEU are fuel-related facilities. U.S.-sponsored programs have not yet focused on reducing the number of these facilities where HEU is located. If the effort to con-

vert research reactors to LEU is successful, however, there will be less and less demand for HEU fuels and targets, and that will presumably lead fuel facilities to concentrate primarily on making LEU fuels. Nevertheless, targeted efforts to ensure that potentially dangerous stocks of HEU do not remain at these fuel facilities will probably be necessary.

Avoiding new HEU-fueled research and power reactors: some progress. Since the effort to convert HEU-fueled research reactors to LEU fuels began in 1978, only one high-power research reactor has been built to use HEU fuel in the Western world, the FRM-II in Germany. Currently, however, Russia is building a new HEU-fueled research reactor, the PIK, in St. Petersburg; Belarus has just started a sub-critical assembly with HEU; and other HEU-fueled reactors are being considered. Russia continues to use HEU fuel (with a maximum enrichment of 26%) in its BN-600 fast-neutron reactor; the BN-800 under construction will probably use plutonium fuel. Early reports indicated that the floating nuclear power plants Russia plans would use HEU fuel, as the submarine reactors the design is based on did, but the Russian government has recently indicated that they will use LEU fuel.⁹⁴ Other power reactor concepts in development appear to emphasize the use of LEU or plutonium fuels.

Consolidating civilian plutonium: not covered by U.S. programs. Currently plutonium is separated and used for civil purposes on a massive scale in several countries. Roughly 20 tons of plutonium—enough for thousands of nuclear weapons—is separated from spent fuel by civilian reprocessing plants in a typical year, and only about ten tons of that is

⁹² U.S. Department of Energy, “GTRI: Two Successful Years of Reducing Nuclear Threats” (Washington, D.C.: DOE, 2006; available at <http://www.nnsa.doe.gov/docs/factsheets/2006/NA-06-FS04.pdf> as of 21 June 2006).

⁹³ U.S. Department of Energy, *Audit Report: Recovery of Highly Enriched Uranium Provided to Foreign Countries*. See also U.S. Congress, *DOE Needs to Consider Options to Accelerate the Return of Weapons-Usable Uranium*.

⁹⁴ “Russia to Start Building Floating Nuclear Power Plant in 2006,” *ITAR-TASS*, 12 January 2006.

used as uranium-plutonium mixed oxide (MOX) reactor fuel. Hence, separated plutonium that is weapons-usable, though reactor-grade, continues to build up in storage. The total quantity of separated civilian plutonium in storage is in the range of 250 tons, roughly equal to all the world's military stockpiles of plutonium combined.⁹⁵

MOX fuel is used in dozens of reactors in several countries in Europe, and Japan plans to begin using it soon. The facilities where the plutonium is separated and fabricated into fuel typically have fairly high levels of security, but some of the reactors where fuel containing large quantities of unirradiated plutonium exists have little more security than other reactor sites. Moreover, transports of large quantities of plutonium oxide from reprocessing plants to fabrication plants, and of MOX fuel from fabrication plants to reactors, occur frequently (particularly in France, which has the largest operating MOX fabrication plant and the largest number of reactors using MOX fuel), and significant concerns have been raised about the security of these transports.⁹⁶ While fresh MOX fuel assemblies are large and heavy, making them more difficult to steal, and chemical processing would be needed to extract the plutonium for use in a bomb, a committee of the U.S. National Academy of Sciences recommended that unirradiated MOX fuel, like other forms of plutonium outside of spent fuel, should be protected, to the extent practicable, to the same standards that nuclear weapons themselves are—because acquiring plutonium or

⁹⁵ David Albright and Kimberly Kramer, *Global Stocks of Nuclear Explosive Materials* (Washington, D.C.: Institute for Science and International Security, 2005; available at http://www.isis-online.org/global_stocks/end2003/tableofcontents.html as of 22 February 2006).

⁹⁶ See, for example, Timm, *Security Assessment Report for Plutonium Transport in France*.

HEU is by far the most difficult part of making a nuclear bomb.⁹⁷

As noted in Chapter 2, the Bush administration acknowledged that these stores of fully separated plutonium posed a proliferation threat in presenting its proposal for a Global Nuclear Energy Partnership (GNEP). GNEP would involve reprocessing technology in which the plutonium would never be fully separated, an approach the Bush administration argues would be more proliferation resistant. Critics, however, have challenged whether the processes proposed for GNEP would offer substantial advantages in proliferation resistance.⁹⁸ In any case, despite the publicly expressed concerns over the proliferation hazards of these plutonium stockpiles, the U.S. government has no specific policies in place to seek to reduce the number of sites where these stockpiles exist or to limit their growth.

Developing a rough metric of overall progress. Information simply does not exist—either in the public domain or in the classified realm—that would make it possible to judge exactly how many buildings, in what countries, require what levels of security upgrades, and therefore to measure accurately what fraction of this job was done. We recommend that the U.S. government seek to compile such a comprehensive assessment, taking into account what is known about all the locations with nuclear warheads and

⁹⁷ U.S. National Academy of Sciences, Committee on International Security and Arms Control, *Management and Disposition of Excess Weapons Plutonium* (Washington, D.C.: National Academy Press, 1994; available at <http://books.nap.edu/html/plutonium/0309050421.pdf> as of 20 March 2006).

⁹⁸ Jungmin Kang and Frank Von Hippel, "Limited Proliferation-Resistance Benefits from Recycling Unseparated Transuranics and Lanthanides from Light-Water Reactor Spent Fuel," *Science and Global Security* 13, no. 3 (2005).

weapons-usable materials worldwide, their security levels, and factors affecting the threat in the areas where these facilities exist (from the levels of terrorist and criminal activity to morale, pay, and corruption among the facility staff).

In the absence of such comprehensive data, as a rough metric of progress beyond the former Soviet Union, we will focus on progress in either removing material from or upgrading security at HEU-fueled research reactors (since these are some of the most vulnerable facilities, and also among the facilities for which the most detailed data are available). In this metric, we count any research reactor that has had all of its HEU removed, or has had U.S.-sponsored upgrades completed, as having had the security issues it posed adequately addressed. (This is somewhat over-generous, since, as noted above, the security upgrades being done outside the Soviet Union are only intended to meet rather vague IAEA recommendations, and are not likely to be sufficient to defend these facilities against the threats that exist in many countries.)

Fraction accomplished. As noted above, it appears that by the end of FY 2005, the U.S. HEU fuel take-back program had removed all the HEU from 10-15 sites since the take-back effort resumed in 1996, all of which were outside the former Soviet Union. The sites where the Russian take-back effort has succeeded in removing all the HEU have largely been within the Soviet Union, and hence are not counted here; the exception is the VR-1 Sparrow reactor in the Czech Republic. Thus we estimate that these programs have removed all HEU from 11-16 sites outside the former Soviet Union and the United States itself.

As discussed above, U.S.-sponsored security upgrades have been completed for an

additional eight sites outside the former Soviet Union – one in China, and seven in other countries performed by the Research Reactor Security program. Thus, 19-24 HEU-fueled research reactor sites outside the former Soviet Union have either had all of their HEU removed or had U.S.-sponsored security upgrades completed.

Today, of the estimated 135 operating research reactors using HEU fuel, roughly 57 are in the former Soviet Union and 24 are in the United States, leaving some 54 reactors in other countries.⁹⁹ In the early 1990s, when cooperative threat reduction programs began, this figure was higher, as some reactors have converted or shut-down since then, so the baseline for assessing changes is likely in the range of 60-80 HEU-fueled research reactors outside of the former Soviet Union and the United States in the early 1990s.

In addition to these operating research reactors using HEU at that time, there were other categories of facilities that need to be counted: there were an unknown but probably significant number of reactors that had shut down or converted to LEU but still had significant amounts of HEU on-site; there were the HEU fuel-related facilities discussed above (though many of these are in the United States or Russia); and there were a limited number of civilian sites where significant quantities of HEU existed for other reasons. Including an estimate of these facilities would make the baseline larger, and therefore shrink the fraction of that baseline that has been addressed to date. Nevertheless, to be generous, we will use 60-80 as our baseline estimate of the sites to be addressed.

⁹⁹Data compiled by Frank von Hippel and Alexander Glaser, Princeton University; personal communication, December 2005.

With that baseline, the 19-24 research reactor sites addressed to date represent some 25-40% of the total.

Rate of progress. During 2005, security upgrades were completed at one HEU site each in China, at Sevastopol in Ukraine, at Alatau in Kazakhstan, and at Photon in Uzbekistan.¹⁰⁰ For at least two of these sites—Sevastopol and Alatau—these were improvements to security upgrades that had been completed previously, however, so we do not count those as new sites addressed during the year. It appears that only the “Sparrow” reactor at the Czech Technical University had 100% of its HEU removed. While this occurred just after the end of fiscal year 2005, we include it here. Hence it appears that 3 sites either had all of their HEU removed or U.S.-funded security upgrades completed for the first time during the course of the year, representing 4-5% of the original 60-80 sites.

In addition, DOE has already had a major success in FY 2006 with the removal of all irradiated HEU from the Institute of Nuclear Physics in Uzbekistan. During FY 2006 DOE plans to complete security

upgrades at several other HEU-fueled reactor sites.

During FY 2005, the number of reactors converted or partly converted increased by only one reactor (from 39 to 40), well short of the target of five additional reactors.¹⁰¹ It appears, however, that the delays at the other four reactors will be short-lived; indeed, some had converted or were in the process of conversion by the spring of 2006.¹⁰² By the end of FY 2006, DOE hopes to have a total of 46 reactors either converted or partly converted.¹⁰³ DOE is unlikely to meet its 2014 deadline for converting 106 reactors, however, unless it gives reactors stronger incentives to agree to convert.

DOE's effort to address Soviet-supplied HEU also fell well short of its target, returning 23 kilograms of HEU to Russia during FY 2005 (bringing the total to 122) rather than the planned 76 kilograms (which would have brought the total to 175).¹⁰⁴ It appears, however, that most of the material that was to have been shipped in FY 2005 will be shipped in FY 2006, along with the material already planned to be shipped in FY 2006; indeed, DOE expects to ship an additional 200 kilograms of fresh Soviet-supplied HEU back to Russia in the last half of FY 2006.¹⁰⁵

¹⁰⁰ Data provided by DOE, December 2005. It is somewhat surprising that the Photon site remains a high-priority HEU site; the HEU-fueled reactor at the site was shut down years ago, and Uzbek scientists had previously told U.S. counterparts that all the nuclear material had been removed. Even if that was not the case, the HEU for this liquid-fueled reactor was dissolved in solution, and it would seem to be a simple matter to dilute it with natural uranium so that it would not require the kind of protection that HEU requires. Monterey Institute for International Studies, Center for Nonproliferation Studies, “Uzbekistan Profile: Nuclear Facilities--Photon Radioelectrical Technical Plant,” in *Nuclear Threat Initiative Research Library: Country Profiles* (Washington, D.C. and Monterey, Cal.: Nuclear Threat Initiative and Center for Nonproliferation Studies, 2005; available at http://nti.org/e_research/profiles/Uzbekistan/Nuclear/5451_5469.html as of 16 May 2006).

¹⁰¹ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 562. Also data provided by DOE, December 2005, and U.S. Department of Energy, *Performance and Accountability Report: FY 2005*, p. 99.

¹⁰² U.S. Department of Energy, “GTRI: Two Successful Years of Reducing Nuclear Threats.”

¹⁰³ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 562.

¹⁰⁴ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 562.

¹⁰⁵ U.S. Department of Energy, “GTRI: Two Successful Years of Reducing Nuclear Threats.”

DOE still hopes to return all of the fresh HEU that it expects to be returned to Russia by the end of 2006 (representing another 83 kilograms of HEU).¹⁰⁶ Since last year's report, that goal has been both postponed a year, from 2005 to 2006, and substantially modified, to exclude some 450 kilograms of fresh HEU that states do not wish to return to Russia, and for which other disposition paths will be pursued on a slower schedule.¹⁰⁷ DOE also hopes to complete the return of eligible irradiated Soviet-supplied HEU that has already been discharged from reactors by 2010. After the Bratislava summit, the United States and Russia agreed on a prioritized schedule to meet that objective. Like the fresh HEU objective, however, this target excludes some important stocks of HEU: HEU that is currently being irradiated in reactors or that will be loaded into these reactors in the future will take longer to return.¹⁰⁸ If it ends up taking as long to convert the Soviet-supplied reactors as it does to convert the U.S.-supplied reactors, the last of the Soviet-supplied HEU may not be returned until nearly the 2019 date planned for the U.S.-supplied HEU.

There is no doubt that the pace of removal of Soviet-supplied material has been substantially higher in FY 2004-2005, since the founding of GTRI, than it was in the previous decade, and the post-Bratislava schedule agreement with Russia is a major step. With the completion of the first shipments of irradiated fuel overcoming a long-standing bureaucratic roadblock in Moscow, the odds of meeting the target set

¹⁰⁶ Data provided by DOE, December 2005.

¹⁰⁷ Data provided by DOE, December 2005.

¹⁰⁸ Data provided by DOE, December 2005. Similarly, GTRI's most recent statement of the 2010 goal refers to completing "all shipments to return eligible Russian-origin HEU spent fuel currently stored outside of reactor cores" by that time. See U.S. Department of Energy, "GTRI: Two Successful Years of Reducing Nuclear Threats."

in the post-Bratislava joint plan improved. Some of the facilities with Soviet-supplied HEU, however, along with the central governments of the countries in which they are located, remain extremely reluctant to give up their HEU. Substantial packages of positive and negative incentives, pursued at high levels with considerable creativity and perseverance, are likely to be necessary to achieve the 2010 goal.

In contrast, the effort to take back U.S.-supplied HEU somewhat exceeded its target, returning 449 fuel assemblies in FY 2005 rather than the planned 359.¹⁰⁹ During the year, the projected end of the U.S. take-back program was extended by a decade (from 2009 to 2019), a very long period for returning U.S.-supplied HEU. DOE plans to offer countries incentives to return their HEU sooner rather than later, however.

Improved Securing Metrics for the Future

In essence, there are three goals that programs to improve nuclear security must achieve:

- Security must be improved fast enough, so that the security improvements get there before thieves and terrorists do.
- Security must be raised to a high enough level, to make sure that the threats terrorists and criminals have shown they can pose to such sites can be defeated.
- Security must be improved in a way that will last, including after foreign assistance phases out, so that these sites

¹⁰⁹ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 562.

do not become vulnerable again in a few years' time.

There are clearly tensions among these three goals: putting in place security systems to defeat larger threats, and security systems that will stand the test of time, inevitably takes longer than slapping together less capable, more temporary systems. Yet meeting all three goals is essential if the objective of keeping nuclear weapons and materials out of terrorist hands is to be met. The metrics discussed in this section really focus only on the first goal, and hence are inevitably incomplete. Moreover, the metrics in this section do not reflect a great deal of other crucial work that is now underway, including: an extensive training program to provide qualified personnel for all aspects of nuclear material security, control, and accounting (including in the key elements of security culture); work with Russian regulators to put in place an effective regulatory program that will give facility managers strong incentives to provide good security; investments to ensure that nuclear material is secure during transport; new computerized national-level systems for real-time accounting for nuclear warheads and materials; and programs to improve personnel reliability checks for people involved in managing or guarding nuclear warheads and materials.

Moreover, even for assessing whether security is improving fast enough, looking only at numbers of buildings or material equipped with modern security and accounting equipment tells only part of the story. General Eugene Habiger, former "security czar" at DOE's nuclear weapons complex and former commander of U.S. strategic nuclear forces, has said: "good security is 20% equipment and 80% culture."¹¹⁰ Assessing how well programs are

doing in changing the crucial "security culture" at these facilities—that is, the degree to which all of the personnel at the site are trained and motivated to maintain high security at all times—is extremely difficult to do, but extremely important.

Ultimately, a balance of a variety of different measures will be needed to get a realistic picture of how much nuclear security is improving. There are a number of plausible metrics for assessing progress toward sustainable security over time.

The fraction of sites with nuclear security and accounting systems that are performing effectively. The best single such measure would be one that was performance-based: 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, comprehensive data for such a measure do not yet exist (and even fewer data of this kind are available for nuclear stockpiles in much of the rest of the world). Another indicator of effective performance—in those cases where nuclear regulatory authorities have set effective nuclear security rules and have put in place effective inspection approaches—would be the fraction of facilities that receive high nuclear security marks in regulatory inspections.¹¹¹ An even more ambitious approach would be to attempt to assess the overall risk of theft at each site, and then track whether these risks were increasing or decreasing, and by how much. At DOE's own facilities, each facility is required to perform such estimates of overall risk, based on the security system's assessed ability to

¹¹⁰ Interview, April 2003.

¹¹¹ DOE uses this metric to track the performance of its own nuclear security program. See U.S. Department of Energy, *Performance and Accountability Report: FY 2005*, p. 83.

defeat a specified design basis threat, and on the quantity and quality of nuclear material at the site. If recipient countries undertook similar approaches (possibly with U.S. assistance in doing so), it might be possible to collect at least partial data on whether these overall assessments of risk were increasing or decreasing, and how substantially. Yet another approach would be to assess, for each site, performance in a broad range of areas important to nuclear security and accounting, and then use some form of weighting (based on expert judgment) to provide an overall performance rating—and then track changes in the overall performance rating at different sites.¹¹²

The priority the recipient state’s government assigns to nuclear security and accounting. This could be assessed by senior leadership attention and resources assigned to the effort, along with statements of priority, decisions to step up nuclear security requirements, and the like.

The presence of stringent nuclear security and accounting regulations that were effectively enforced. The effectiveness of regulation of nuclear security and accounting could be judged by whether rules have been set which, if 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, other 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.¹¹³ Surveys of managers and other personnel at nuclear sites about their experience with regulators and inspectors, and with enforcement and other approaches to encouraging compliance, could also be helpful in assessing the effectiveness of regulations.

The fraction of sites with long-term plans in place for sustaining their nuclear security and accounting systems, and resources budgeted to fulfill those plans. DOE 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 that task, 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.)

The presence of 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

¹¹² An approach of this kind was developed at Lawrence Livermore National Laboratory some years ago for use in the MPC&A program, but was never accepted for broad implementation.

¹¹³ Malcolm K. Sparrow, *The Regulatory Craft: Controlling Risks, Solving Problems, and Managing Compliance* (Washington, D.C.: Brookings Institution Press, 2000).

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 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.¹¹⁴

The presence of 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.

In 2001, DOE's MPC&A program took a first cut at the complex task of developing appropriate metrics to assess the real state of progress toward achieving sustainable security at former Soviet sites.¹¹⁵ The program is now putting a substantial focus on progress toward strong security cultures and long-term sustainability as part of developing a new strategic plan. 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 policy-makers.

¹¹⁴ 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-TECDOC-1329 (Vienna: IAEA, 2002; available at http://www-pub.iaea.org/MTCD/publications/PDF/te_1329_web.pdf as of 28 March 2006).

¹¹⁵ U.S. Department of Energy, *MPC&A Program Strategic Plan* (Washington, D.C.: DOE, 2001; available at http://www.nti.org/e_research/official_docs/doe/mpca2001.pdf as of 7 March 2005), pp. 26-28.

TRACKING PROGRESS: INTERDICTING NUCLEAR SMUGGLING

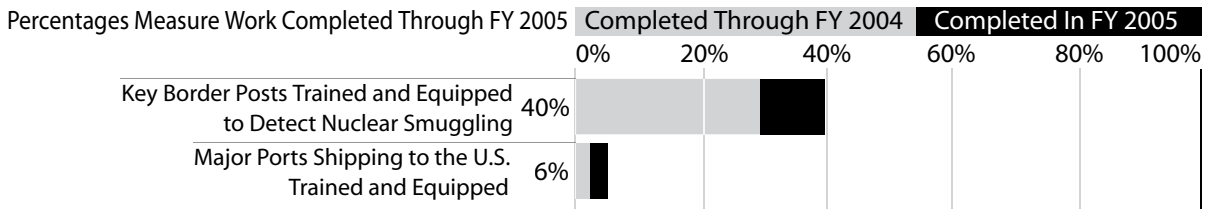
Developing metrics for the goal of interdicting nuclear smuggling is difficult, as many different elements are essential to accomplishing the overall goal. These include, among other steps: providing adequate capabilities to detect nuclear materials being smuggled across borders; establishing appropriate police and intelligence units in the relevant countries that are trained and equipped to deal with nuclear smuggling cases; creating stronger legal infrastructures so that nuclear thieves and smugglers face a greater chance of a larger punishment; expanding international intelligence and police cooperation focused on finding and arresting those involved in nuclear smuggling; and carrying out stings and other operations designed to break up nuclear smuggling rings and make it more difficult for thieves and buyers to reliably connect with each other.¹¹⁶

Two steps that are necessary but not sufficient to accomplishing the goal are to ensure that:

- at least the most critical border crossings in the key source and transit states for nuclear material have personnel trained and equipment designed to detect smuggled nuclear materials; and
- major ports and other locations shipping cargo to the United States and major ports and other entry points into the United States are equipped to be

¹¹⁶ For a discussion, see, for example, Anthony Wier, "Interdicting Nuclear Smuggling," in *Nuclear Threat Initiative Research Library: Controlling Nuclear Warheads and Materials* (2002; available at http://www.nti.org/e_research/cnwm/interdicting/index.asp as of 1 March 2006).

Figure 3-3
How Much Interdicting Work Have U.S.-Funded Programs Completed?



able to detect smuggled nuclear weapons or materials.

Measuring progress in these two areas provides a rough guide as to how much initial progress in addressing nuclear smuggling has been accomplished, but many of the complex suite of activities involved in interdicting nuclear smuggling are not captured by these metrics. Official border crossings are only a tiny fraction of the thousands of miles of border across which nuclear material might be smuggled, and many seizures of stolen nuclear material have occurred within countries, not at borders, as a result of effective police and intelligence work.

UNSCR 1540 obliges all states to put in place “appropriate effective” border and export controls and law enforcement efforts to prevent illicit trafficking in nuclear weapons-related material. As we have discussed in earlier reports, we believe the U.S. government should work with other states to define the essential elements of appropriate effective border and export controls and then evaluate whether states have put those measures in place, offering assistance where states need help in doing so.¹¹⁷

Export control and nuclear smuggling interdiction are two different activities (though they overlap to some degree).

¹¹⁷ For more on possible measures, see Bunn and Wier, *Securing the Bomb 2005*, pp. 47-49.

Nevertheless, the measures used by the State Department’s Export Control and Related Border Security (EXBS) Assistance program offer a useful analogy. EXBS annually assesses the number of the national export control systems receiving State Department assistance that meet “international standards.”¹¹⁸ By the end of FY 2005, the EXBS program had graduated Poland, Hungary, the Czech Republic, and two other countries into a “limited sustainment” phase of the State Department export assistance program. By the end of FY 2006, the State Department expects that the export control systems of three more countries will reach the international level.

Given the many dimensions of an effective national export control system, these assessments are necessarily complex, and appear to focus primarily on the degree to which various elements judged to be essential to an effective overall system are present, more than how effective on-the-ground enforcement really is.¹¹⁹

¹¹⁸ U.S. Department of State, *FY 2007 Congressional Budget Justification for Foreign Operations* (Washington, D.C.: U.S. Department of State, 2005; available at <http://www.state.gov/documents/organization/60647.pdf> as of 20 March 2006), p. 135.

¹¹⁹ For a discussion of an early version of the University of Georgia’s approach to evaluating export control systems, see Gary Bertsch and Michael Beck, *Nonproliferation Export Controls: A Global Evaluation* (Athens, Georgia: Center for International Trade and Security, The University of Georgia, 2000; available at http://www.uga.edu/cits/documents/html/nat_eval_execsumm.htm as of 7 March 2006).

Interdicting Metric 1: Key Border Posts Trained and Equipped to Detect Nuclear Smuggling

Fraction accomplished. Understanding how many sites should be considered high priorities for installing nuclear detection equipment is itself a difficult task, though in recent years DOE has provided much more information about the number of border crossings equipped and trained. Currently DOE's Second Line of Defense program anticipates installing radiation detection equipment at approximately 350 sites around the world (updated from an estimated target of 330 in February 2005).¹²⁰ Of these, approximately 120 are at Russian points of entry (Russian customs officials have installed portal monitors at approximately 120 other sites, and plan to install equipment at another 110 sites, totaling approximately 350 international points of entry in Russia). The remaining 230 sites currently targeted by DOE are located in 29 other countries.¹²¹ By the end of FY 2005, DOE had completed providing equipment and training for 83 "core" Second Line of Defense program sites (excluding two megaports, which are noted below).¹²² Seventy eight

¹²⁰ This figure represents the total set of sites that are to be equipped with radiation detection equipment—though there are some additional border crossings in these key countries that are not included. Interviews with DOE officials, February 2003. The February 2005 figure is from U.S. Department of Energy, *FY 2006 Defense Nuclear Nonproliferation Budget Request*, p. 485. The current figure is from U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 514.

¹²¹ See David Huizenga's written testimony in Homeland Security and Governmental Affairs Committee, Permanent Subcommittee on Investigations, *Hearing on Nuclear and Radiological Threats*, U.S. Senate, 109th Congress, 2nd Session (28 March 2006; available at <http://hsgac.senate.gov/index.cfm?Fuseaction=Hearings.Detail&HearingID=335> as of 30 March 2006).

¹²² U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 514.

of the sites are in Russia, four are in Greece (these were installed in connection with preparations for the 2004 Olympics), and one is in Lithuania.¹²³

During FY 2005, DOD's Weapons of Mass Destruction Proliferation Prevention Initiative completed portal monitor and related installation at the first 11 sites in Uzbekistan, out of 17 anticipated sites (DOD efforts in other countries have provided handheld radiation detection equipment; in Ukraine, DOD is complementing, with training and additional equipment, DOE efforts to install radiation detection at key points of entry).¹²⁴ DOE has also taken over maintenance of radiation portal monitors and mobile x-ray and gamma detection vans located at approximately 75 sites in 21 countries, originally provided by the State Department.¹²⁵ Also, the State

¹²³ U.S. Department of Energy, *2006 Strategic Plan: Office of International Material Protection and Cooperation, National Nuclear Security Administration* (Washington, D.C.: DOE, 2006).

¹²⁴ For the WMD-PPI programs in Ukraine and Uzbekistan, see U.S. Department of Defense, *FY 2007 CTR Annual Report*, pp. 39-41.

¹²⁵ For site count, interviews with DOE officials, April 2006. Portal monitors were installed by the State Department in the Czech Republic, Slovakia, Romania, Bulgaria, Estonia, Latvia, Lithuania, Ukraine, Azerbaijan, Georgia, Turkmenistan, and Kazakhstan. X-ray/gamma-detecting vans were provided by State to Slovenia, Hungary, Poland, Moldova, Armenia, Uzbekistan, and Kyrgyzstan, along with the Czech Republic, Slovakia, Romania, Bulgaria, Estonia, Latvia, Lithuania, Azerbaijan, and Kazakhstan. The State Department also installed radiation portal monitors in Turkey, but DOE is not maintaining that equipment at the request of the Turkish government. DOD provided portal monitors to Belarus, but current U.S. policy prevents DOE from maintaining that equipment. U.S. Congress, Government Accountability Office, *Combating Nuclear Smuggling: Corruption, Maintenance, and Coordination Problems Challenge U.S. Efforts to Provide Radiation Detection Equipment to Other Countries*, GAO-06-311 (Washington, D.C.: GAO, 2006; available at http://hsgac.senate.gov/_files/GAOREPORTInternational.pdf as of 30 March 2006), pp. 45-48.

Department funded installation of portal monitors at a site in Armenia (across from a site in Georgia where DOE plans to install monitors, thus providing a redundant system to confront possible corruption). The State Department and DOD both may target additional sites for assistance, in coordination with DOE.¹²⁶

All told, it appears likely that through FY 2005 the fraction of the identified set of priority border crossings that have been provided with appropriate equipment and trained personnel is in the range of 40%, as shown in Figure 3-3.¹²⁷

As with securing weapons or materials, however, just because a site has U.S.-provided equipment and training does not mean that it is necessarily invulnerable to nuclear smuggling. Much of the equipment that has been installed would likely have difficulty detecting shielded HEU. Moreover, equipment must be maintained and used effectively, and border officials must be honest and alert, for illicit nuclear shipments to be stopped. In a March 2006 report, the Government Accountability Office (GAO) noted that the equipment provided by the State Department was less sophisticated in its detection capability than the equipment provided by the DOE Second Line of Defense program (detecting gamma radiation, instead of both neutron and gamma radiation).¹²⁸ DOE officials have stated that by the end

¹²⁶ For a discussion on State plans, see U.S. Congress, *Combating Nuclear Smuggling: Problems Challenge U.S. Efforts*, pp. 14-16. On DOD, see U.S. Department of Defense, *FY 2007 CTR Annual Report*, p. 42.

¹²⁷ As a baseline, we use the estimate of 350 sites targeted by DOE, 17 sites targeted in Uzbekistan by DOD, and 75 sites where assistance has been provided by the State Department, for a total of 442 sites.

¹²⁸ U.S. Congress, *Combating Nuclear Smuggling: Problems Challenge U.S. Efforts*, pp. 18-20.

of FY 2007 it will overhaul with complete upgrade suites (that is, including communication links and other improvements) those sites that fit into the DOE plan; otherwise by the end of FY 2007 it will upgrade the portal monitors installed by the State Department to dual-channel gamma and neutron detectors, and then add the full suite later.¹²⁹

With corruption among customs officials often widespread, U.S. programs are providing anti-corruption training for customs officers. In addition, the DOE and DOD programs are deploying communication packages with their detection systems that would notify a central command center when an alarm occurs or when a portal monitor is shut off, making it more likely that a border customs guard would be caught if he or she tried to let someone bypass the detection system.¹³⁰

Rate of progress. Using the target number of sites identified above, we estimate that approximately 30% of the key border sites had radiation detection equipment installed by the end of FY 2004, meaning that approximately 10% of the sites were completed in FY 2005.¹³¹

¹²⁹ Interview with DOE officials, April 2006. Also, *Hearing on Nuclear and Radiological Threats*.

¹³⁰ U.S. Congress, *Combating Nuclear Smuggling: Problems Challenge U.S. Efforts*, pp. 16-18.

¹³¹ In last year's report, based on the data we had available at the time, we put this figure at 25%, rather than 30%. Bunn and Wier, *Securing the Bomb 2005*, pp. 45-47. At that time, the government had not yet provided data on the number of individual sites addressed by State Department work for which DOE had inherited maintenance responsibilities, and our estimate was only 21, for the 21 countries where this equipment is located, rather than the approximately 75 sites that DOE now reports it inherited from the State Department. Last year's figure also differs because of the increase in the government's estimate of the total number of sites to be addressed.

By the end of FY 2004, DOE reports that it had completed installations at 64 sites (59 in Russia, 4 in Greece, and 1 in Lithuania); thus, DOE completed 14 sites in FY 2005, though it had hoped to install equipment at 29 sites.¹³² It had trouble completing implementing agreements with Georgia, Slovenia, Azerbaijan, Ukraine, and Kazakhstan, thus delaying installations of equipment until at least FY 2006.¹³³ With agreements completed with all of those countries except Kazakhstan, DOE expects to complete 21 border sites in FY 2006, bringing the total up to 104.¹³⁴

Interdicting Metric 2: Major Ports Shipping to the United States Trained and Equipped to Detect Nuclear Smuggling

Fraction accomplished. There are some 6,000 shipping ports worldwide, roughly 700 of which ship directly to the United States.¹³⁵ The United States, in the aftermath of the September 11 attacks, has attempted to “push the borders out” with programs designed to make sure that cargo is examined appropriately before it ever reaches U.S. shores.¹³⁶ This is particularly important in the case of possible smuggling of a crude nuclear bomb: inspections after the ship holding the bomb has already arrived at the port in New York or Los Angeles or other U.S.

¹³² U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 514.

¹³³ U.S. Congress, *Combating Nuclear Smuggling: Problems Challenge U.S. Efforts*.

¹³⁴ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 514.

¹³⁵ Interview with DOE officials, April 2006.

¹³⁶ U.S. Department of Homeland Security, *A National Cargo Security Strategy White Paper*, Draft Version 1.8 (Washington, D.C.: DHS, 2004; available at http://www.homelandsecurity.org/bulletin/White_Paper_12-09-04_ver__1_8.pdf as of 1 June 2006).

cities could be too late, with the bomb detonating before the inspection occurred and causing horrifying damage. Hence, the U.S. government has launched a “Megaports Initiative,” in support of the broader “Container Security Initiative,” to equip with radiation detection equipment those ports that generate the largest volumes of shipping headed for the United States. DOE has developed a Maritime Prioritization Model that now identifies 64 ports at which the Megaports Initiative hopes to work.¹³⁷ The model looks at total container traffic coming into the United States, at the regional threat, and at factors such as how most containers enter the port (via trucks directly or from other ports).¹³⁸ Some ports tend to have more container traffic that enters the port via truck or rail, while others are mainly transshipment ports, in which containers are brought in on one ship and sent off on another; the Megaports Initiative targets both types of ports, looking for choke points in the port operations to scan containers.

By the end of FY 2005, DOE had completed installation of radiation detection equipment at ports in four countries: Rotterdam in the Netherlands, Piraeus in Greece, Colombo in Sri Lanka, and a pilot project at Freeport in the Bahamas.¹³⁹ This

¹³⁷ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 514. In recent testimony, a DOE official cited the number as approximately 70 ports, in 35 countries; see *Hearing on Nuclear and Radiological Threats*. It is not clear if this is a revision of the target, or just rounding up of the figure of 64.

¹³⁸ U.S. Congress, Government Accountability Office, *Preventing Nuclear Smuggling: DOE Has Made Limited Progress in Installing Radiation Detection Equipment at Highest Priority Foreign Seaports*, GAO-05-375 (Washington, D.C.: GAO, 2005; available at <http://www.gao.gov/new.items/d05375.pdf> as of 30 March 2006), p. 11.

¹³⁹ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 514.

represents some 6% of the 64 ports DOE expects to target for these installations, as shown in Figure 3-3. By the spring of 2006, DOE reported that systems were operational at two more ports, at Algeciras in Spain and in Singapore.¹⁴⁰

Rate of progress. By the end of FY 2004 the Megaports Initiative had completed work in 3% of the ports targeted, so an additional 3% were completed in FY 2005.

DOE had expected to have nuclear detection operational at 5 of the 64 megaports targeted by the end of FY 2005, but as noted above, the fifth port was not completed until spring of 2006. DOE has completed agreements to install equipment in eight other countries (Belgium, China, the United Arab Emirates, Honduras, Israel, Oman, the Philippines, Singapore, and Thailand). Beyond Spain, DOE expects to complete work at four ports in those countries by the end of FY 2006, bringing the total by that date to ten ports, or 16% of the ports targeted. Barring any expansion of the number of targeted sites, DOE anticipates completing radiation detection equipment installations at the 64 targeted ports by the end of calendar year 2013.¹⁴¹

Improved Interdicting Metrics for the Future

As noted above, interdicting nuclear smuggling requires a broad complex of activities, many of which are not included in metrics focused on the fraction

¹⁴⁰ U.S. Department of Energy, National Nuclear Security Administration, *Fact Sheet on NNSA's Second Line of Defense Program* (Washington, D.C.: DOE, 2006; available at <http://www.nnsa.doe.gov/docs/factsheets/2006/NA-06-FS01.pdf> as of 7 March 2006).

¹⁴¹ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 514.

of key border sites and ports trained and equipped to detect nuclear contraband. In particular, official border crossings are only a tiny fraction of the thousands of miles of border across which nuclear material might be smuggled, and many seizures of stolen nuclear material have occurred within countries, not at borders, as a result of effective police and intelligence work.

Hence, we believe the U.S. government should also track measures including both the fraction of countries considered key source or transit countries that have at least one unit of the national police trained and equipped to deal with nuclear smuggling cases (and which have informed the rest of the nation's law enforcement personnel about how to involve that unit when such a case arises), and the fraction of those key source or transit countries that have established in-depth intelligence and law enforcement sharing on nuclear smuggling with the United States, with each other, and/or with international agencies. As with securing nuclear stockpiles, measures of actual effectiveness would be even more telling indicators of how much real progress had been made. In the United States, for example, security at airports is often checked by government testers attempting to smuggle knives, guns, or explosives through security checkpoints. One could imagine contracting for testers to attempt to smuggle nuclear material through border crossings that had been equipped with radiation detectors, tracking the percentage of the time they were detected as one measure of progress. At the national level, an interesting measure of effectiveness to track would be the percentage of nuclear or radiological smuggling cases in which all the conspirators were identified and brought to justice, though these cases, fortunately, are rare enough in any particular country

that this percentage might vary randomly a great deal.

Alternatively, it would be desirable to establish and track more complex sets of measures of the overall effectiveness of each country's measures to prevent nuclear smuggling on its territory, comparable to the assessments of export control effectiveness used by the State Department's EXBS program, discussed above. Widely publicizing the full results of each year's assessment might not be appropriate because it might highlight specific, exploitable deficiencies in particular countries' systems, but releasing summary evaluations of the performance of countries' efforts to stop nuclear smuggling systems should not pose any significant risk. At an absolute minimum, relevant policy-makers in the executive and legislative branches should have access to the assessments, and, as a management tool, should examine links between countries' year-to-year performance on the assessment and the resources spent in those countries.

TRACKING PROGRESS: STABILIZING EMPLOYMENT FOR NUCLEAR PERSONNEL

Measuring the impact of U.S. attempts to alter the incentives facing personnel with access to nuclear weapons, materials, and expertise is highly challenging.¹⁴² There are multiple conceptions of the threat such programs are designed to address (e.g., scientists emigrating to a

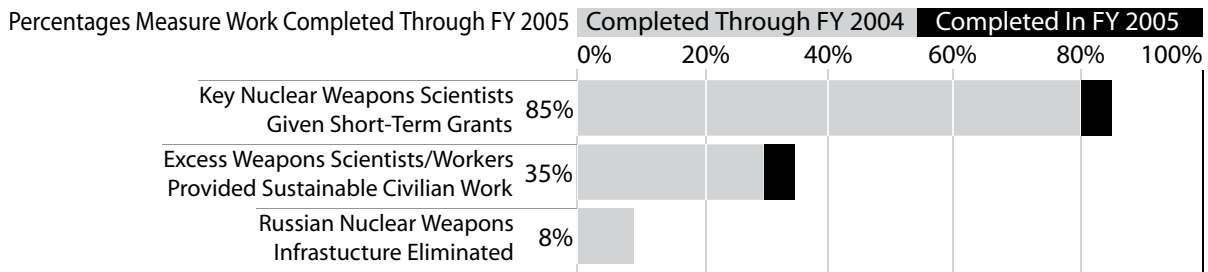
¹⁴² For longer discussions on measurement issues, see Bunn and Wier, *Securing the Bomb: An Agenda for Action*, pp. 64-72; Matthew Bunn, Anthony Wier, and John Holdren, *Controlling Nuclear Warheads and Materials: A Report Card and Action Plan* (Cambridge, Mass., and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, 2003; available at http://www.nti.org/e_research/cnwm/overview/report.asp as of 1 February 2006), pp. 75-78.

proliferating state, insiders helping a terrorist group, whole facilities collaborating with outside regimes, or countries calling upon their weapons infrastructure to expand weapons programs). Indeed, the same programs may be asked to address multiple types of threats. For instance, addressing the problem of intellectual proliferation in the vast nuclear complex left to the former Soviet states, after a decade of economic transition and government-to-government collaboration, is certainly a different task than targeting the relatively limited number of scientists with critical proliferation knowledge who are trying to adjust to a dangerous, uncertain future in post-Saddam Iraq; nevertheless, the State Department's Nonproliferation of WMD Expertise program is nevertheless dealing with both scenarios.¹⁴³

Developing metrics in this area is particularly difficult, because data on just how many knowledgeable scientists, engineers, and technicians should be targeted by U.S. programs are murky at best. Partner countries are necessarily secretive about participants in their former weapons programs. U.S. programs will never be able to reduce to zero the probability that a scientist or scientists in a targeted country will lend their assistance to other states or to terrorists, so assessing when U.S. help is no longer necessary will always be a challenge. Perhaps even more than in the securing task, developing recipients' ability to sustain improvements in the economic situation of nuclear personnel is critical. Building scientists' and their insti-

¹⁴³ The original philosophy in coping with Russia, namely, tiding over scientists to stave off desperation, drove the opening phase of interaction with Iraqi former WMD scientists, though even the latter effort appears to be broadening; see U.S. Department of State, *FY 2007 Congressional Budget Justification for Foreign Operations* (Washington, D.C.: U.S. Department of State, 2006; available at <http://www.state.gov/documents/organization/60647.pdf> as of 20 March 2006), p. 143.

Figure 3-4
How Much Stabilizing Work Have U.S.-Funded Programs Completed?



tutes' capacity to sustain their own work has thus long been integral to U.S. efforts.

One of the few systematic studies of the recipients of U.S. assistance seems to confirm that U.S.-funded grants for former weapons scientists do reduce the recipients' willingness to help developing countries with mass destruction programs, thus reducing proliferation risks. The survey, conducted in 2002 and 2003, found that Russian scientists who had received even short-term grant assistance from a Western program were significantly less likely to say they would be willing to work for a state of proliferation concern than those who had not received such assistance.¹⁴⁴

In the discussion below, we will focus on three simple measures of progress in

¹⁴⁴ Deborah Yarsike Ball and Theodore P. Gerber, "Russian Scientists and Rogue States: Does Western Assistance Reduce the Proliferation Threat?" *International Security* 29, no. 4 (Spring 2005). Because those who had sought Western assistance but received no funding held attitudes about working for a proliferating state similar to those who did not seek Western assistance in the first place, the authors of the study conclude that the attitudes of the grant recipients were a result of their Western interaction, and not a reflection of their willingness to seek Western assistance. Oddly, receiving similar grants from Russian sources did not have a significant effect on these attitudes, suggesting that the effect of these programs related both to the money received and the connection to the West resulting from them.

these programs: the fraction of the key nuclear weapon scientists who have received short-term grants; the fraction of excess nuclear weapon scientists and workers provided with sustainable civilian employment for the long haul; and the fraction of Russia's nuclear weapons infrastructure eliminated. Particularly for the first two measures, data are admittedly incomplete, but the measures give the reader at least a rough guide to the scope of work completed and remaining. We try to distinguish between what U.S.-funded programs can take credit for, and what has been accomplished through Russia's own efforts or those of others.

Our measures continue to focus on the former Soviet Union, because new programs focused on redirecting weapons scientists in Iraq and Libya are very small in comparison to the massive former Soviet complex, and because those programs have provided too little public information to understand what fraction of their mission the Iraqi and Libyan efforts have completed. It is worth noting that beyond Iraq and Libya, the State Department's Nonproliferation of WMD Expertise program has stated its intention for FY 2007 to expand its program "to engage scientists, engineers, and technicians in key regional areas who have dual-use expertise that could be easily applied to WMD."¹⁴⁵ The

¹⁴⁵ U.S. Department of State, *FY 2007 Congressional Budget Justification for Foreign Operations*, p. 139.

program has not specified which “key regional areas” it intends to target.

Stabilizing Metric 1: Key Nuclear Weapons Scientists Given Short-Term Grants

Fraction accomplished. Using available anecdotal information, in our previous reports we concluded that it was likely that in the nuclear sector at least, the International Science and Technology Centers in Moscow (ISTC) and Ukraine (STCU), the Initiatives for Proliferation Prevention (IPP), or similar projects have provided grants to a very large fraction—perhaps 80% or more—of those nuclear scientists and technicians most in need and seeking assistance.¹⁴⁶ Such anecdotal evidence was supported by the same survey of Russian nuclear, chemical, and biological scientists noted above, which found that fewer than 20% of those scientists who had sought Western grant assistance had failed to receive any.¹⁴⁷ In fact, the survey’s reported percentages are likely too high for the nuclear field, because the study’s authors were unable to include scientists at nuclear weapons research institutes—which have been heavily targeted by ISTC, IPP, and DOE’s Nuclear Cities Initiative (NCI)—and because the survey’s results had been calibrated to reduce the overrepresentation of nuclear scientists, the field receiving the most foreign attention thus far. (Despite a heightened focus by U.S. programs in the last several years, the fraction reached by grant assistance is likely less in the chemical and biological

¹⁴⁶ Bunn and Wier, *Securing the Bomb: An Agenda for Action*, p. 68; Bunn, Wier, and Holdren, *Controlling Nuclear Warheads and Materials: A Report Card and Action Plan*, pp. 74-77.

¹⁴⁷ There were also nearly 40% of the scientists surveyed who had never sought such assistance; see Ball and Gerber, “Russian Scientists and Rogue States.”

areas; important progress is being made in those areas.¹⁴⁸)

By the end of FY 2005, DOE reports that IPP and NCI, the two efforts that make up the Global Initiatives for Proliferation Prevention (GIPP), employed 11,500 scientists and technicians either through DOE-funded grants or in long-term private sector jobs enabled by such grants.¹⁴⁹ That 11,500 figure for FY 2005 compares to 11,200 for FY 2004, a difference of 300. DOE said it is targeting 17,000 people for such employment by 2015. It bases that target on an estimate of 60,000 experts originally requiring attention less attrition among the working target population and the experts reached by ISTC, STCU, or other efforts.

The State Department’s Nonproliferation of WMD Expertise program, which is the lead U.S. agency supporting ISTC and STCU, no longer reports on how many individuals its efforts have reached (the most recent period the State Department reported on individual experts was for FY 2003, when it said it had engaged about 26,000 former weapons scientists over the course of its work).¹⁵⁰ The State Department instead focuses on the number of “proliferation-relevant” institutes or groups of scientists “engaged.” By the end of FY 2005, the State Department reports that it has provided assistance to some 469 Russian and other Eurasian institutes or groups, up from 460 in FY 2004

¹⁴⁸ U.S. Department of State and U.S. Agency for International Development, *FY 2007 Performance Summary* (Washington, D.C.: U.S. Department of State, 2005; available at <http://www.state.gov/s/d/rm/rls/perfplan/2007/pdf/> as of 4 April 2006).

¹⁴⁹ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 497.

¹⁵⁰ U.S. Department of State and U.S. Agency for International Development, *FY 2007 Performance Summary*, p. 84.

and 430 in FY 2003.¹⁵¹ Many of the institutes newly engaged appear to focus on chemical or biological work, as opposed to nuclear-related research, which had been the focus in the earlier years of the effort. Unlike DOE, the State Department declines to define the scope of the target population it hopes to reach.

Last year we did not change our estimate of progress from the year before. Given that the efforts at both the State Department and DOE are reporting that they have reached out to additional scientists, it is reasonable to revise our estimate upward. We therefore estimate that some 85% of the key nuclear weapons scientists targeted have received short-term grants, as noted in Figure 3-4.

Rate of progress. On this metric (if not on others) the effort in the nuclear sector has largely stabilized, though U.S. programs have identified no clear target for ending grant assistance. While it does appear that there was slight progress in the past year in reaching a few more weapons experts, it is not clear how many key former Soviet nuclear scientists have not yet been reached by foreign grant assistance, with the exception of those at the warhead assembly/disassembly facilities.

Stabilizing Metric 2: Excess Nuclear Weapon Scientists and Workers Provided Sustainable Civilian Work

Fraction accomplished. As we have discussed at length in our previous reports, creating sustainable civilian employment for former Soviet weapons scientists remains an important measure of success for U.S. efforts to stabilize nuclear person-

¹⁵¹ See the description for the Nonproliferation of WMD Expertise program in U.S. Office of Management and Budget, *Program Assessment Rating Tool*.

nel.¹⁵² GIPP, which contains both the NCI and IPP, and the State Department's Nonproliferation of WMD Expertise program (particularly through support of the ISTC and STCU program to partner with foreign companies) have directly supported creating commercial operations based on technologies and expertise drawn from the weapons complex.

These are not the only governmental and nongovernmental efforts creating employment for excess nuclear weapon experts, however. For instance, NCI supplied seed money to set up European Bank for Reconstruction and Development (EBRD) loan programs in the Russian nuclear cities Sarov, Snezhinsk, Zheleznogorsk, and Seversk.¹⁵³ These programs have made over a thousand small-business loans in these cities, presumably supporting the creation of thousands of new jobs in these towns, some of which may be held by former employees of the nuclear weapons complex. Other U.S.-funded programs not directly focused on job creation, such as the U.S.-Russian HEU Purchase Agreement, the MPC&A program, and initiatives to develop new monitoring and detection technologies and procedures, have also led to the creation of large numbers of jobs. Other U.S.-supported efforts to improve the business climate and promote general economic development in Russia's nuclear cities, such as the International Development Centers in Zheleznogorsk and Snezhinsk, might

¹⁵² For our earlier discussions of metrics for stabilizing employment for nuclear personnel, see Bunn and Wier, *Securing the Bomb 2005*, pp. 53-56; Bunn and Wier, *Securing the Bomb: An Agenda for Action*, pp. 68-72; Bunn, Wier, and Holdren, *Controlling Nuclear Warheads and Materials: A Report Card and Action Plan*, pp. 74-77.

¹⁵³ See also, Sharon K. Weiner, "Preventing Nuclear Entrepreneurship in Russia's Nuclear Cities," *International Security* 27, no. 2 (Spring 2002), p. 156.

also help add to job growth that could absorb former nuclear weapons workers. Privately financed initiatives have also created substantial numbers of jobs for former nuclear workers.¹⁵⁴ In addition, other countries, through the G8 Global Partnership, help contribute to job creation.¹⁵⁵ Though there clearly has been some contribution, specific numbers of jobs created by these endeavors are unknown. Nevertheless, to the extent all of these initiatives, plus Russia's own efforts, create sustainable, long-term jobs, the total requirement for jobs to be created by U.S. efforts is reduced.

DOE estimates that by the end of FY 2005, the programs included in GIPP had helped create 3,800 long-term jobs, out of a population of 11,000 displaced former Soviet weapons experts for whom DOE hopes to find employment by FY 2019.¹⁵⁶

The State Department does not provide performance data on the number of jobs created for former weapons experts. Instead, it reports that, as of FY 2005, 27 institutes or groups of scientists have "graduated" into "commercially sus-

¹⁵⁴ These includes independent ventures by private companies, as well as work supported by non-governmental operations such as the Nuclear Threat Initiative; see Bunn and Wier, *Securing the Bomb: An Agenda for Action*, p. 70.

¹⁵⁵ For more on G8 nations' efforts, see Center for Strategic and International Studies, "Donor Fact Sheets: Scientist Employment," in *Strengthening the Global Partnership Project* (Washington, D.C.: CSIS, 2004; available at <http://www.sgppproject.org/Donor%20Factsheets/ProjectAreas/SciEmploy.html> as of 9 March 2006). Also, see the 2005 official report of G8 donors, at *GPWG Annual Report 2005: Consolidated Report Data (Annex A)* (Gleneagles, United Kingdom: G8 Summit, 2005; available at <http://www.sgppproject.org/resources/Gleneagles/AnnualReport2005.pdf> as of 23 June 2006).

¹⁵⁶ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 497.

tainable ventures."¹⁵⁷ Because the State Department has not published a list of which institutes have graduated or the average number of scientists employed at these institutes, it is difficult to estimate what fraction of these institutes focused on nuclear technologies, and how many former nuclear weapon experts may be employed in these new commercial ventures.

In last year's report, we estimated that, through a combination of jobs added by direct U.S. efforts and jobs created in some other manner (which reduce the total number of jobs that need to be provided to address the proliferation problem), the various U.S.-funded initiative might have created approximately 30% of the roughly 15,000-20,000 jobs that might be needed to cope with the downsizing of Russia's nuclear complex (while acknowledging that this might overestimate progress, as many of these jobs might not be held by personnel from key positions in the nuclear weapons complex). With the further progress reported by DOE and the State Department this year, we estimate that U.S.-funded programs have now provided some 35% of the necessary sustainable civilian employment for personnel from Russia's nuclear weapons complex.

Rate of progress. The publicly available data on the total number of jobs provided for former nuclear weapons scientists and workers in the last year are very limited, but that number appears unlikely to have been more than 5% of the total need. DOE reports that during FY 2005 its efforts created sustainable employment for 300 former Soviet weapons experts. For FY 2006, GIPP is hoping to

¹⁵⁷ See the description for the Nonproliferation of WMD Expertise program in U.S. Office of Management and Budget, *Program Assessment Rating Tool*.

create sustainable jobs for another 300 experts. The State Department reports that 3 institutes graduated from the assistance program, up from 24 at the end of FY 2004.¹⁵⁸ Through FY 2007, the State Department hopes to graduate 2-3 more institutes per year.¹⁵⁹

Stabilizing Metric 3: Russian Nuclear Weapons Infrastructure Eliminated

Fraction accomplished. Russia's nuclear weapons complex remains far too large to support Russia's current nuclear stockpile (estimated at some 16,000 total warheads, including 7,200 active warheads), much less for a smaller stockpile of around 5,000-6,000 strategic, tactical, and reserve warheads that would be consistent with Russia's obligations under the 2002 Strategic Offensive Reductions Treaty.¹⁶⁰ In last year's report, we assumed as a target for U.S. downsizing assistance programs a Russian nuclear weapons complex that was focused in four closed cities (and a few facilities in open cities), and that would employ about 30,000 people (a difference of about 45,000 employees from the weapons complex as it existed in 2000).¹⁶¹

¹⁵⁸ U.S. Office of Management and Budget, *Program Assessment Rating Tool*.

¹⁵⁹ U.S. Department of State and U.S. Agency for International Development, *FY 2007 Performance Summary*, p. 84.

¹⁶⁰ Estimates of the warhead stockpile size come from Robert S. Norris and Hans M. Kristensen, "NRDC Nuclear Notebook: Russian Nuclear Forces, 2005," *Bulletin of the Atomic Scientists* 61, no. 2 (March/April 2005; available at http://www.the-bulletin.org/article_nn.php?art_ofn=ma05norris as of 1 March 2006)

¹⁶¹ See Bunn and Wier, *Securing the Bomb 2005*, pp. 56-58. The scenario was based on the discussion in Appendix II in Oleg Bukharin, Matthew Bunn, and Kenneth N. Luongo, *Renewing the Partnership: Recommendations for Accelerated Action to Secure Nuclear Material in the Former Soviet Union* (Washington, D.C.: Russian American Nuclear Security Advisory

Only one U.S. program, NCI, is specifically focused on supporting Russia in closing down excess nuclear weapons-related facilities; to do so it seeks to alleviate Russian reluctance to downsize facilities by fostering viable local civilian alternatives to which the facility and its employees might turn. Though the formal NCI intergovernmental agreement expired in 2003, the program has continued to support projects approved before the agreement expired, and has sought to direct money for new projects through the ISTC.¹⁶²

NCI has set nuclear weapons complex reduction targets for six Russian nuclear weapons complex sites, including two nuclear weapons assembly-disassembly facilities (Avangard in Sarov and Zarechnyy), two plutonium production facilities (Seversk and Zheleznogorsk), and two weapons design institutes (VNIIEF at

Council, 2000; available at http://bcsia.ksg.harvard.edu/BCSIA_content/documents/mpca2000.pdf as of 10 March 2006), pp. 60-71. An updated version can be found in Oleg Bukharin, *Russia's Nuclear Complex: Surviving the End of the Cold War* (Princeton, N.J.: Program on Science and Global Security, Woodrow Wilson School of Public and International Affairs, Princeton University, May 2004; available at <http://www.ransac.org/PDFFrameset.asp?PDF=bukharinminatomsurvivalmay2004.pdf> as of 8 March 2006). This would include consolidation of several functions to fewer facilities: HEU and plutonium component manufacture would be centered at Mayak in Ozersk (as has mostly already occurred), Lesnoy would handle warhead assembly and disassembly and some non-nuclear component manufacture, and weapons R&D and other non-nuclear component work would take place at VNIIEF in Sarov, VNIITF in Snezhinsk, and the Institute of Automatics in Moscow. Though the three plutonium production reactors at Zheleznogorsk and Seversk are no longer serving a specific military purpose, the connected workers are part of the 75,000 baseline used to establish the target for this metric, so their eventual shutdown will contribute to progress on this metric.

¹⁶² Personal communication with DOE officials, October 2004.

Sarov and VNIITF at Snezhinsk).¹⁶³ By U.S.-Russian agreement, NCI initially focused its work on projects at Sarov, Snezhinsk, and Zheleznogorsk. But the program now plans to phase out most work in Sarov and Snezhinsk in the next year or so: in Sarov, NCI believes the situation has improved enough to shift resources elsewhere, and in Snezhinsk, Russia is refocusing the nuclear facility on its defense mission, reducing the need for defense conversion efforts.¹⁶⁴ NCI now plans to shift its attention to projects in Seversk and Zheleznogorsk, in part to help absorb the excess employees and infrastructure created as another U.S.-sponsored program works to shut down Russia's remaining plutonium production reactors.¹⁶⁵

NCI has met with moderate success in supporting Russian weapons complex downsizing. The program facilitated the transition of roughly 40% of the Avangard nuclear weapons assembly and disassembly facility from weapons work to open civilian work, though Russia subsequently closed the entire Avangard facility on its own. The remaining employees at Avangard were absorbed into the VNIIEF weapons-design institute also located in the city of Sarov. With roughly 2,700 employees in 2000, Avangard was thought to be the smallest of Russia's four warhead assembly/disassembly facilities.¹⁶⁶ Without

¹⁶³ "Nuclear Cities Initiative" (Washington, D.C.: National Nuclear Security Administration, no date; available at http://www.nnsa.doe.gov/na-20/nci/about_unprec.shtml as of 29 March 2006); U.S. Department of Energy, *FY 2006 Defense Nuclear Nonproliferation Budget Request*, p. 496.

¹⁶⁴ Personal communication with DOE officials, October 2004. See also, Bukharin, *Surviving the End of the Cold War*, p. 21.

¹⁶⁵ U.S. Department of Energy, *FY 2006 Defense Nuclear Nonproliferation Budget Request*, p. 496.

¹⁶⁶ By comparison, Lesnoy (formerly Sverdlovsk-45) is thought to have had some 7,000-10,000 employ-

U.S. assistance, Russia has also closed its next-smallest nuclear weapons assembly and disassembly facility, at Zarechnyy (though some non-nuclear, weapons work may still be going on there).¹⁶⁷ Only the two largest weapons assembly-disassembly plants—Lesnoy and Trekhgornyy—remain in operation. In addition, Russia appears to have closed one of its two facilities for manufacturing HEU and plutonium components for nuclear weapons (at Seversk). Most of the thousands of employees at Seversk who once worked manufacturing weapons components are reportedly now involved in dismantling these components and blending the HEU down for sale to the United States as commercial reactor fuel,¹⁶⁸ though thousands of workers remain at the plutonium production reactors at Seversk who will be displaced by those reactors' closure.

For FY 2005, GIPP dropped reporting of performance on targets for reducing the Russian nuclear weapons complex. (For FY 2004, GIPP had reported that some 53% of the program's internal "workforce reduction and facility closure" targets in six nuclear cities have been met, though it did not disclose the specific targets.¹⁶⁹)

ees in 2000; Trekhgornyy (formerly Zlatoust-36) probably had some 3,600; and Zarechnyy (formerly Penza-19) also had some 7,000-10,000 workers. In all of these cases, some of these workers probably also performed some work related to non-physics nuclear weapons component manufacturing. Bukharin, Bunn, and Luongo, *Renewing the Partnership: Recommendations for Accelerated Action to Secure Nuclear Material in the Former Soviet Union*, pp. 38-42, 57-59.

¹⁶⁷ Interview with former First Deputy Minister of Atomic Energy Lev Ryabev, September 2003.

¹⁶⁸ Personal communication from Oleg Bukharin, Princeton University, March 2004.

¹⁶⁹ U.S. Department of Energy, *Performance and Accountability Report: FY 2004*, p. 133. Although the only major facility whose closure the United States has substantially contributed to is Avangard, DOE's statement that 53% of the combined total of the

Without any specific information to the contrary, we maintain our estimate that NCI has helped shut down roughly 7-8% of Russia's remaining excess nuclear weapons complex.¹⁷⁰

Rate of progress. Further dramatic reductions in the nuclear weapons labs at Sarov and Snezhinsk appear unlikely, as NCI has largely shifted its focus to Seversk and Zheleznogorsk. There is no agreement for the United States and Russia to cooperate on closing down more of Russia's nuclear weapons complex. In its FY 2005 Performance and Accountability Report, however, DOE reports that in FY 2005 it sought authority to negotiate a new agreement with the Russian Federation that, in its words, is "designed to permit expanded work at closed nuclear cities in Russia."¹⁷¹

Improved Stabilizing Metrics for the Future

The publicly available data for assessing programs in this area are very limited. The total scope of the problem being addressed is not well understood (or even well defined), and there are important gaps in understanding what fraction of that problem has in fact been addressed by the work performed so far. The measures that are readily available provide valuable information on the outputs of the programs, such as the number of institutes engaged or the number of scientists receiving grants. But to the policy-maker or citizen outside the program, such output measures do not answer their essential questions: how much of the problem of

reduction targets for the six sites have been accomplished suggests that the targets for the other five may be modest.

¹⁷⁰ Bunn and Wier, *Securing the Bomb 2005*, pp. 57-58.

¹⁷¹ U.S. Department of Energy, *Performance and Accountability Report: FY 2005*, p. 92.

potential leakage of nuclear knowledge has been solved, and how could we solve more of it?

Of course, if such measures were easy to come by, we would see them by now. Establishing the full scope of the problem by identifying and quantifying just who did and still does what in one of the most sensitive national security activities—the production of nuclear weapons—in the successor states of the Soviet Union is an extremely challenging task. Given its sensitivity, much of that task can not be carried out in the public realm.

In essence, more data are needed on the denominator of the problem, that is, how many people with what kinds of knowledge and access need new civilian employment. Different kinds of nuclear workers each pose a different type of concern. There is the lead scientist who could design an entire weapon. There is the engineer who might be able to help another state acquire an indigenous nuclear capability, for example by providing knowledge relevant to centrifuge manufacture or machining of nuclear weapons components. There is the production worker who might be able to access HEU or plutonium, and might provide a terrorist group with enough fissile material for a bomb. There is the guard who might provide crucial help in getting others inside a facility. Key questions include: What is the employment distribution of these types of workers in the former Soviet nuclear complex today? How are these categories distributed among defense-related facilities, non-defense enterprises, retirees, or other jobs? How many are now unemployed or underemployed, and how many can be expected to lose their jobs in the near future? How many should be expected to retire (and how many to die) over the next several years? How many should be expected to

move into civilian jobs outside the nuclear weapons complex without any programs to help them?

Then, in evaluating program performance, we would want to know how many workers from each of these categories have been redirected into sustainable civilian employment where they no longer have access to nuclear material and where they are not in a desperate economic situation. At the same time, Russian performance in their efforts should also be tracked, to recalibrate as necessary the scope of the problem U.S. and other international programs would need to address. Continuously updated understanding of the evolution of economic conditions, attitudes toward proliferation, security enforcement, and the like for Russian nuclear personnel is also a crucial part of understanding how the problem is evolving over time.

We acknowledge that getting specific answers on all these questions is an ideal that will not be achieved in full. But finding more detailed, more accurate information will only serve to help these programs better articulate and execute their mission. Better data on exactly what these efforts have been able to achieve will also make it easier for these programs to find supporters and fend off critics. At the same time, continued efforts to assess the potential willingness of nuclear scientists and workers to contribute to proliferation activities—through polling, individual interviews, focus groups, and the like—can also help improve understanding of the threat, and of the extent to which these programs are in fact helping to convince these individuals not to sell their knowledge or the material to which they have access.¹⁷²

¹⁷² For an example of such polling and interviews, see Ball and Gerber, “Russian Scientists and Rogue

TRACKING PROGRESS: MONITORING NUCLEAR STOCKPILES AND REDUCTIONS

Currently, few programs are focused on declarations and monitoring of nuclear weapons and fissile material stockpiles in the United States, Russia, and the other nuclear weapon states, or of nuclear weapon dismantlement, though the Bush administration has proposed some limited transparency measures relating to tactical and strategic nuclear weapons.¹⁷³ Nevertheless, we continue to include metrics of the status of monitoring and declarations of nuclear stockpiles because we believe implementation of such transparency measures would serve international security by contributing to steps to ensure that all nuclear stockpiles are secure and accounted for and by laying the foundation for verifiable deep reductions in nuclear arms.¹⁷⁴

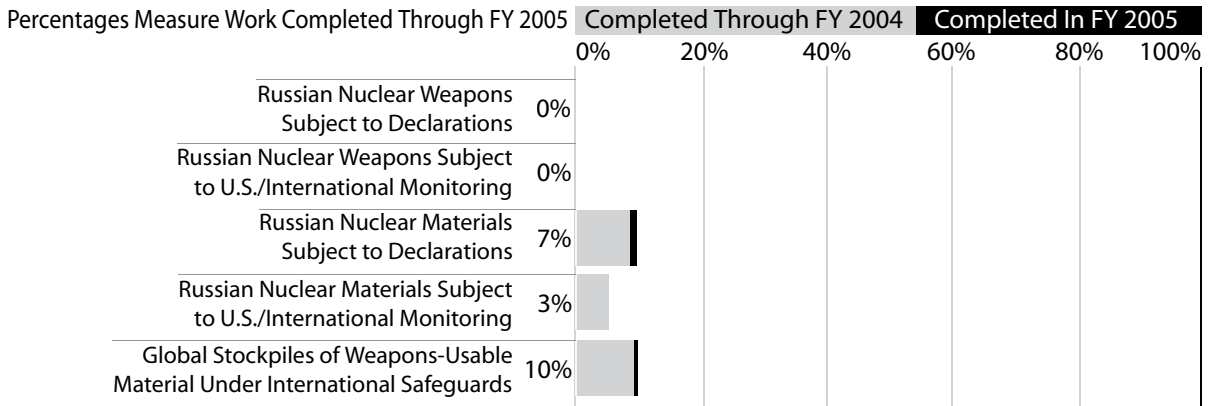
We judge progress in this area with: the fraction of Russia’s nuclear warheads and

States.” Also, Valentin Tikhonov, *Russia’s Nuclear and Missile Complex: The Human Factor in Proliferation* (Washington D.C.: Carnegie Endowment for International Peace, 2001; available at <http://www.ceip.org/files/projects/npp/resources/humanfactor-flyer.htm> as of 9 June 2006).

¹⁷³ See, for example, the brief discussion in U.S. Department of State, *FY 2005 Performance and Accountability Report* (Washington, D.C.: U.S. Department of State, 2005; available at <http://www.state.gov/documents/organization/58043.pdf> as of 16 May 2006), p. 162.

¹⁷⁴ For discussions, see U.S. National Academy of Sciences, Committee on International Security and Arms Control, *Monitoring Nuclear Weapons and Nuclear-Explosive Materials* (Washington, D.C.: National Academy Press, 2005; available at <http://books.nap.edu/catalog/11265.html> as of 8 April 2006); Bunn, Wier, and Holdren, *Controlling Nuclear Warheads and Materials: A Report Card and Action Plan*, pp. 147-149; Nicholas Zarimpas, ed., *Transparency in Nuclear Warheads and Materials: The Political and Technical Dimensions* (Oxford: Oxford University Press for the Stockholm International Peace Research Institute, 2003).

Figure 3-5
How Much Monitoring Work Have U.S.-Funded Programs Completed?



materials that have been the subject of detailed declarations; the fraction of those warheads and materials that are subject to actual monitoring; and the fraction of global stockpiles of weapons-usable materials that are under international safeguards.

Monitoring Metric 1: Russian Nuclear Weapons and Materials Subject to Declarations

Fraction accomplished. Remarkably, the United States and Russia have never told each other how many nuclear weapons or how many tons of plutonium and HEU they have. Nor has either country ever allowed the other to verify the dismantlement of a single nuclear warhead. Therefore the fraction of nuclear warheads subject to detailed declarations is zero.

In the case of nuclear materials, every year another 30 tons of HEU is blended down, and becomes subject to declarations (and monitoring, as described below) as part of that process. (Blending that material down, of course, also shrinks the total quantity of material remaining.) In addition, under the terms of the Plutonium Production Reactor Agreement (PPRA), Russia makes declarations of the amount

of plutonium produced in its plutonium production reactors since January 1, 1997, all of which is stored in oxide form at Seversk and Zheleznogorsk.¹⁷⁵ While these declarations are kept confidential, at an estimated rate of 1.2 tons per year, this should now amount to some 8-12 tons of plutonium. Russia also makes public declarations every year on its stockpiles of separated civilian plutonium. As of the end of 2004 (the most recent year for which declarations are yet available), Russia's civil separated plutonium declaration included 41.2 tons of material.¹⁷⁶ Hence, as shown in Figure 3-5, the total amount of nuclear material subject to declarations is in the range of 80 tons, almost 7% of the

¹⁷⁵ *Agreement between the Government of the United States of America and the Government of the Russian Federation Concerning Cooperation Regarding Plutonium Production Reactors* (Washington, D.C.: U.S. Department of Energy, 1997; available at http://www.nnsa.doe.gov/na-20/docs/PPRA_new.pdf as of 16 May 2006).

¹⁷⁶ International Atomic Energy Agency, *Communication Received from the Russian Federation Concerning Its Policies Regarding the Management of Plutonium*, INFCIRC/549/Add.9/7 (IAEA, 2005; available at <http://www.iaea.org/Publications/Documents/Infcircs/2005/infirc549a9-7.pdf> as of 30 March 2006). As the annual increases in Russia's reports have been increasing by amounts ranging from 1 ton to 2.8 tons in recent years, by the end of 2005, Russia's total quantity of civilian separated plutonium probably amounted to 41-43 tons.

estimated 1,215 tons of weapons-usable nuclear material in Russia as of the end of 2005, or some 13% of the 600 tons of that total stockpile that is believed to be outside of nuclear weapons themselves.¹⁷⁷

Rate of progress. The only increases in the amount of material subject to declarations in the past year have been the additional plutonium produced in Russia in the past year—roughly 1.2 tons in the old plutonium production reactors, and roughly 1.5 tons of civilian plutonium separated at Mayak. In the future, if transparency measures are eventually agreed for the Mayak Fissile Material Storage Facility and fissile material begins to be loaded there, that material may effectively come under declarations, as the United States may, depending on the specific measures agreed to in the final transparency arrangements, be informed of roughly how much material is present in the facility. Thus, over the next few years, some 25 tons of plutonium should be added to the amounts just described—or more, if the United States and Russia agree on policy changes that

¹⁷⁷ The 1,215-ton figure is an update from the end-2003 figures presented in Albright and Kramer, *Global Stocks of Nuclear Explosive Materials*. They estimate 145 tons of military plutonium; 38 tons of civilian separated plutonium reported by Russia; 1,070 tons of remaining military HEU; and 22 tons of civilian HEU, for a total of 1,275 tons of separated plutonium and HEU. These estimates all have substantial uncertainties: the total is uncertain to plus or minus hundreds of tons. In the two years between the end of 2003 and the end of 2005, an additional 60 tons of HEU was blended down in the U.S.-Russian HEU purchase agreement; roughly 2.4 tons of plutonium was produced in the plutonium production reactors; roughly 3 tons of plutonium was separated at Mayak (assuming the 2005 rate was comparable to the 2004 rate declared by Russia); and perhaps 4 tons of HEU was either destroyed as part of the Material Consolidation and Conversion program or consumed in reactors, reducing the total to something in the range of 1,215 tons. In our previous reports, we had incorrectly failed to include the plutonium from the plutonium production reactors in the total subject to declarations.

would allow more material to be stored there.¹⁷⁸ Beyond that, progress in bringing additional weapons or materials under declarations is minimal.

Monitoring Metric 2: Russian Nuclear Weapons and Materials Subject to U.S. or International Monitoring

Fraction accomplished. As with declarations, no warheads are currently subject to monitoring. In the case of nuclear materials, the 30 tons of HEU being downblended each year are subject to limited monitoring during that process (and are removed from the total stockpile). Limited monitoring of the plutonium produced in Russia's plutonium production reactors since 1994 (amounting to some 8-12 tons of plutonium) is now occurring, although as of early 2006, U.S. monitors had still not been allowed to take measurements on the canisters containing this material (as provided for under the plutonium reactor agree-

¹⁷⁸ Currently, the United States takes the view that only weapons-grade plutonium or weapons-grade HEU which will never be returned to weapons can be stored in this facility. Russia takes the view that the HEU in this category is already being blended for sale to the United States under the HEU purchase agreement and does not require storage at Mayak, and the only plutonium it is willing to place in this category is the 34 tons covered by the 2000 U.S.-Russian Plutonium Management and Disposition Agreement, of which 9 tons is material produced in the plutonium production reactors in recent years and stored there, leaving only 25 tons of plutonium eligible for placement in the Mayak storage facility—enough to fill one-quarter of the facility. The United States is considering approaches that would allow additional material to be stored at Mayak, such as having one portion of the facility limited to excess plutonium that would never be returned to weapons and would be subject to monitoring, and another portion where Russia could store a portion of the plutonium still reserved for support of its military stockpile. See Matthew Bunn, "Mayak Fissile Material Storage Facility," in *Nuclear Threat Initiative Research Library: Controlling Nuclear Warheads and Materials* (2004; available at http://www.nti.org/e_research/cnwm/securing/mayak.asp as of 14 February 2006).

ment), because of disagreements over the specifics of the measurements to be taken and the equipment to be used.¹⁷⁹ Together, the plutonium and HEU being monitored represents some 3% of Russia's total nuclear material stockpile, or nearly 7% of the estimated 600 tons outside of weapons.

Rate of progress. As noted earlier, there are no current plans for monitoring of warhead stockpiles. For material stockpiles, the rate of increase in the amounts of materials subject to monitoring has been painfully slow. As just noted, 25 tons or more of plutonium is slated to be loaded into the Mayak Fissile Material Storage Facility over the next few years, and if all goes well, this will be subject to some form of transparency. Over the longer term, monitoring of plutonium being burned as fuel in the plutonium disposition effort would begin, but all of this material would be either from the plutonium stored at Mayak (which, if transparency arrangements are agreed, will already be subject to monitoring), or plutonium from the stocks at Russia's plutonium production reactors (also already subject to monitoring).

Monitoring Metric 3: Global Stockpiles of Weapons-Usable Material Under International Safeguards

Fraction accomplished. All non-nuclear-weapon states which are party to the Nonproliferation Treaty (NPT)—which is to say, all but nine states in the world—are required to place all their nuclear stockpiles under IAEA safeguards. In addition to their role in confirming that states have not diverted nuclear material under safe-

¹⁷⁹ Defense Threat Reduction Agency, "Plutonium Production Reactor Agreement" (Fort Belvoir, Vir.: DTRA, 2006; available at http://www.dtra.mil/press_resources/fact_sheets/display.cfm?fs=ppra as of 9 June 2006).

guards for military purposes, safeguards provide an important measure of international transparency and confidence, and impose multilateral discipline on the quality of material accounting. The IAEA does not safeguard military nuclear material, and nuclear weapon states are not required to place their nuclear materials under IAEA safeguards (though a small amount of material in these states is under safeguards under voluntary offer agreements, and French and British civilian material is under Euratom safeguards, integrated with the IAEA).

Hence, as of the end of 2004, only 89 tons of separated plutonium outside of reactor cores (of which over 74 tons were in Britain and 2 tons in the United States) and 32 tons of HEU, was under IAEA safeguards.¹⁸⁰ Britain and France, however, declared that a total of 181 tons of separated civilian plutonium was on their soil as of the end of 2004.¹⁸¹ While only a portion of this material (largely in Britain) is subject to IAEA safeguards, all of it is subject to EURATOM safeguards, so the total quantity of plutonium subject to some form of international safeguards at the end of 2004 was in the range of 195

¹⁸⁰ See Table A18 in International Atomic Energy Agency, *Annual Report 2004* (Vienna: IAEA, 2005; available at http://www.iaea.org/Publications/Reports/Anrep2004/anrep2004_full.pdf as of 13 February 2006). Supplemented by personal communication from IAEA safeguards officials, June 2006.

¹⁸¹ This includes 102.7 tons for Britain and 78.5 tons for France. See International Atomic Energy Agency, *Communication Received from the United Kingdom of Great Britain and Northern Ireland Concerning Its Policies Regarding the Management of Plutonium*, INFCIRC/549/Add. 8/8 (Vienna: IAEA, 2006; available at <http://www.iaea.org/Publications/Documents/Infcircs/2006/infcirc549a8-8.pdf> as of 16 May 2006); International Atomic Energy Agency, *Communication Received from France Concerning Its Policies Regarding the Management of Plutonium*, INFCIRC/549/Add. 5/9 (Vienna: IAEA, 2005; available at <http://www.iaea.org/Publications/Documents/Infcircs/2005/infcirc549a5-9.pdf> as of 16 May 2006).

tons.¹⁸² Similarly, Britain and France have declared that as of the end of 2004, just under 8 tons of civil HEU was on their soil.¹⁸³ Again, all of this material is under EURATOM safeguards, though none of it appears to be included in the total under IAEA safeguards, so the total quantity of HEU subject to some form of international safeguards at the end of 2004 was in the range of 40 tons.

The separated plutonium under some form of international safeguards represented nearly 40% of the global stockpile of separated plutonium at that time, but the HEU under safeguards represented only about 2% of the global stock of that material (reflecting the much smaller scale of civilian use of HEU). All told, it appears that approximately 10% of the global stockpile of weapons-usable nuclear material was under some form of international safeguards as of the end of 2004.

Rate of progress. There are currently no major moves underway to place additional plutonium and HEU under international safeguards. The only additional separated plutonium or HEU placed under safeguards in most years is the additional amount of separated plutonium produced in those countries

¹⁸² This includes 12.3 tons in states with comprehensive IAEA safeguards; 0.1 tons in states with safeguards limited to particular facilities under Information Circular (INFCIRC) 66 safeguards (this is material in India); 2 tons of plutonium in the United States declared excess to U.S. military needs; and the 181 tons of separated civil plutonium in Britain and France.

¹⁸³ This includes roughly 6.4 tons in France and 1.5 tons in the United Kingdom. See International Atomic Energy Agency, *Communication Received from the United Kingdom of Great Britain and Northern Ireland Concerning Its Policies Regarding the Management of Plutonium*; International Atomic Energy Agency, *Communication Received from France Concerning Its Policies Regarding the Management of Plutonium*.

where these operations are under safeguards. Ultimately, all civilian separated plutonium and HEU worldwide, and all military plutonium and HEU no longer needed for military purposes, should be placed under safeguards.

Improved Monitoring Metrics for the Future

The U.S. government should assess what declarations, monitoring, and other transparency measures would give it confidence that nuclear weapons and weapons-usable nuclear materials around the world were safe and secure, and being managed in compliance with international agreements. It should then track what fraction of the measures needed to achieve that confidence have yet been put in place.

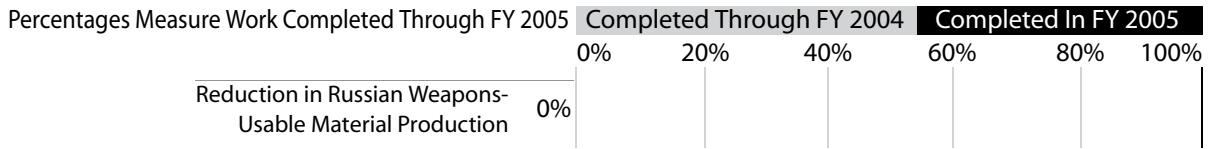
TRACKING PROGRESS: ENDING PRODUCTION

World stocks of nuclear weapons, separated plutonium, and HEU are far larger than needed for any current or future military or civilian purposes. Adding further to these stockpiles will increase the cost and complexity of ensuring they are effectively guarded and controlled. Hence, ending production of these materials for both military and civilian purposes is an important objective.

As discussed in the previous chapter, there has been very little progress in stopping production of bomb material in potential new nuclear weapon states or in stopping production of military and civilian weapons-usable nuclear material worldwide, though the last year did see some forward movement in the effort to build alternative power sources to allow Russia's plutonium production reactors to shut down.

Figure 3-6

How Much Ending Production Work Have U.S.-Funded Programs Completed?



**Ending Production Metric 1:
Reduction in Russian Weapons-Usable Material Production**

Fraction accomplished. The ultimate metric here is very simple: the reduction in the rate of weapons-usable material production resulting from U.S. sponsored programs. So far, this is zero, as U.S.-funded programs have not affected this production rate—and it will remain zero until the first of the three remaining plutonium production reactors actually shuts down (Figure 3-6 reflects this outcome-oriented assessment).

The picture is more promising if judged by the fraction of all the work that needs to be done to shut these reactors down that has been completed. In 2005, major construction got underway on the refurbishment of a coal plant in Seversk; DOE estimates that by the end of FY 2005, that project was more than 25% complete (though this fell more than 6% short of the target for the year).¹⁸⁴ DOE is requesting a sharp increase in funding to accelerate the Zheleznogorsk project in FY 2007 (from \$47 million in FY 2006 to \$120 million in FY 2007), but to date the project is only in its earliest stages; just under 5% of the Zheleznogorsk project was completed by the end of FY 2005.¹⁸⁵

¹⁸⁴ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, pp. 525-526.

¹⁸⁵ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, pp. 525-529.

Rate of progress. As just noted, DOE estimates that more than 25% of the work needed to shut down the Seversk reactors was done by the end of FY 2005, essentially doubling the percentage completed by the end of FY 2004. DOE expects to complete another 30% of the work during FY 2006, bringing the total to 55%, and to complete the project by December 2008.¹⁸⁶ DOE expects to complete less than 5% of the Zheleznogorsk effort in FY 2006, but hopes that the project will then accelerate during FY 2007–2009. Completion of the Zheleznogorsk efforts is slated for December 2010.¹⁸⁷

Improved Ending Production Metrics for the Future

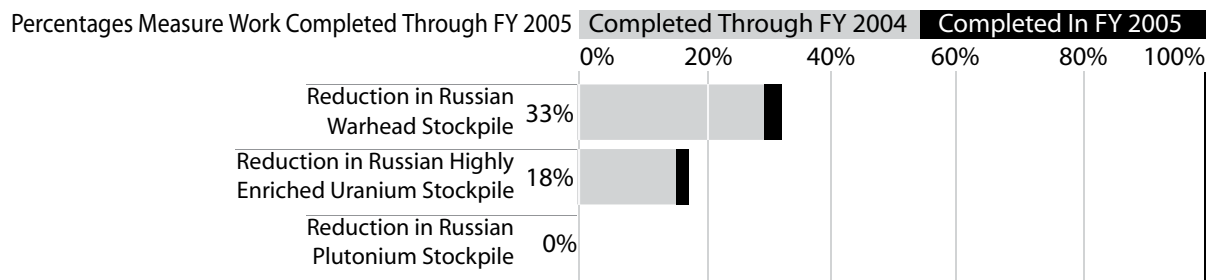
The U.S. government should develop measures to assess progress in ending (or preventing) production of nuclear material in potential or new nuclear weapon states such as North Korea and Iran. It should also estimate global production of nuclear materials for weapons each year and progress in bringing that production to an end. Finally, it should develop estimates of *total*—that is, both military and civilian—worldwide production of weapons-usable nuclear material each year, and of progress in reducing (and ultimately ending) that production.

¹⁸⁶ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 525.

¹⁸⁷ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 525.

Figure 3-7

How Much Reducing Stockpiles Work Have U.S.-Funded Programs Completed?



TRACKING PROGRESS: REDUCING NUCLEAR STOCKPILES

Ultimately, the only way to guarantee that any particular nuclear weapon or cache of weapon-usable nuclear material will not be stolen is to destroy it. Reductions in the total size of these stockpiles are also an important long-term foundation for deep and difficult-to-reverse reductions in nuclear arms.

Between them, the United States, Russia, France, and Britain have dismantled thousands of nuclear weapons since the end of the Cold War. Non-government estimates suggest that as of the end of 2005 there were still some 27,000 nuclear weapons in the world, compared to well over 40,000 when the Soviet Union collapsed.¹⁸⁸ To date, however, there are no arms control agreements that call for destroying nuclear warheads themselves (as opposed to simply taking them off of delivery systems)—though the United

States and Russia made unilateral pledges to destroy large portions of their tactical nuclear weapons in 1991-1992. Moreover, although DOD's Cooperative Threat Reduction (CTR) program, commonly known as Nunn-Lugar, is often thought of as a weapons dismantlement effort, no U.S. money has ever gone to finance the actual dismantlement of Russian nuclear warheads (as that would require verification that the warheads were in fact being dismantled, which the two sides have never agreed to do). CTR does pay for shipments of warheads to storage and dismantlement sites, and it routinely pays for the dismantlement of nuclear missiles, bombers, and submarines; but it does not pay for dismantlement of the warheads themselves.

With respect to reductions in nuclear materials, the key agreements in place are the U.S.-Russian HEU Purchase Agreement, which commits Russia to eliminating 500 tons of weapons-grade HEU by blending it to LEU for sale to the United States, and the Plutonium Management and Disposition Agreement (PMDA) of 2000, which commits both Russia and the United States to carry out disposition of 34 tons of weapons-grade plutonium (possibly mixed with up to an additional four tons of reactor-grade plutonium).¹⁸⁹

¹⁸⁸ For current estimates, see, for example, Hans M. Kristensen, "Status of World Nuclear Forces" (Washington, D.C.: Nukestrat.com, 2006; available at <http://www.nukestrat.com/nukestatus.htm> as of 21 June 2006). For an estimate of the global stockpile at the time of the Soviet collapse in 1991, see, for example, Robert S. Norris and Hans M. Kristensen, "NRDC Nuclear Notebook: Global Nuclear Stockpiles, 2002," *Bulletin of the Atomic Scientists* (November/December 2002; available at http://www.thebulletin.org/article_nn.php?art_ofn=nd02norris as of 17 May 2006).

¹⁸⁹ For more, see Matthew Bunn, "HEU Purchase Agreement," in *Nuclear Threat Initiative Research Library: Controlling Nuclear Warheads and Materials* (2003; available at http://www.nti.org/e_research/

Implementation of the HEU Purchase Agreement (and of unilateral U.S. programs to reduce its own excess HEU stockpile) continues, but disposition of both U.S. and Russian excess plutonium has been delayed for years. In addition to destroying weapons-usable HEU, the HEU Purchase Agreement also gives Russia a financial incentive to continue large-scale weapons dismantlement, in order to provide the HEU for blending and sale to the United States.

Our metrics in this area are very simple—the fractions of the relevant stockpiles that have been reduced. Because U.S.-funded cooperative programs in these areas have focused only on Russia, our metrics focus only on the reductions achieved in the Russian stockpiles, rather than those achieved in the global stockpiles.

Reducing Metric 1: Reduction in Russian Warhead Stockpile

Fraction accomplished. As noted above, there are no current U.S.-funded programs directly focused on reducing the Russian stockpile of nuclear warheads. Nevertheless, Russia has dismantled thousands of nuclear warheads since the collapse of the former Soviet Union, and some U.S. programs provide indirect assistance in or incentives for that process.

Under DOD's nuclear warhead transportation program, by the end of FY 2005 the United States had paid for 284 nuclear

warhead shipments, typically carrying some 20-30 warheads each, either to central storage facilities or to dismantlement facilities.¹⁹⁰ This represents a shipment of some 5,000-9,000 warheads. No public breakdown is available of how many of these shipments were to storage sites and how many were for dismantlement; if half of these shipments led to the dismantlement of shipped warheads, this effort would have contributed to the dismantlement of some 2,500-4,500 nuclear warheads.

The U.S.-Russian HEU Purchase Agreement has also provided a financial incentive to dismantle warheads, by arranging for the commercial sale of uranium blended from the HEU warheads contain. By the end of 2005, over 260 tons of HEU had been blended down under this agreement; if we assume that, on average, Russian warheads contain 25 kilograms of HEU, this is the equivalent of well over 10,000 nuclear warheads.¹⁹¹ Presumably a large fraction of the warheads transported to dismantlement facilities with U.S. assistance were the same as warheads dismantled to provide HEU for the HEU Purchase Agreement, and hence these figures should not be added together. What is unknown, however, is (a) how much of the HEU blended down to date was from warheads dismantled even before the HEU Purchase Agreement was negotiated (dismantlement of which the agreement therefore could not take credit for), and (b) how many warheads Russia had when the agreement began. By some public estimates, Russia had some

cnwm/reducing/heudeal.asp as of 29 March 2006). On plutonium disposition, see U.S. Department of Energy, *Agreement between the Government of the United States of America and the Government of the Russian Federation Concerning the Management and Disposition of Plutonium Designated as No Longer Required for Defense Purposes and Related Cooperation* (Washington, D.C.: DOE, 2000; available at http://www.nnsa.doe.gov/na-20/docs/2000_Agreement.pdf as of 30 March 2006).

¹⁹⁰ U.S. Department of Defense, *FY 2007 CTR Annual Report*, p. 3.

¹⁹¹ USEC, "Chronology: U.S.-Russian Megatons to Megawatts Program: Recycling Nuclear Warheads into Electricity (as of January 3, 2006)" (Bethesda, Md.: USEC, 2006; available at http://www.usec.com/v2001_02/HTML/Megatons_chronology.asp as of 31 March 2006).

32,000 warheads in 1993, when the HEU Purchase Agreement began, and has since reduced this figure to some 16,000.¹⁹² If all of the HEU blended to date came from warheads dismantled in part as a result of this HEU deal (a generous assumption), then it could be argued that U.S. programs have contributed to the dismantlement of roughly 33% of the total stockpile of nuclear warheads that Russia had when the agreement began, as noted in Figure 3-7.

Rate of progress. The nuclear warhead transportation program resumed in June 2005, after the United States and Russia resolved a dispute that had brought the program to a halt in November 2004. The dispute centered on whether Russia might be using some U.S.-funded shipments for operations of its nuclear stockpile (rather than for storage and dismantlement). It was resolved with an amended transparency agreement.¹⁹³ DOD financed 25 such shipments in FY 2005 after the program resumed, and plans through FY 2012 to finance an average of roughly 50 shipments per year, transporting some 1,000-1,500 warheads per year.¹⁹⁴

Today, some 30 tons of HEU is being blended down every year under the HEU Purchase Agreement, representing the equivalent of some 1,200 warheads per year, roughly an additional 4% each year of the warheads Russia had when the HEU Purchase Agreement began. The HEU Purchase Agreement is currently scheduled to end in 2013, and no decisions have yet been announced concerning

¹⁹² Robert S. Norris and Hans M. Kristensen, "NRDC Nuclear Notebook: Russian Nuclear Forces, 2005."

¹⁹³ U.S. Department of Defense, *FY 2007 CTR Annual Report*, p. 30.

¹⁹⁴ U.S. Department of Defense, *FY 2007 CTR Annual Report*, p. 3.

what will happen to the large remaining Russian stockpile of HEU that will exist at that time, much of which is far beyond Russia's plausible military needs.

Reducing Metric 2: Reduction in Russian Highly Enriched Uranium Stockpile

Fraction accomplished. As just noted, by the end of 2005, 262 metric tons of HEU had been destroyed (by blending it to low enriched uranium reactor fuel) as part of the U.S.-Russian HEU Purchase Agreement. In addition, by the end of FY 2005, some 7.1 tons of HEU had been destroyed as part of the Material Consolidation and Conversion (MCC) effort in DOE's MPC&A program.¹⁹⁵ This represents some 21% of the over 1,200 tons of weapons-grade HEU equivalent Russia was believed to possess when the HEU deal began.¹⁹⁶

Rate of progress. As already described, an additional 30 tons of HEU is currently being destroyed each year, representing roughly an additional 2% of the original Russian HEU stockpile. The program is

¹⁹⁵ U.S. Department of Energy, *FY 2006 Defense Nuclear Nonproliferation Budget Request*, p. 485.

¹⁹⁶ David Albright has recently estimated that Russia had 1,070 tons of military HEU as of the end of 2003, and 15-30 tons of civil HEU. (These are somewhat inconsistently expressed, as the 1,070 figure is also the centerpoint of an estimate with a wide uncertainty range.) These figures would have been somewhat more than 200 tons higher when the HEU Purchase Agreement began, before HEU began to be destroyed in that effort. See Albright and Kramer, eds., *Global Fissile Material Inventories*. For a discussion of a range of previous unclassified estimates, and of the various uses that are drawing down Russia's HEU stockpile over time, see Matthew Bunn, "Unclassified Estimates of Russia's Plutonium and HEU Stockpiles—and World Civil Separated Plutonium Stockpiles: A Summary and Update, Rev. 1" (Cambridge, Mass.: unpublished, 2003).

currently scheduled to end in 2013, after 500 tons—some 40% of the original stockpile—has been blended. In addition, DOE plans to blend down 1.5 tons of HEU in FY 2006 and 1.1 tons in FY 2007 in the MCC effort (scaled back from previous projections of two tons per year).¹⁹⁷ Russia is also consuming some of its HEU stockpile as fuel for naval, icebreaker, research, and plutonium production reactors, and is using some for commercial production of LEU fuel from European reprocessed uranium.¹⁹⁸ To address a larger fraction of the stockpile more quickly, the blend-down of HEU should be substantially accelerated, and expanded well beyond the 500 tons initially agreed.¹⁹⁹

Reducing Metric 3: Reduction in Russian Plutonium Stockpile

Fraction accomplished. Years of effort and hundreds of millions of dollars of investment have been focused on laying the groundwork for disposition of excess weapons plutonium. Russia has almost completed site preparation work where the plutonium fuel fabrication facility is to be built. DOE, meanwhile, has been working closely with Russian regulators to lay the groundwork for licensing fabrication of MOX fuel in Russia and its use in Russian reactors. Early preparations to use MOX fuel in Russia's VVER-1000 reac-

tors have also been underway. But Russia has recently reiterated its reluctance to use its excess plutonium as MOX fuel in light-water reactors, arguing that it is more efficient to use it in fast-neutron reactors, both the BN-600 that already exists, and the modestly larger BN-800 Russia hopes to build. This shift has once again thrown the program into some disarray, with the United States and Russia again discussing what technological approaches to plutonium disposition should be pursued. In any case, the program is not yet at the point where any substantial amounts of excess weapons plutonium have been used as reactor fuel or otherwise transformed into forms unsuitable for weapons use. Indeed, large-scale construction of the MOX for fabricating light-water-reactor fuel has not yet begun, and now may never begin. Hence, the fraction accomplished to date in actually reducing the stockpile of Russian weapons plutonium is zero.

Rate of progress. To date, the annual rate of progress in reducing excess plutonium stockpiles is also zero, if measured by actual plutonium eliminated. As noted above, while some obstacles were overcome in the past year, others remain. Actual construction of the needed MOX plant in Russia did not begin in FY 2005, and DOE does not include actual plant construction among the expected activities in Russia in FY 2006.²⁰⁰ Even if the two sides returned to the idea of building a MOX plant to manufacture fuel for existing reactors, and all other current issues were resolved quickly, it would probably take some five years after construction got under way to build the MOX plant and other needed facilities. Hence, it is unlikely that disposition of substantial amounts of plutonium will begin before

¹⁹⁷ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 514. For the earlier projection, see U.S. Department of Energy, *FY 2006 Defense Nuclear Nonproliferation Budget Request*, p. 485.

¹⁹⁸ Bunn, "Unclassified Estimates of Russia's Plutonium and HEU Stockpiles—and World Civil Separated Plutonium Stockpiles."

¹⁹⁹ The Nuclear Threat Initiative (NTI) has sponsored a detailed study by Russian experts (including experts from the facilities doing the work) of the feasibility, schedule, and costs for various approaches to accelerating the blend-down of HEU. A follow-on study to optimize the approaches to reduce total costs is now underway.

²⁰⁰ Rather, DOE refers to continued work on preparing the site and relevant licensing documents. U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 534.

2012—though there is some possibility for “early disposition” at a modest rate in the existing BN-600 fast reactor, using fabrication facilities that already exist or can be upgraded. Under the 2000 agreement, Russia and the United States were each to carry out disposition of two tons of plutonium a year—far more than can be done in the BN-600 alone—and then shift up to four tons of plutonium per year thereafter. Even if such rates could be achieved, completing disposition of just the 34 tons of excess weapons plutonium covered by the agreement—a small fraction of Russia’s total plutonium stockpile—would take until 2020-2030. Indeed, as Russia’s plutonium production reactors continue to produce plutonium, and Russia continues to separate weapons-usable civilian plutonium as well, if these are not stopped in a timely way, a two-ton-per-year disposition program would effectively be running in place—eliminating as much plutonium every year as is produced every year.²⁰¹ If production were stopped, but disposition of all 170 tons of Russia’s stockpile except the amount needed to sustain a stockpile of 10,000 warheads were included in the program, at four tons a year, completion of the plutonium disposition effort would stretch beyond 2040 (or beyond 2070 at two tons per year).

Improved Reducing Metrics for the Future

The U.S. government should develop an assessment of (a) the total world stock-

²⁰¹ The plutonium production reactors continue to produce in the range of 1.2 tons of plutonium per year, and Russia’s declarations of separated civilian plutonium have increased, on average, by 1.3 tons per year for the past several years. Thus, the total increase in separated plutonium stocks is in the range of 2.0–2.5 tons per year.

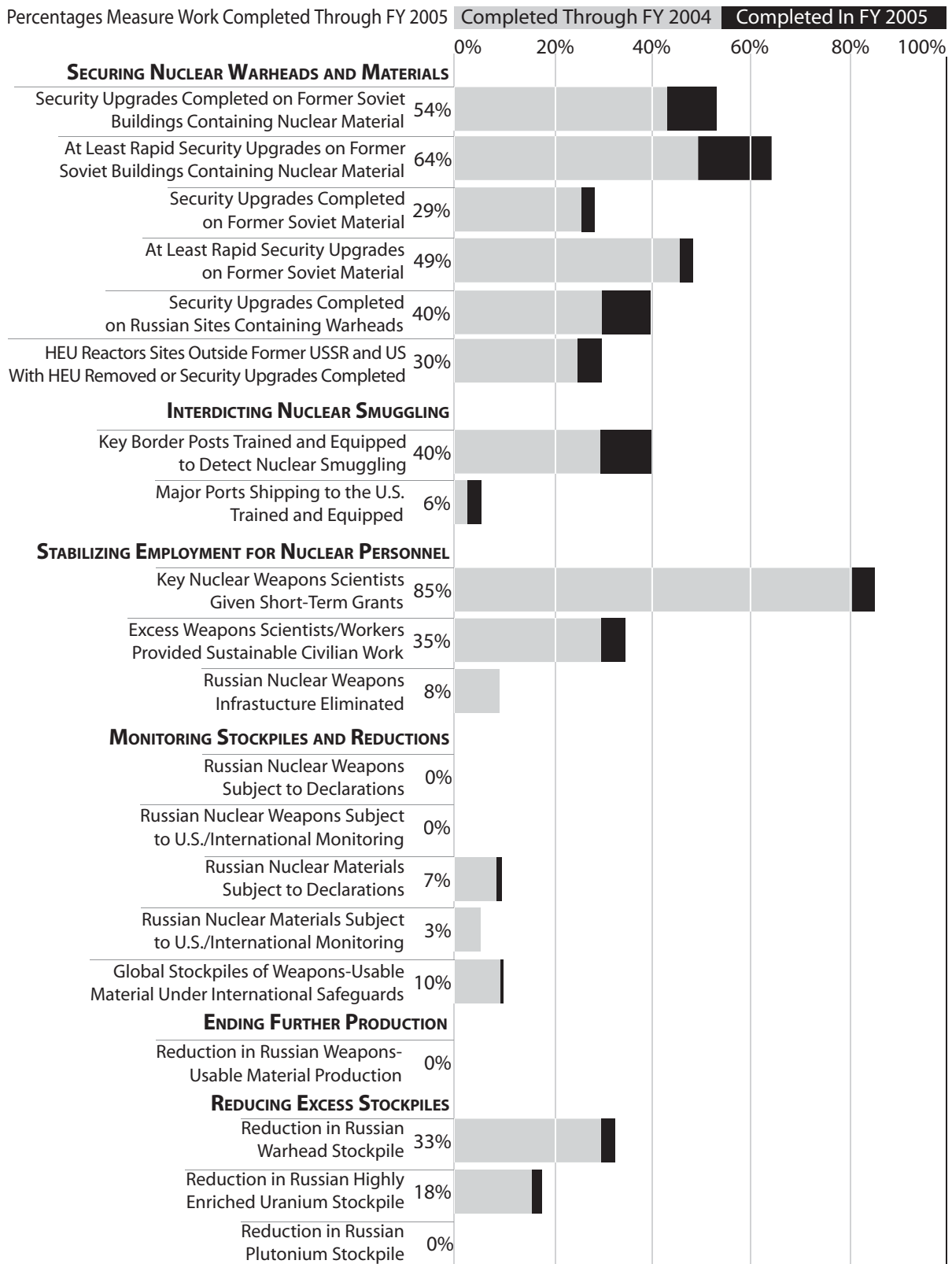
piles of nuclear weapons; (b) the total world military stockpiles of HEU and separated plutonium, and (c) the total world civilian stockpiles of HEU and separated plutonium. It should then track progress in reducing these total stockpiles.

SUMMARY: HOW MUCH OF THE JOB IS DONE?

Figure 3-8 summarizes what fraction of the job has been accomplished, when judged by the metrics described above for each of the six categories of effort. Also shown is the fraction of the job that was accomplished during FY 2005, to give an impression of the current rate of progress when judged by these metrics. There are substantial uncertainties in all of these estimates—even those based on official government data, since those data are themselves uncertain.

Overall, it is clear that while much has been accomplished in these efforts, across a broad range of metrics, an immense amount of work remains. Despite the dedicated efforts of hundreds of experts and officials from the United States, Russia, and other countries and organizations, there remains too much space on this chart—space that represents thousands of warheads that may be insufficiently secure, enough nuclear material for tens of thousands more for which security upgrades have not yet been installed, and thousands of excess nuclear weapons scientists and workers not yet permanently redirected to civilian work. If the world is to win the race to lock down nuclear stockpiles before terrorists and thieves can get to them, urgent steps remain needed to accelerate, expand, and strengthen these critical efforts.

Figure 3-8
Controlling Nuclear Warheads, Material, and Expertise:
How Much Work Have U.S.-Funded Programs Completed?



4 UPDATE OF THE BUDGET PICTURE

For fiscal year (FY) 2007, which will start October 1, 2006, the Bush administration has proposed an estimated budget of \$1,077.1 million for programs focused on controlling nuclear warheads, materials, and expertise around the world.¹

¹This is out of a total threat reduction request of \$1.353 billion (using a broad definition that includes programs beyond the boundaries of the former Soviet Union, but does not include spending on managing the United States' own stockpiles). The total request is discussed in detail below. These figures are recorded in Anthony Wier, "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, 2006; available at http://www.nti.org/e_research/cnwm/overview/funding.asp as of 15 March 2006). Users can use this database to compile custom charts on the cooperative threat reduction goals, agencies, and programs of their choice. For a discussion of which programs are counted in our totals, see Anthony Wier, "Funding Summary," 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, 2004; available at http://www.nti.org/e_research/cnwm/overview/funding.asp as of 15 March 2006). It should be noted that many programs related to controlling expertise or interdicting smuggling cover chemical, biological, and missile technologies as well as nuclear technologies, and hence, by including the full budgets for these programs, we inevitably overestimate somewhat the total budget that is specifically for controlling nuclear warheads, materials, and expertise. The figures are taken from the following budget documents: U.S. Department of Energy, *FY 2007 Congressional Budget Request: National Nuclear Security Administration—Defense Nuclear Nonproliferation*, vol. 1, DOE/CF-002 (Washington, D.C.: DOE, 2006; available at http://www.cfo.doe.gov/budget/07budget/Content/Volumes/Vol_1_NNSA.pdf as of 24 February 2006); U.S. Department of Defense, *Cooperative Threat Reduction Annual Report to Congress: Fiscal Year 2007* (Washington, D.C.: U.S. Department of Defense, 2006); U.S. Department of State, *FY 2007 Congressional Budget Justification for Foreign Operations* (Washington, D.C.: U.S. Department of

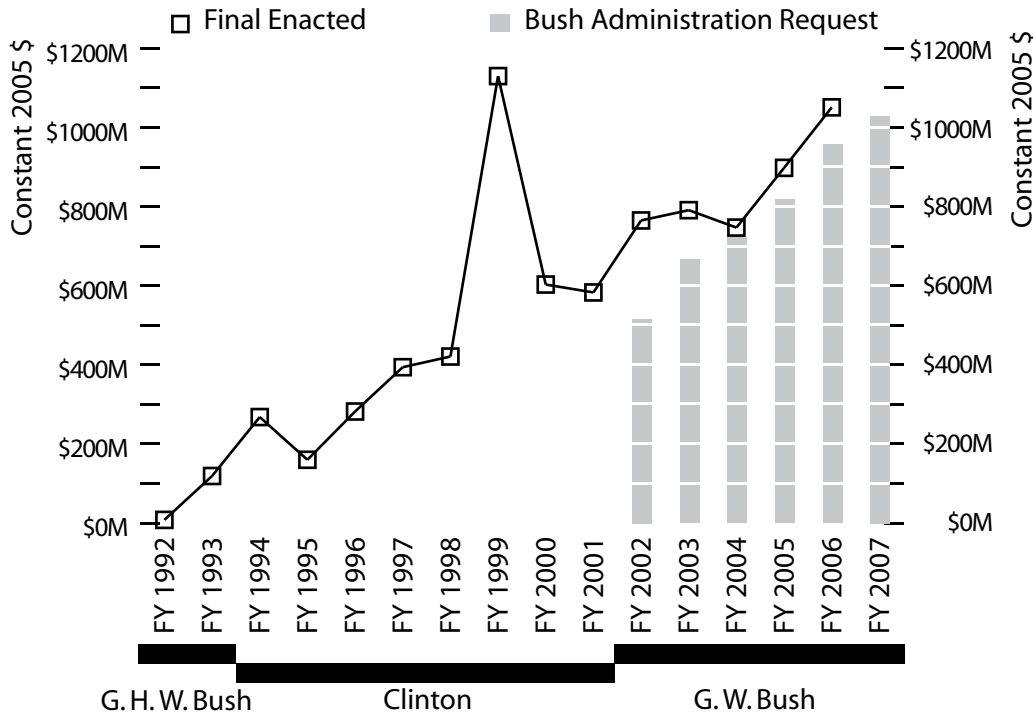
If approved, that resource level would be a slight decrease from the estimated \$1,078.2 million appropriated by the spring of 2006 for FY 2006.

Overall, U.S. government programs to control nuclear warheads, materials, and expertise around the world collectively have more budgetary resources to work with than ever before. While this is certainly good news, the total funding for these purposes still represents only one quarter of one percent of U.S. defense spending. Moreover, as will be described in this chapter, the budget appears to be inadequately prioritized, with very large sums allocated to some projects whose benefits will be real but modest, and opportunities for rapid progress in other areas going begging for lack of funds.

A wide variety of policy-makers and experts—with President Bush and Senator Kerry in the 2004 election and the 9/11 Commission at the top of the list—have said that preventing a terrorist attack with nuclear weapons must be the top national security priority of the United States. Lack of funding should not be allowed to slow progress in reducing this top-priority danger. Most programs to secure, monitor,

State, 2006; available at <http://www.state.gov/documents/organization/60647.pdf> as of 20 March 2006); U.S. Office of Management and Budget, *Fiscal Year 2007 Budget of the United States Government* (Washington, D.C.: OMB, 2006; available at <http://www.whitehouse.gov/omb/budget/fy2007/> as of 20 March 2006). For initial summaries of the FY 2007 proposals, also see: William Hoehn, "Preliminary Analysis of the U.S. Department of Energy's Fiscal Year 2007 Nonproliferation Budget Request" (Washington, D.C.: Russian American Nuclear Security Advisory Council, 2006; available at <http://www.ransac.org/> as of 20 March 2006).

Figure 4-1
Enacted U.S. Budgets for Controlling Nuclear Warheads, Material, and Expertise, with Bush Administration Requests for Comparison



Notes: Dollar figures are constant 2005 dollars, and therefore do not match amounts listed in the tables, which are all current year dollars. FY 1999 includes one-time funding of added by the FY 1999 Omnibus and Supplemental Appropriations Act to buy natural uranium to solidify the HEU Purchase Agreement, and a one-time appropriation to support Russian plutonium disposition.

Source: Authors' calculations, based on data in "Interactive Budget Database," Nuclear Threat Initiative Research Library: Controlling Nuclear Warheads and Materials, May 2006 (available at http://www.nti.org/e_research/cnwm/overview/funding.asp as of 17 May 2006).

and reduce nuclear stockpiles around the world are currently more cooperation-constrained than funding-constrained, more in need of high-level leadership to overcome the obstacles than of larger checks.

But if sustained leadership succeeds in opening new opportunities for cooperation to secure nuclear stockpiles, more funding will certainly be needed—and there are some programs where additional funding could have an immediate impact, expanding both the scope and pace of the work that could be carried out.

Congress has frequently acted to increase Bush administration requests for key threat reduction programs, as shown in Figure 4-1. Indeed, most of the growth in these programs since 9/11 has come from congressional add-ons.² This may be a difficult year, however, as Congress will have to act on these budgets in the context

²Matthew 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; available at http://www.nti.org/e_research/cnwm/overview/2004report.asp as of 1 February 2006), pp. 94-99.

of severe pressure to cut spending in the run-up to the 2006 elections.

This chapter examines some of the highlights of the current and most recent budget cycles, and then analyzes some of the key budget issues and needs facing these programs.

HIGHLIGHTS OF THE FY 2007 BUDGET PROPOSAL

As Table 4–1 shows, the proposed budget for programs focused on controlling nuclear warheads, materials, and expertise around the world, which we estimate at \$1,077.1 million, would drop new funding slightly below the amount provided in FY 2006, but if approved, this proposal would provide these programs approximately 20% more, in nominal terms, than they had in FY 2005.

For context, for FY 2007 the administration has proposed about a 6% cut from the previous year in new budget authority for all the discretionary programs that are not related to the Department of Defense (DOD), the Department of State and other international assistance efforts, or homeland security. The administration has requested a 6.9% increase over the previous year for the “core” DOD discretionary military budget—that is, the budget other than supplemental appropriations for on-going combat and reconstruction operations in Afghanistan and Iraq. For discretionary homeland security funding (both inside and outside the Department of Homeland Security), the administration has sought a 3.3% increase. For the State Department, the U.S. Agency for International Development, and other international assistance programs, the administration has asked for 12.2% more

funding than those programs received in FY 2006.³

Within the totals for controlling nuclear warheads, materials, and expertise, the proposal seeks significant changes for a number of programs:

- The Department of Energy (DOE) has proposed to reduce new funding for the “core” Material Protection, Control, and Accounting (MPC&A) program—that is, excluding the anti-smuggling Second Line of Defense program—from \$325.8 million to \$289.2 million, an 11% reduction. The reduction would be borne by programs working on the Rosatom Weapons Complex (down \$28.8 million, to \$56.5 million), Civilian Nuclear Sites (down \$25.6 million, to \$21.2 million, thus relying on prior-year balances to support work that now includes countries outside the former Soviet Union), and the Material Consolidation and Conversion program (down \$10.9 million, to \$16.8 million). Increased funding has been proposed for work on securing warhead storage sites managed by the Russian Navy Complex and by Russia’s Strategic Rocket Forces and 12th Main Directorate. For the National Programs and Sustainability line, DOE has requested a substantial increase over the previous year, from \$29.7 million to \$48.1 million, as DOE works to ensure that MPC&A upgrades provided in Russia and elsewhere will be sustained (though the FY 2007 level would still be well below the FY 2005 level of \$56.0 million for this work).
- The Global Threat Reduction Initiative (GTRI), which is working to “identify, secure, remove, and/or facilitate the

³ Authors’ calculations based on U.S. Office of Management and Budget, *FY 2007 President’s Budget*.

Table 4-1
Requested and Enacted U.S. Budgets for Controlling
Nuclear Warheads, Material, and Expertise

	(Current \$, in millions; numbers may not add due to rounding)	Final Enacted		
		Administration Request	Final Enacted	Change from Previous Year
		% Change from Previous Year		
		FY 2005	FY 2006	FY 2007
Total ¹		898	1,078	
Enacted, FY 1992-2006 (Constant 2005 \$, in millions)	8,218	817 +172 +24%	982 +181 +20%	1,077 -1 -0%
Securing Warheads and Materials ²	4,288	462 310 +139 +43%	542 453 +80 +17%	 522 -21 -4%
Stabilizing Employment for Nuclear Personnel	1,155	106 107 +5 +5%	107 105 +1 +1%	 99 -7 -7%
Reducing Excess Stockpiles	1,011	63 74 +7 +13%	34 64 -29 -46%	 0 -34 -100%
Interdicting Nuclear Smuggling	996	160 237 +32 +25%	191 194 +31 +19%	 217 +26 +14%
Ending Further Production	479	67 50 -15 -18%	174 132 +107 +159%	 207 +32 +18%
Monitoring Stockpiles and Reductions	290	39 39 +4 +10%	29 34 -9 -24%	 32 +3 +10%

¹ The Final Enacted figure for FY 2005 differs from that reflected in Table 4-1 of our 2005 report because of changes in past budget information reported by DOD and DOE.

² As of early May 2006, Congress and the administration were still deliberating on a FY 2006 supplemental appropriations bill, so no funding from that supplemental is reflected in this table. The administration requested up to \$44 million for Nuclear Warhead Storage Security in Russia, to accelerate security upgrades at warhead storage sites following the February 2005 Bratislava summit.

disposition of high-risk, vulnerable nuclear and radioactive materials around the world," would receive \$106.8 million for FY 2007, a \$9.8 million increase over the previous year. The Reduced Enrichment for Research and Test Reactors (RERTR) program and the Russian Research Reactor Fuel Return (RRRFR) effort would both receive important increases if Congress approved the requested FY 2007 budget; RERTR would go up to \$32.1 million, from \$24.7 million, while RRRFR would more than double its new funding, from \$14.7

million to \$30.0 million. The GTRI proposal also includes \$1 million for Global Research Reactor Security; funding for this effort is being shifted out of the International Nuclear Security program at DOE, to group efforts to remove material from vulnerable research reactors with work to secure research reactors where material remains. The \$1 million for FY 2007 would pay for security upgrades at only one facility.

- The administration has proposed reducing new funding for the Global

Initiatives for Proliferation Prevention program from \$39.6 million to \$28.1 million, a 28.9% reduction. This budget item funds both the Nuclear Cities Initiative (NCI) and the Initiatives for Proliferation Prevention (IPP). If approved, this amount would be the lowest amount of annual funding for these combined programs since FY 1996.

- In contrast with DOE's proposed cuts to its programs to redirect and re-employ weapons scientists, the State Department has proposed to increase new funding for its Nonproliferation of WMD Expertise program from \$52.1 million in FY 2006 to \$56.2 million in FY 2007. This program supports the International Science and Technology Centers in Moscow and Kyiv, as well as modest redirection efforts in Iraq and Libya.
- For the program to shut down three plutonium producing reactors in Seversk and Zheleznogorsk by replacing their heat and energy with coal-fired plants, DOE has requested \$206.6 million, an 18% increase over FY 2006 in funding.
- The Fissile Materials Disposition program has requested \$603.3 million, up from \$468.8 million in FY 2006 (which had been a cut from the FY 2005 level of \$619.1 million). All of that increase is for the program to dispose of surplus U.S. plutonium and highly enriched uranium; the administration has sought no new funding for the effort to dispose of Russia's excess plutonium, planning instead to spend \$34.7 million left over from the supplemental funding Senator Pete Domenici managed to get appropriated originally in FY 1999.
- The Second Line of Defense program, which installs radiation detection

equipment at border crossings and key shipping "Megaports," is seeking \$124.0 million, up from \$97.0 million in FY 2006. \$83.9 million of the new funding would support installation of radiation detection equipment at an additional 63 foreign sites, increasing the total non-Megaport sites with completed installations to 167. DOE believes it can complete installations at 3 Megaports with \$40.1 million in new funding, down from the \$73.2 million allocated for FY 2006.

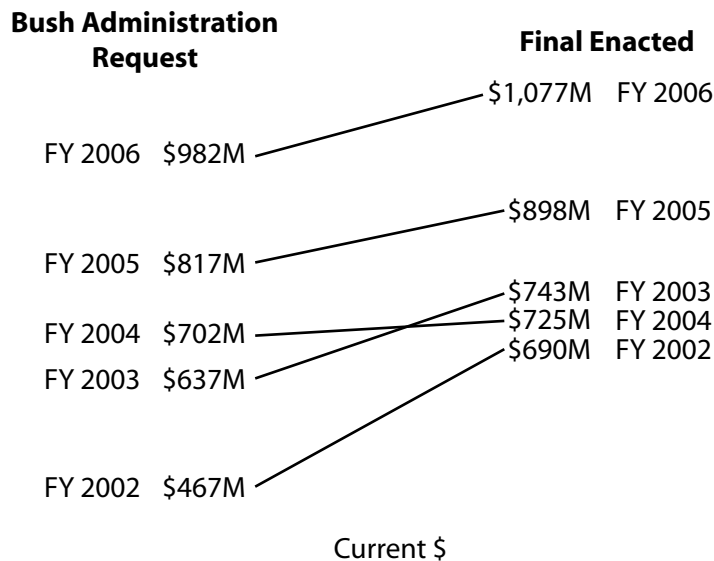
- Though smaller than the proposed increase for DOE's Second Line of Defense program, the Export Control and Related Border Security Assistance program at the State Department has requested a \$2.1 million increase in new funding, from \$43.0 million to \$45.0 million.

RECAP OF THE FY 2006 BUDGET CYCLE

The FY 2007 budget proposal came on the heels of a FY 2006 budget season in which Congress added significant funding beyond the administration's initial request for the MPC&A account, but reduced funding levels for other programs (see Figure 4-2 to compare this increase to those of previous years). All told, Congress provided a net increase of approximately \$96.0 million over the administration's original request of \$982.2 million.⁴

⁴This comparison of what was requested to what was appropriated in FY 2006 does not yet include the supplemental request of \$44.5 million for nuclear warhead storage security upgrades carried out by DOD that the Bush administration made in February 2006, because, at the time of this writing Congress had yet to complete consideration of that request. Adding more funds to the request but not to the appropriated total would distort the picture, making it appear as though Congress had rejected

Figure 4-2
Bush Administration Requests and Final Congressional Enacted Levels for
Controlling Nuclear Warheads, Material, and Expertise



Three programs accounted for almost all of the \$134.4 million gross increase over the FY 2006 administration request. The offsetting decrease was driven largely by a significant cut to one program, coupled with a 1% across-the-board rescission for FY 2006 that Congress used to offset supplemental funding to cope with the 2005 hurricanes and avian flu. Some of the most significant outcomes from the FY 2006 budget cycle included:⁵

- The final FY 2006 Energy and Water Appropriations bill, after accounting for the rescission, provided \$80.3 million more than the administration’s

\$245.5 million request for the “core” MPC&A program, for a FY 2006 total of \$325.8 million. The conferees provided this increase over the request, in the words of their report, to “accelerate the new opportunities to secure nuclear warhead storage sites resulting from the Bratislava Summit agreement.”⁶ The House and Senate negotiators reconciling their two bodies’ original versions of the bill put in over \$40 million more than either of their houses had originally deemed necessary, though each of those initial bills had been voted on well after Presidents Bush and Putin had met in Bratislava.

this supplemental request, which is unlikely. If Congress does appropriate the supplemental funding for FY 2006, both the total request figure and the total appropriated figure will increase, compared to those used here.

⁵ For a recap of the 2005 legislative session, see Anthony Wier, “Legislative Update,” 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; available at http://www.nti.org/e_research/cnwm/overview/legislative.asp as of 1 April 2006). The highlights that follow are derived from that analysis.

⁶ U.S. House of Representatives, *Making Appropriations for Energy and Water Development for the Fiscal Year Ending September 30, 2006, and for Other Purposes*, 109th Congress, 1st Session, House Report 109-275 (2005; available at <http://thomas.loc.gov/cgi-bin/bdquery/z?d109:h.r.2419>: as of 20 March 2006).

- For DOE's program to eliminate weapons-grade plutonium production in Russia, negotiators from the House and the Senate settled on an amount that, after accounting for the rescission, resulted in \$174.4 million in FY 2006 funding, a level about midway between the House's initial amount of \$197 million and the Senate's proposed level of \$152 million. The administration had originally only asked for \$132 million, \$44.6 million below the final appropriation. The FY 2006 budget for this effort is nearly three times greater than the \$67 million budget for FY 2005.
- DOD, following a congressionally approved procedure, reallocated \$10 million into its Nuclear Weapons Storage Security program in Russia, increasing the FY 2006 budget to \$84.1 million, instead of the \$74.1 million request.
- For the program to aid Russia in disposing of its excess weapons plutonium, both the House and Senate originally had endorsed the administration's requested amount of \$64 million, but the final Energy and Water Appropriations bill combined with the rescission resulted in only \$34.2 million in new money for FY 2006. House and Senate negotiators cut the request despite noting in their report that the dispute with Russia over liability for the project has been resolved and that work can move forward.
- Congress directed that the GTRI program set aside up to \$7 million in FY 2006 funds to support conversion of as many as four U.S. university research reactors from a highly enriched uranium (HEU) core to a low-enriched uranium (LEU) core.⁷ Congress also

required DOE use \$3 million from the funding provided for the Nonproliferation and International Security subaccount to provide grants to institutions of higher learning and non-profit organizations for research on nuclear nonproliferation and detection of chemical and biological weapons. No one grant may be larger than \$225,000.

ISSUES AND CONCERNS FOR BUDGETS GOING FORWARD

As Congress considers the administration's FY 2007 request, it will need to consider a number of issues for programs under each of our goals.

Securing Nuclear Warheads and Materials

Congress has added unrequested funding both of the last two fiscal years for the MPC&A program and for GTRI. For FY 2007, the administration is seeking to slightly reduce the FY 2006 budget for MPC&A, the most critical part of the mission to control nuclear weapons and materials.

Even though Congress has provided some extra funding and has made clear that GTRI enjoys broad authority to offer

sion: Purdue University, Oregon State University, the University of Wisconsin, and Washington State University. In April 2005, DOE had announced that reactors at the University of Florida and Texas A&M University would be converted; DOE projected that conversions would be completed by late 2006. For more information, see Matthew Bunn and Anthony Wier, "Removing Material from Vulnerable Sites," 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, 2004; available at http://www.nti.org/e_research/cnwm/securing/vulnerable.asp as of 2 February 2006).

⁷These are the four university reactors for which no funding had previously been dedicated for conver-

Table 4-2
Requested and Enacted U.S. Budgets for
Securing Nuclear Warheads and Materials

	Final Enacted		
	Administration Request		Change from Previous Year
	% Change from Previous Year		
(Current \$, in millions; numbers may not add due to rounding)	FY 2005	FY 2006	FY 2007
Total, Securing Nuclear Warheads and Materials ¹	310 462 +139 +43%	453 542 +80 +17%	522 522 -20 -0%
Material Protection, Control, & Accounting (DOE) ²	199 328 +116 +55%	246 326 -3 -1%	289 289 -37 -4%
Global Threat Reduction Initiative (DOE) ³ of which:	[85] [0] [85] N/A N/A	97 97 [+12] [+15%]	107 107 +10 +10%
<i>Reduced Enrichment for Research and Test Reactors (RERTR)</i> ³	10 19 +10 +112%	[25] [25] [+6] [+31%]	[32] [32] [+7] [+30%]
<i>Russian Research Reactor Fuel Return</i> ³	10 16 +6 +61%	[15] [15] [-1] [-6%]	[30] [30] [+15] [+104%]
<i>Foreign Research Reactor Spent Nuclear Fuel Acceptance</i> ³	5 5 -2 -26%	[9] [8] [+4] [+80%]	[6] [6] [-2] [-22%]
<i>BN-350 Fuel Security</i> ³	2 2 -6 -76%	[8] [8] [+6] [+303%]	[4] [4] [-4] [-51%]
<i>Emerging Threats and Gap Materials</i> ³	0 11 N/A N/A	[5] [5] [-6] [-55%]	[6] [6] [+1] [+14%]
<i>Global Research Reactor Security</i> ³	0 0 N/A N/A	[0] [0] N/A N/A	[1] [1] [+1] N/A
International Nuclear Security (DOE) ⁴	9 8 +1 +12%	6 6 -2 -31%	6 6 +0 +1%
Nuclear Weapons Storage Security - Russia (DOD) ¹	49 74 +26 +54%	74 84 +10 +14%	87 87 +3 +4%
Nuclear Weapons Transportation Security - Russia (DOD)	26 0 -23 -100%	30 30 +30 N/A	33 33 +3 +10%

¹ As of early May 2006, Congress was still deliberating on a FY 2006 supplemental appropriations bill, so no funding from that supplemental is reflected in this table. For FY 2006 the administration requested up to an additional \$44 million for Nuclear Warhead Storage Security in Russia to accelerate security upgrades at warhead storage sites.

² Excludes Second Line of Defense; International Radiological Threat Reduction moved from MPC&A to GTRI in FY 2006.

³ For FY 2005, programs making up GTRI are shown under their original program name. Starting in FY 2006, those programs were rolled into the GTRI budget line. Bracketed figures are for comparison, and do not add to total.

⁴ For FY 2007, DOE is proposing to move from International Nuclear Security to GTRI funding for security upgrades (but not security reviews) for those research reactors and related facilities outside the United States and former Soviet Union.

incentives to convince research reactor operators and their host countries to remove vulnerable HEU, a funding increase targeted at GTRI could give program officials greater freedom and greater motivation to explore incentives to convince facilities and states to give up nuclear material that could fuel a terrorist nuclear attack. There are often powerful incentives driving facility operators and their host states to want to retain their HEU; GTRI program officials trying to counteract those incentives should not be unduly limited by funding inadequacies.

Similarly, for material that cannot be removed from vulnerable sites, additional funding could enable DOE to provide security upgrades for more facilities, to defend against a greater threat. United Nations Security Council Resolution 1540, which was passed largely through the initiative of the Bush administration, creates a binding legal obligation on every country to put in place “appropriate effective” security and accounting for their nuclear and other weapons of mass destruction stockpiles.⁸ Additional funding in FY 2007 beyond DOE’s proposed \$6 million budget for the International Nuclear Security effort and \$1 million for the Global Research Reactor Security program under GTRI would make it possible both to improve security more rapidly at more sites, and to invest in more substantial upgrades that could defend against more sophisticated threats. More specific recommendations for GTRI funding are discussed in Chapter 5.

As the MPC&A program completes the installation of security upgrades at facilities in Russia, DOE expects costs to decrease for the overall program. Balanced against

⁸United Nations, “1540 Committee” (New York: UN, 2005; available at <http://disarmament2.un.org/Committee1540/index.html> as of 25 February 2006).

the costs of equipment installation will likely be broadened efforts to ensure security improvements are sustained by the Russians themselves. Though the FY 2007 proposal for sustainability is an increase over the previous year, it would still provide fewer resources than the effort received in FY 2005 (FY 2007 proposal: \$48.1 million; FY 2006 appropriated: \$29.7 million; FY 2005 appropriated: \$56.0 million). Additional resources may well be needed to fully support efforts to ensure the gains in security for Russian nuclear weapons and material are sustained into the future.

Future funding will also need to accommodate expanded MPC&A cooperation with countries outside the former Soviet Union. For FY 2005, Congress provided \$55 million in supplemental funding for MPC&A efforts outside of the former Soviet Union, but in FY 2007, DOE requested only \$21.2 million for the budget line that covers both the last work to be completed at Russian civilian nuclear sites and work in other countries. Additional funding will likely be needed to sustain any DOE push to expand and accelerate MPC&A cooperation beyond the former Soviet Union.

Interdicting Nuclear Smuggling

Budgets for this aspect of preventing nuclear terrorism—that is, programs working to improve other countries’ ability to identify and intercept trafficking in illicit nuclear material even after such material is removed from a facility—have grown dramatically since the 9/11 attacks. In real terms, the FY 2006 budget for programs serving this goal was nearly three times what it had been in FY 2001.⁹ Col-

⁹Author’s calculations, using figures from Wier, “Interactive Budget Database.” Inflation-adjusted figures were created using defense (DOD and DOE) and non-defense (State) deflators from Table 10.1, “Gross Domestic Product And Deflators Used in

Table 4-3
Requested and Enacted U.S. Budgets for
Interdicting Nuclear Smuggling

	Final Enacted		
	Administration Request		Change from Previous Year
	% Change from Previous Year		
(Current \$, in millions; numbers may not add due to rounding)	FY 2005	FY 2006	FY 2007
Total, Interdicting Nuclear Smuggling ¹	160 237 +39 +32%	191 194 +31 +19%	217 +26 +12%
Second Line of Defense (DOE) ²	75 149 +29 +62%	97 98 +22 +29%	124 +27 +28%
Export Control and Related Border Security Assistance (State)	36 38 +1 +2%	43 44 +6 +6%	45 45 +2 +5%
International Counterproliferation (DOD)	12 10 +2 +26%	11 11 -1 -11%	11 11 +0 +0%
WMD Proliferation Prevention (DOD)	37 40 +7 +25%	41 41 +4 +11%	37 37 -3 -8%

¹This total only includes programs to provide assistance to foreign countries; it does not include domestic nuclear and radiological detection efforts.

²DOE lists funding for the Second Line of Defense program (which includes the Megaports Initiative) under the Material Protection, Control, & Accounting budget line item.

lectively, from FY 2002 through FY 2006 these programs have had over three times more funding than they would have if the FY 2001 budget had been kept the same in real terms. The Second Line of Defense program at DOE went from a budget under \$2 million in FY 2001 to a proposed budget for FY 2007 of nearly \$124 million.

This growth trend is very likely to continue. DOE, DOD, and the State Department each continue to operate some type of border security assistance program, and there is a long list of concerns about countries' capacities to secure their borders against nuclear smuggling. With the Megaports Initiative within the

Second Line of Defense program, DOE continues to install radiation detection systems at major ports overseas. DOE hopes to install equipment at up to 35 ports overseas, but anticipates that the FY 2007 proposal will only allow the total number of ports completed to rise to 13.¹⁰ With heightened attention focused on port security following the controversy over the bid by a United Arab Emirates company to operate ports in the United States, a program to increase the chances of detecting nuclear cargo before a ship even departs for U.S. shores will likely continue to receive robust funding.

Furthermore, as with security for materials, UNSCR 1540 created a legal obligation

the Historical Tables: 1940–2011," in U.S. Office of Management and Budget, *FY 2007 President's Budget*.

¹⁰U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 519.

**Table 4-4
Requested and Enacted U.S. Budgets for
Stabilizing Employment for Nuclear Personnel**

	Final Enacted		
	Administration Request		Change from Previous Year
	% Change from Previous Year		
(Current \$, in millions; numbers may not add due to rounding)	FY 2005	FY 2006	FY 2007
Total, Stabilizing Employment for Nuclear Personnel	106 107 +5% +5	106 107 +1% +1	99 99 -7% -7
Nonproliferation of WMD Expertise (State)	50 51 -0% -0	52 53 +4% +2	56 56 +7% +4
Global Initiatives for Proliferation Prevention (DOE)	41 41 +2% +1	40 38 -3% -1	28 28 -29% -11
Civilian Research and Development Foundation (State) ¹	15 15 +36% +4	15 15 0% 0	15 15 0% 0

¹ Amount can only be estimated until further information is made available by the State Department.

for all 191 member states of the United Nations to put in place “appropriate effective” controls on the movement of WMD and related materials across their borders.¹¹ Most of these states will require assistance to put effective controls in place. A U.S.-led effort to help countries around the world truly meet the UNSCR 1540 mandate will likely require that these U.S.-sponsored programs have additional money and personnel with which to work.

Stabilizing Employment for Nuclear Personnel

The cumulative FY 2007 budget proposed for the programs in this category would be a drop from the previous year.¹² Over-

¹¹ United Nations, “1540 Committee.”

¹² None of the programs focus solely on redirecting former Soviet scientists and engineers with nuclear expertise (except for NCI), but their entire budgets are included here because of the difficulty of breaking out how much of each is spent on nuclear scientists and engineers versus other scientists and

all, the budgets for these programs have been largely stable in nominal terms over the last several years; because of inflation, real annual budgets in this area have been declining.

Nevertheless, these programs appear interested in taking on more work: the scientist redirection efforts at both the State Department and DOE state in the budget justifications that they intend to conduct operations in countries outside the former Soviet Union, such as Iraq and Libya. For FY 2007 the State Department’s Nonproliferation of WMD Expertise expects to go even further, seeking in FY 2007 to develop “a new targeted strategic engagement program for scientists, engineers and technicians with WMD-applicable expertise...in key regions where terrorists and proliferating states may be able to access this [weapons of mass de-

engineers with nuclear, biological, or chemical weapons knowledge.

struction (WMD)]-applicable expertise.¹³ Congress and the administration will have to carefully review proposals to broaden the scope of these programs to ensure that additional funding demands do not undermine support for on-going efforts to cope with un- or under-employed nuclear expertise in the former Soviet states.

For instance, as noted above, for FY 2007 DOE has requested a lower funding level for GIPP, which contains both IPP and NCI. If approved, the administration's proposal would reduce these combined programs' budgets to their lowest annual levels since FY 1996. This proposed reduction comes despite the fact that the White House Office of Management and Budget (OMB), using its Program Assessment Rating Tool, assigned GIPP its highest rating of "effective."¹⁴ The reduction came in part because the U.S.-Russian agreement governing NCI had expired, making it difficult to start new NCI projects; with the resolution of the U.S.-Russian liability dispute, however, DOE now has authority to negotiate a new NCI agreement.¹⁵ DOE appears to be betting that the program will be able to do the same with less money, as it expects annual performance in FY 2007 to match that of FY 2005, using the program's metric of "Cumulative number of the GIPP target population of displaced Russian and former Soviet WMD experts who are currently employed in GIPP grants or long-term private sector jobs."¹⁶

¹³ U.S. Department of State, *FY 2007 Congressional Budget Justification for Foreign Operations*, p. 140. DOE's intention are in U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 140.

¹⁴ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 495.

¹⁵ Interview with DOE official, April 2006.

¹⁶ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 497.

Presumably in part because of the stagnant or declining budget resources and the broadened ambitions, both the DOE and State Department programs are trying to elicit greater contributions from private partners in scientific redirection projects, and are increasing training and support so that scientists and their institutes can move away from U.S. support. For FY 2005 DOE reports that the cumulative non-U.S. government (that is, private and foreign government) contributions equaled 65% of the cumulative DOE funding for GIPP; DOE hopes to reach 75% by FY 2007.¹⁷ For FY 2005, the State Department's Nonproliferation of WMD Expertise program says that private sector funding for collaborative projects equaled approximately 9% as a percentage of the U.S. funding provided for such projects (this figure does not include the projects funded by other countries through the International Science and Technology Center in Moscow — where contributions from the European Union and Canada outweigh direct contributions from the State Department — and the Science and Technology Center of Ukraine).¹⁸

Monitoring Stockpiles and Reductions

By far the least funded of these goals, programs focused on transparency and monitors received largely stable budgets over the last several years. But for FY 2006 Congress went even farther than the Bush administration had proposed in reducing funding for the Warhead and Fissile Material Transparency program; the FY 2006 budget is \$10.2 million, as

¹⁷ U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 497.

¹⁸ U.S. Office of Management and Budget, *Program Assessment Rating Tool* (Washington, D.C.: OMB, 2006; available at <http://www.whitehouse.gov/omb/expectmore/> as of 27 March 2006).

Table 4-5
Requested and Enacted U.S. Budgets for
Monitoring Stockpiles and Reductions

	Final Enacted		
	Administration Request		Change from Previous Year
	% Change from Previous Year		
(Current \$, in millions; numbers may not add due to rounding)	FY 2005	FY 2006	FY 2007
Total, Monitoring Stockpiles and Reductions	39 39 +10%	34 29 -24%	32 32 +10%
HEU Transparency Implementation (DOE)	21 21 +16%	19 20 -7%	18 18 -9%
Warhead and Fissile Material Technology (DOE)	16 16 +4%	13 10 -38%	15 15 +45%
Trilateral Initiative (DOE) ¹	2 2 0%	0 0 -100%	0 0 N/A

¹ Funding for this activity was once embedded in a larger budget item, allowing us only to estimate funding levels. As the activity is largely dormant, for FY 2006 and beyond, we have stopped making any assumptions about the funding level until further information becomes publicly available.

opposed to \$16.4 million in FY 2005. In general, though, funding is not the greatest constraint for these efforts. As we have discussed in prior reports, the most critical issues blocking or delaying progress are almost entirely policy issues.¹⁹ Breakthroughs on these policy blockages would likely require additional funding to implement, however.

Ending Further Production

Budget estimates for the program to eliminate three weapon-grade plutonium production reactors in Russia have risen

since our previous report. For FY 2006, Congress provided \$174.4 million for the program, though the administration had requested \$132 million. The change was driven by the House Energy & Water Appropriations Subcommittee, which initially proposed FY 2006 funding of \$197 million, based on skepticism that a DOE proposal to solicit additional funding from other governments would succeed.²⁰ DOE's FY 2007 budget request is \$206.7 million (in February 2005, before the congressional increase, DOE had anticipated that the FY 2007 budget would be \$137.6 million).²¹ To round out the program, DOE now expects

¹⁹ 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/cnmw/overview/report.asp as of 1 February 2006), pp. 147-150.

²⁰ FY 2006 Energy and Water Appropriations Act House Report.

²¹ U.S. Department of Energy, *FY 2006 Congressional Budget Request: National Nuclear Security Administration—Defense Nuclear Nonproliferation*, vol. 1, DOE/ME-0046 (Washington, D.C.: DOE, 2005; available at http://www.cfo.doe.gov/budget/06budget/Content/Volumes/Vol_1_NNSA.pdf as of 27 February 2006), p. 505.

Table 4-6
Requested and Enacted U.S. Budgets for
Ending Further Production and Reducing Excess Stockpiles

	Final Enacted		
	Administration Request		Change from Previous Year
	% Change from Previous Year		
(Current \$, in millions; numbers may not add due to rounding)	FY 2005	FY 2006	FY 2007
Total, Ending Further Production	50 67 -15 -18%	132 174 +107 +159%	207 207 +32 +18%
Elimination of Weapons Grade Plutonium Production (DOE) ¹	50 67 -15 -18%	132 174 +107 +159%	207 207 +32 +18%
Total, Reducing Excess Stockpiles	74 63 +7 +13%	64 34 -29 -46%	0 0 -34 -100%
Russian Plutonium Disposition (DOE) ²	64 63 +8 +15%	64 34 -29 -46%	0 0 -34 -100%
HEU Reactor Fuel Purchase (DOE) ³	10 0 -1 -100%	0 0 0 N/A	0 0 0 N/A

¹ \$4.189 million in FY 2002 funds transferred to DOE from DOD expired, and were reappropriated to DOE in FY 2005 by National Defense Authorization Act of FY 2004.

² FY 2007 Administration Request excludes \$34.695 million in planned expenditures from carryover balances from FY 1999 Emergency Supplemental of \$200 million.

³ Updated to reflect lack of allocation specified in FY 2007 Congressional Budget Justification.

that it will request \$182.0 million for the effort in FY 2008, \$139.4 million in FY 2009, and \$24.9 million in FY 2010.²²

As noted in Chapter 3, this program has become very expensive, if judged on the basis of cost per ton of plutonium whose production will be avoided. Nevertheless, it has received support from both the administration and Congress, and there is little point in trying to save money this year by spreading the funding over a longer period: that would only increase total costs and allow plutonium production to continue longer. But the rapidly rising budgets for this effort should not

be allowed to cut into funding for even higher-priority programs in the struggle to prevent nuclear terrorism, such as MPC&A and GTRI.

Reducing Excess Stockpiles

In FY 2005 the program to dispose of Russia's excess weapons plutonium escaped a House effort to halve new funding, but as noted above, for FY 2006 Congress sliced nearly \$30 million from the \$64 million request. For FY 2007, the administration is planning to continue at the lower level voted by Congress in FY 2006, using funds appropriated in FY 1999. As of February 2006, DOE projected continuing at roughly that level in FY 2008 and FY 2009, and then returning

²² U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 523.

to the earlier budgets in the range of \$63 million per year in FY 2010 and FY 2011, presumably assuming that construction of facilities would be underway in Russia by then.²³ DOE and the State Department are also working to secure financing from other governments rather than having the United States pay entirely for this effort on its own (having secured \$844 million in commitments thus far, counting U.S. commitments, enough to fund facility construction, but not operation). As noted earlier, the dispute over liability protection for contractor work has been resolved; but as discussed in Chapter 2, the Russian plutonium disposition program faces many other issues that could still undermine the program's future and the prospects for gaining additional foreign contributions for it.

For HEU, as we discussed in earlier reports, sufficient funds are in place to carry out the current approaches to disposition of U.S. HEU, and the purchase of Russian HEU, which is financed primarily through commercial means rather than government expenditure. If the United States and Russia decided to pursue a large-scale acceleration of the HEU blend-down rate, significant additional funding would be required.

TOTAL THREAT REDUCTION FUNDING

With the FY 2006 allocation, total appropriations since 1992 for all cooperative threat reduction efforts, including chemical, biological, and other nonproliferation

²³U.S. Department of Energy, *FY 2007 Defense Nuclear Nonproliferation Budget Request*, p. 523.

cooperation, has eclipsed \$13 billion in constant 2005 dollars (using a broad definition of threat reduction funds that includes some funds spent outside the former Soviet Union that the administration does not count toward its G8 Global Partnership contribution).²⁴ Just under half of that sum has been appropriated to DOD, though DOE programs (predominantly focused on nuclear technologies, rather than chemical, biological, or missile technologies) have accounted for most of the recent growth. The overall threat reduction budget is slated to fall in FY 2007, largely because less new funding is required to pay for construction of a chemical weapons destruction facility at Shchuch'ye, Russia.

Beyond the accomplishments already discussed in this report, that \$13 billion investment has produced clear results: over 6,500 former Soviet warheads have been deactivated, nearly 1,200 intercontinental and submarine-launched ballistic missiles have been destroyed, and almost 30 ballistic missile-carrying strategic submarines have been demolished.²⁵ \$13 billion is not a small amount of money, but spread out over fifteen fiscal years it is dwarfed by other defense expenditures. Taken as a whole, this effort has directly reduced the nuclear, chemical, biological, and missile threat pointed at the United States, at a remarkably low cost.

²⁴Calculations on data contained in Wier, "Interactive Budget Database."

²⁵U.S. Defense Threat Reduction Agency, "Cooperative Threat Reduction: Scorecard" (Washington, D.C.: DTRA, 2006; available at <http://www.dtra.mil/toolbox/directorates/ctr/scorecard.cfm> as of 27 March 2006).

5 RECOMMENDATIONS

The danger of nuclear theft and terrorism is a global problem, requiring a global response. The presidents of the United States and Russia, along with the heads of state of other leading nuclear weapon and nuclear energy states, should join together in taking three actions:

- launching a global coalition to prevent nuclear terrorism;
- forging effective global nuclear security standards; and
- accelerating current efforts toward a global cleanout, in which weapons-usable material would be removed from the world's most vulnerable sites as rapidly as possible.

To make these three initiatives work will likely require five key changes in current approaches:

- new steps to build the sense of urgency about, and commitment to addressing, the threat of nuclear terrorism among political and nuclear leaders around the world;
- sustained leadership from the highest levels (including the appointment, in the United States and Russia, and possibly in other participating countries as well, of senior officials with direct access to the head of state when needed, with full-time responsibility for leading the myriad efforts directed toward preventing nuclear terrorism);
- truly partnership-based approaches, incorporating ideas and resources from

all cooperating partners, moving away from donor-recipient relationships;

- more flexible approaches to nuclear security cooperation that can allow important improvements to be made without in all cases requiring that U.S. personnel be able to travel to the most sensitive nuclear sites; and
- expanded efforts to ensure that high levels of nuclear security will be sustained for the long haul, and to build strong “security cultures,” in which all staff relevant to security give it the priority it deserves.

After describing each of these recommended initiatives and changes in approach, this chapter also outlines possible options for the U.S. Congress.

There is still much to be done in Russia, to complete the cooperative upgrades now under way, to ensure that security measures are put in place that are sufficient to meet the threats that exist in today's Russia, to forge a strong security culture, and to ensure that high levels of security for nuclear stockpiles will be sustained after international assistance phases out. But increasingly, the work with Russia should become a true partnership of near-equals, framed as one part of a global approach—and the United States should redouble its efforts to expand its programs to prevent nuclear terrorism across the globe.¹ The

¹ For an especially useful discussion of specific approaches to strengthening U.S.-Russian nuclear security cooperation through partnership-based approaches, written jointly by U.S. and Russian experts, see U.S. Committee on Strengthening U.S.

recommendations below, therefore, while applicable to the work in Russia, are global in nature.

INITIATIVE 1: A GLOBAL COALITION TO PREVENT NUCLEAR TERRORISM

President Bush should immediately begin working with Russia and other leading nuclear-weapon and nuclear-energy states to gain their agreement to participate in a global coalition to prevent nuclear terrorism. The participants in this coalition would agree to:

- Ensure that all stockpiles of nuclear weapons and weapons-usable materials under their control would be protected at least to a common security standard sufficient to defeat the threats terrorists and criminals have demonstrated they can pose. (Participants would be free to protect their stockpiles to higher standards if they perceived a higher threat in their country.) For example, the commitment could be to provide protection at least against two small groups of well-armed and well-trained outsiders, and one to two well-placed insiders, or both outsiders and insiders working together.

and Russian Cooperative Nuclear Nonproliferation, National Research Council, and Russian Committee on Strengthening U.S. and Russian Cooperative Nuclear Nonproliferation, Russian Academy of Sciences, *Strengthening U.S.-Russian Cooperation on Nuclear Nonproliferation* (Washington, D.C.: National Academy Press, 2005; available at <http://fermat.nap.edu/catalog/11302.html> as of 4 April 2006). See also Matthew Bunn, "Building a Genuine U.S.-Russian Partnership for Nuclear Security," in *Proceedings of the 46th Annual Meeting of the Institute for Nuclear Materials Management, Phoenix, Ariz., 10-14 July 2005* (Phoenix, Ariz.: INMM, 2005; available at http://bcsia.ksg.harvard.edu/BCSIA_content_stage/documents/inmmpartnership205.pdf as of 16 February 2006).

- Work with other states to convince them to join the commitment to this common standard, and provide assistance where necessary to help countries put this level of security in place.
- Develop and put in place transparency measures that will help build international confidence that the agreed security measures have in fact been taken, without providing public information that would be helpful to terrorists.
- Sustain security levels meeting the agreed standard indefinitely, using their own resources, after any international assistance they may be receiving comes to an end.
- Reduce the number of locations where nuclear weapons and weapons-usable nuclear materials are located, achieving higher security at lower cost.
- Put in place border and transshipment controls that would be as effective as practicable in interdicting nuclear smuggling, as required by United Nations Security Council Resolution 1540, and help other states around the world to do likewise.
- Drastically expand intelligence and law enforcement sharing related to indicators of nuclear theft risks, nuclear smuggling and criminal networks that might contribute to those risks, groups with ambitions to commit catastrophic terrorism, and other subjects related to preventing nuclear terrorism.
- Pass laws making actual or attempted theft of a nuclear weapon or weapons-usable nuclear material, unauthorized transfers of such items, or actual or attempted nuclear terrorism crimes comparable to treason or murder.

- Cooperate to strengthen nuclear emergency response capabilities—including nuclear materials search capabilities that could be deployed rapidly anywhere in the world in response to an unfolding crisis.
- Exchange best practices in security and accounting for nuclear warheads and materials—to the extent practicable—as is already done in the case of nuclear safety.
- Strengthen the ability of the International Atomic Energy Agency (IAEA) to contribute to preventing nuclear terrorism.
- Take such other actions as the parties agree are needed to reduce the risk of nuclear terrorism.

As discussed in Chapter 2, deliberate decisions by hostile states to provide nuclear bomb materials to terrorists are a smaller part of the danger of nuclear terrorism than nuclear theft, because regimes focused on their own survival know that any such act would risk overwhelming retaliation. Nevertheless, gaining international agreement on packages of carrots and sticks large and credible enough to convince Iran and North Korea that it is in their interests to verifiably abandon their nuclear weapons efforts would be a key contribution to reducing the danger of nuclear terrorism, and should also be a focus of the global coalition.

Such a coalition does not yet exist. To date, the Global Partnership Against the Spread of Weapons and Materials of Mass Destruction announced at the summit of the Group of Eight (G8) industrialized democracies in Kananaskis, Canada, in 2002 has nothing global about it except its name, and only a dribble of non-U.S. funds in the Global Partnership have so far been focused on improving nuclear

security measures. Instead, the Global Partnership is almost entirely focused within Russia (now with Ukraine as an added recipient), and the non-U.S. funds have primarily been devoted to chemical weapons destruction and submarine dismantlement (the two areas Russia's requests have focused on most intensely). The G8 summit in St. Petersburg in July 2006 will represent another opportunity to launch such a global coalition against nuclear terrorism; that opportunity should not be missed.

The coalition against nuclear terrorism that is urgently needed could be built around a fundamentally reenergized and refocused Global Partnership, or, if that proves impossible, it could be a new initiative—a complementary but separate effort, building on the experience of the Global Partnership. The United States should work with like-minded countries to return the Global Partnership to its original ambitions, which included a commitment to take the steps necessary to “prevent terrorists, or those that harbor them, from acquiring” the materials needed for weapons of mass destruction, specifically called on “all countries,” not just Russia, to join in providing effective security and accounting for their stockpiles of nuclear weapons and weapons-usable nuclear materials, and offered assistance to any country needing help to provide such effective security.²

Whatever approach is taken to building it, this global coalition should include the G8 members, along with China, India, Pakistan, and ideally Israel (which is believed to have a significant stockpile of nuclear weapons) and South Africa (which once

²“The G8 Global Partnership against the Spread of Weapons and Materials of Mass Destruction” (Kananaskis, Canada: Government of Canada, 2002; available at <http://www.g7.utoronto.ca/summit/2002kananaskis/arms.html> as of 27 June 2006).

had nuclear weapons, and still has one of the largest stockpiles of highly enriched uranium (HEU) among the developing non-nuclear-weapon states).³

Offering these states roles as co-leaders, with the world's leading nuclear states, of a global effort to improve all participants' security will be much more politically appealing than framing cooperation as a matter of assistance necessitated because they were unable to properly secure their own stockpiles. Between them, these countries have all of the world's nuclear weapons (except for the handful that may exist in North Korea) and more than 95% of the world's weapons-usable nuclear material. If they were all participating, it is likely that other states with smaller amounts of HEU or separated plutonium would sign up as well.

To be effective in accelerating and strengthening global efforts to reduce the risk of nuclear terrorism, the coalition would need a strong mechanism for ensuring that the initial commitments were followed through. The participants should each designate senior officials to be responsible for all aspects of implementing the global coalition commitments, and these senior officials should meet regularly to develop agreed plans with measurable milestones, to oversee progress in implementation, and to develop means to overcome obstacles. In particu-

³This is similar in some ways to the proposal to create a "Contact Group to Prevent Nuclear Terrorism," including many of the G8 states along with China, India, Pakistan, Israel, and other states with weapons-usable nuclear material that wish to join, designed to pursue securing the world's nuclear stockpiles at very high levels of each government. See George Perkovich et al., *Universal Compliance: A Strategy for Nuclear Security* (Washington, D.C.: Carnegie Endowment for International Peace, March 2005; available at <http://www.carnegieendowment.org/files/UC2.FINAL3.pdf> as of 21 March 2006), pp. 87-88.

lar, the coalition partners should agree on a target of putting in place security measures sufficient to meet the agreed minimum standard for all stockpiles of nuclear weapons and weapons-usable materials worldwide within six years or less. Since this would be an operational initiative going well beyond the G8, this group should be a standing organization. It should report to the leaders of the participating states on a regular basis, perhaps once every six months. Such a mechanism would help to avoid the fate of past summit initiatives, which have sometimes been announced with great fanfare and then went nowhere when the summit spotlight was gone.

Bilateral cooperation with Russia and with other countries should continue, but framed as part of this global coalition. As President Bush and President Putin acknowledged in their Bratislava statement, as the countries with by far the world's largest nuclear stockpiles, the United States and Russia bear a special responsibility for action. They should seek to take such effective action in securing their own stockpiles that they set a strong example for the rest of the global coalition participants. In addition, they should apply their experience to work together to help other countries around the world to secure their stockpiles. In particular, it is very important to get a presidential-level Russian commitment to provide the resources needed to sustain high levels of nuclear security in Russia after international assistance phases out—and to ensure that mechanisms are in place to follow up on implementation of that commitment. It is also important to work to forge strong security cultures, where all personnel take security seriously, and cutting corners on security is not widespread (see discussion below).

Adapting the threat-reduction approaches developed in cooperation with Russia and other former Soviet states to the specific circumstances of each other country where cooperation must go forward is likely to be an enormous challenge. Attempts to simply copy the approach now being used in Russia are almost certain to fail.⁴ Cooperation with states with small nuclear weapons arsenals, such as Pakistan, India, China, and Israel, is likely to be especially difficult. For all of these states, nuclear activities take place under a blanket of almost total secrecy, and direct access to many nuclear sites by U.S. personnel is likely to be impossible in the near term (an issue discussed in more detail below). In general, working out arrangements to improve nuclear security—and to build confidence that effective nuclear security really is in place—will require considerable creativity and persistence. (Providing security equipment and training in such cases in no way contravenes the United States' obligation under the Nonproliferation Treaty

⁴For discussion, see "Challenges of Adapting Threat Reduction to New Contexts," in 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; available at http://www.nti.org/e_research/cnwm/overview/2004report.asp as of 1 February 2006), pp. 104-105. See also James E. Goodby et al., *Cooperative Threat Reduction for a New Era* (Washington, D.C.: Center for Technology and National Security Policy, National Defense University, September 2004; available at <http://www.ndu.edu/ctnsp/CTR%20for%20a%20New%20Era.pdf> as of 21 March 2006); 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, May 2002; available at <http://www.ceip.org/files/pdf/wp27.pdf> as of 21 March 2006); Rose Gottemoeller and Rebecca Longworth, *Enhancing Nuclear Security in the Counter-Terrorism Struggle: India and Pakistan as a New Region for Cooperation* (Washington, D.C.: Carnegie Endowment for International Peace, August 2002; available at <http://www.ceip.org/files/pdf/wp29.pdf> as of 21 March 2006).

(NPT) not to assist non-nuclear-weapon states in acquiring nuclear weapons, and can be done in a way that is consistent with all U.S. export control laws as well.) In general, working out arrangements to improve nuclear security—and to build confidence that effective nuclear security really is in place—will require considerable creativity and persistence.

This coalition would be focused on taking concrete actions to reduce the risk of nuclear terrorism—and in particular, on ensuring that every nuclear weapon and every kilogram of nuclear material worldwide is secure and accounted for. The goal would be to accomplish that objective as quickly and effectively as possible. In many cases, this would mean countries taking action to improve security for their own stockpiles, perhaps with a modest amount of international advice and exchange of best practices. In others, U.S. or other international funding or expertise might be critical for getting the job done effectively and quickly.

Those participating states in a position to help fund the efforts of others should collectively make substantial pledges of funds for implementing the needed actions around the world. These pledges should be additional to, not substitutes for, the pledges already made to the Global Partnership. As discussed in Chapter 3, the number and magnitude of the upgrades needed around the world are not publicly known, and depend on how high the bar is set (that is, the security standard it is agreed upgraded security systems should reach). As a result, providing a reliable estimate of the total global cost is difficult. It seems very likely, however, that total *additional* funding substantially less than the \$20 billion pledged to the Global Partnership would be sufficient to drastically reduce the danger of nuclear terrorism. The participants

should commit to providing the resources necessary to ensure that lack of funding does not constrain the pace at which nuclear stockpiles around the world can be secured and consolidated. As the senior contact group developed more detailed plans, they should be tasked with estimating the costs of implementation, and coalition members should make pledges sufficient to implement them at the fastest practicable pace.

The coalition partners should act to give states and facilities strong incentives to provide effective security for their nuclear stockpiles.⁵ The United States should work with all states with nuclear stockpiles to ensure that effective and well-enforced nuclear security rules are put in place, giving all facilities with nuclear stockpiles strong incentives to ensure they are effectively secured—including the possibility of being fined or temporarily shut down if a facility does not follow the rules. It would also be desirable to work to convince these states to structure financial and other rewards for strong nuclear security performance (comparable, for example, to the bonus payments contractors managing U.S. Department of Energy (DOE) facilities can earn for high performance). The United States should also establish a preference in all U.S. contracts (not just those supporting DOE nonproliferation programs) for facilities that have positively demonstrated effective security performance in realistic tests, and should seek to convince other leading nuclear states to do the same. Ultimately, effective nuclear security should become a fundamental “price of admission” for doing business in the international nuclear market.

⁵Matthew 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).

INITIATIVE 2: EFFECTIVE GLOBAL NUCLEAR SECURITY STANDARDS

Facing terrorists with global reach, nuclear security is only as good as its weakest link: as former Senator Sam Nunn has said, insecure nuclear material anywhere is a threat to everyone, everywhere. Yet today, there are no binding global standards for how well nuclear weapons and materials should be secured, and the actual security in place ranges from excellent to appalling. Efforts to negotiate an effective global standard in a treaty have not succeeded in the past, and are not likely to succeed in the near-term future, as such negotiations inevitably become bogged down by country representatives who see little urgency for action and considerable potential for added costs and unwanted intrusion for the organizations they represent. The most plausible means to overcome such obstacles is for high-level leaders who see the need for a minimum global nuclear security standard, in the interests of all, to quickly put in place a broad political commitment to such a standard—such as the one included in the proposed global coalition against nuclear terrorism, described above.

One promising approach to following through on such a high-level political commitment is by fleshing out the specifics of what is required by United Nations Security Council Resolution 1540. UNSCR 1540, passed unanimously in April 2004, created a new binding legal obligation on every state to provide “appropriate effective” security and accounting for whatever nuclear stockpiles it may have. This provides a crucial opportunity for the United States to work with other countries and the IAEA to: detail the essential elements of an “appropriate effective” system for nuclear security; assess what improvements countries around the world need to make to put

these essential elements in place; and assist countries around the world in taking the needed actions. If broad agreement could be reached on what key elements a nuclear security and accounting system must include to meet the “appropriate effective” requirement, 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.

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 set of insider and outsider threats comparable to those terrorists and criminals have demonstrated in that country (or nearby). This approach has the following advantages: the logic is simple, easy to explain, and difficult to argue against; the standard is general and flexible enough to allow countries to pursue their own specific approaches, as long as they are effective enough to meet the threats; and at the same time, it is specific enough to be effective, and to provide the basis for questioning, assessment, and review.⁶

⁶Questions to explore 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

The United States should immediately begin discussions with other leading governments, as part of the effort to forge a global coalition to prevent nuclear terrorism, on a common minimum standard for nuclear security, strong enough to be

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? Others have proposed other standards to meet similar objectives: Graham T. Allison, for example, has proposed a “gold standard,” arguing that given the devastating potential consequences of nuclear theft, all nuclear stockpiles should be secured to levels similar to those used for large stores of gold such as Fort Knox. See Graham T. Allison, *Nuclear Terrorism: The Ultimate Preventable Catastrophe*, 1st ed. (New York: Times Books/Henry Holt, 2004). In 1994, a committee of the National Academy of Sciences argued that because getting the essential ingredients of nuclear weapons was the hardest part of making a nuclear bomb, plutonium should, to the extent practicable, be secured and accounted for to the same standards applied to nuclear weapons themselves—and argued further that this “stored weapon standard” should be applied to all separated plutonium and HEU worldwide (an approach that presupposes that nuclear weapons themselves have effective protection, which may not always be the case); U.S. National Academy of Sciences, Committee on International Security and Arms Control, *Management and Disposition of Excess Weapons Plutonium* (Washington, D.C.: National Academy Press, 1994; available at <http://books.nap.edu/html/plutonium/0309050421.pdf> as of 20 March 2006), pp. 31, 102. Other sources could also be drawn on for insight in defining what should be included in an “appropriate effective” physical protection system, including the “principles and objectives” in the proposed amendment to the physical protection convention (though these are very general and include few specifics), and the IAEA’s recommendations on physical protection (INFIRC/225 Rev. 4). Unfortunately, while both of these provide valuable considerations for physical protection, it is possible to comply fully with both of them and still not have a secure system.

effective but general enough to allow each state to follow the approaches it has found best achieve the security objective in its own context. The United States should also seek agreement that such a standard represents the minimum required for an “appropriate effective” system as required by UNSCR 1540. The United States and other nations agreeing to such a standard should then launch an intensive effort to persuade other states to bring their nuclear security arrangements up to that standard, and help them to do so as needed.

The United States should also make clear to all countries where nuclear stockpiles exist that with the passage of UNSCR 1540, providing effective security for these stockpiles is now a legal obligation, and a positive relationship with the United States depends on fulfilling that obligation. As it already does with respect to cooperation on drug interdiction and prevention of human trafficking, the United States should put in place mechanisms to regularly report on how cooperative different countries are being in the struggle to prevent nuclear terrorism. The United States should toughen the standards of security it demands from countries that receive U.S. nuclear exports (while avoiding abrupt shifts in this respect that would only lead countries to get their nuclear material and technology elsewhere), and should work with the other members of the Nuclear Suppliers Group (NSG) to toughen the NSG guidelines on physical protection.

Building Confidence in Nuclear Security

A particularly difficult problem is how to build confidence that nuclear security commitments have been implemented once they have been made. Such confidence is critical, as every country has a

direct national security interest in making sure that all countries with nuclear weapons and weapons-usable materials provide effective security for them. But in nearly every country with such stockpiles, the details of nuclear security arrangements are highly classified, making it difficult to reveal enough information to prove that the security measures in place are fully effective.⁷

For those countries willing to accept international peer reviews of their security arrangements, IAEA-led peer reviews can be effective in building confidence. Such peer reviews should increasingly become a normal part of the nuclear business for developed and developing states alike, just as international safety reviews are. But the reality is that some nuclear stockpiles—from those at U.S. and Russian nuclear warhead assembly plants to those in Pakistan and Israel—are extremely unlikely to be welcoming IAEA visitors anytime in the next decade. Graham Allison has proposed that nuclear weapon states invite experts from another nuclear weapon state 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.⁸

Another approach might focus on providing, at least in general terms, the results of tests of security system effectiveness. In the case of U.S.-Russian cooperation,

⁷ Even at sites in Russia where the United States has invested heavily in improving security, Russia does not inform the United States about operational details of day-to-day security measures important to the effectiveness of the overall system; and the United States has given Russia very little information about the day-to-day effectiveness of U.S. nuclear security systems.

⁸ Allison, *Nuclear Terrorism: The Ultimate Preventable Catastrophe*, pp. 150-153.

for example, to build understanding of what was being tested and how, U.S. and Russian adversary teams used to test the effectiveness of nuclear security systems against outsider and insider threats might train together, and perhaps conduct tests with joint U.S.-Russian teams at one or two 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. 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 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.

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 without helping terrorists and criminals plan their attacks.

Strengthening the Nuclear Security Role of the IAEA

The IAEA Office of Nuclear Security, established in its current form in the wake of the 9/11 attacks, can play a crucial role in helping to set standards and disseminate best practices for nuclear security, in providing training, in assessing countries' needs, and in coordinating nuclear security assistance to countries around the world. In many countries, assessment teams and assistance organized by the IAEA would be far more welcome than U.S. assessment and assistance. With UNSCR 1540, there are now scores of countries that may require assistance to meet the binding legal obligations to provide effective nuclear security that they now face. Yet the Office of Nuclear Security has so far labored with an extraordinarily small staff and a tiny budget (a total of \$35 million has been pledged to the IAEA's Nuclear Security Fund in the three and a half years since the 9/11 attacks, while the cost of substantially upgrading security at one site often exceeds \$10 million).

The United States should work with other leading governments to expand the mission, personnel, and resources of the Office of Nuclear Security, allowing the IAEA to substantially increase its contribution to preventing nuclear terrorism. Specifically, this office should be given the resources both to perform larger numbers of more in-depth nuclear vulnerability assessments and other evaluations of needs for prevention of nuclear terrorism and to finance itself some of the security upgrades identified in reviews, rather than relying entirely on donor states to provide needed upgrades. It should also be given the mission and resources to take a leading role in assessing states' needs and helping them to comply with the nuclear provisions of UNSCR 1540. This office

can also play a key role in identifying and promoting best practices in nuclear security, and organizing international best-practice discussions; it should be given the resources and mandate to do so. The budget of the Office of Nuclear Security should be increased to at least the range of \$30-\$50 million, and most of the office's budget should become part of the IAEA's regular assessed budget, rather than relying entirely on voluntary contributions.

An Industry Nuclear Security Initiative

In addition to governments, the nuclear industry itself has a major role to play in forging effective global nuclear security standards and exchanging best practices for achieving high levels of security. A new Chernobyl caused by a terrorist sabotage, or worse yet a city being destroyed by a terrorist nuclear bomb, would not only cause catastrophic damage and human suffering, it would also be a political disaster of epic proportions for the nuclear industry, spelling the end of any realistic prospect that nuclear energy could be expanded to deal with the challenge of climate change. Hence, just as in the case of safety, industry has a strong self-interest in ensuring that those facilities with the worst security performance are helped to reach the standards of the top performers. The nuclear industry should take the lead, launching a World Institute of Nuclear Security (WINS)—modeled in some respects on the World Association of Nuclear Operators (WANO), which has played a key role in improving nuclear safety around the world—which would develop standards, exchange and circulate best practices, perform industry peer reviews and other advisory services on request, and more. Just as has been the case with WANO's role in nuclear safety, such an industry-led effort could effectively

complement (rather than undermine) related ongoing work being done by the IAEA and by national governments. The Nuclear Threat Initiative (NTI) has challenged the Institute for Nuclear Materials Management (INMM) to play a central role in launching such an initiative.⁹ In response, a team of INMM experts developed a more detailed concept of how such an organization might function, and several stakeholders are now working to develop the concept in more detail.

To ensure that such an initiative has the necessary clout, it will be important to develop it in a way that maximizes industry buy-in, particularly from those controlling the purse-strings. What made WANO and its U.S.-based predecessor, the Institute of Nuclear Power Operations (INPO), so effective was that the industry perceived them as its own ideas, operating to serve the industry's own interest. These organizations also had direct access to the utility CEOs, who could bring powerful peer pressure to bear on any CEO whose utility was lagging behind.¹⁰

INITIATIVE 3: AN ACCELERATED GLOBAL CLEANOUT

The only foolproof way to ensure that nuclear material will not be stolen from a particular site is to remove it. What is needed now is a fast-paced effort to remove the weapons-usable nuclear

⁹ Charles Curtis, "Promoting Global Best Practices," in *Proceedings of the 46th Annual Meeting of the Institute for Nuclear Materials Management, Phoenix, Ariz., 10-14 July 2005* (Northbrook, Ill.: INMM, 2005; available at http://www.nti.org/c_press/speech_curtisINMM_071105.pdf as of 8 June 2006).

¹⁰ For a fascinating discussion of INPO, its record of effectiveness, and the factors that caused that outcome, see Joseph V. Rees, *Hostages of Each Other: The Transformation of Nuclear Safety since Three Mile Island* (Chicago: University of Chicago, 1996).

material entirely from the world's most vulnerable sites, particularly HEU-fueled research reactors, while upgrading security for those now-vulnerable sites where weapons-usable nuclear material will remain. The Global Threat Reduction Initiative (GTRI), launched in the spring of 2004, was established to accomplish that goal—but there is still much to be done to accelerate and strengthen that effort.¹¹ The goal should be to remove the nuclear material entirely from the world's most vulnerable sites within four years—substantially upgrading security wherever that cannot be accomplished—and to eliminate all HEU from civilian sites worldwide within roughly a decade.¹² The United States should make every effort to build international consensus that the civilian use of HEU is no longer acceptable, that all HEU should be removed from all civilian sites, and that all civilian commerce in HEU should be brought to an end as quickly as possible.¹³

¹¹ GTRI also addresses radiological materials that could be used in a so-called “dirty bomb,” both within the United States and internationally. That important topic is not the subject of this report, however.

¹² In saying that all the HEU should be removed from the world's most vulnerable sites within four years—a recommendation we have been making for several years—we are *not* suggesting that it is possible to convert every HEU-fueled research reactor within four years. Rather, the argument is that all HEU should be removed from those sites identified as having both (a) enough HEU for a nuclear bomb, and (b) inadequate security to meet the threats they face, within that time. In some cases, this may mean encouraging reactors that are no longer needed to shut down rather than converting; where neither conversion nor shut-down is realistically possible in a short time span, substantial security upgrades need to be put in place rapidly, sufficient to remove the site from the list of the world's most vulnerable facilities.

¹³ For a similar recommendation, see Charles Ferguson, *Preventing Catastrophic Nuclear Terrorism* (Washington, D.C.: Council on Foreign Relations, 2006; available at <http://www.cfr.org/content/publications/attachments/NucTerrCSR.pdf> as of 8 June 2006).

The global coalition should seek: to close and decommission HEU-fueled research reactors and other sites with HEU or separated plutonium that are no longer needed; to accelerate conversion of HEU or plutonium-fueled research reactors that will continue to operate, and for which replacement low-enriched uranium (LEU) fuel is available; to assure that fuels are developed as soon as possible to convert all or nearly all of the remaining still-needed research reactors; and to ensure that effective security is in place (meeting global standards such as those described above), and that both the on-site inventories of HEU and the enrichment of HEU are minimized, for those sites where all the HEU cannot be removed immediately.¹⁴

The goals just outlined are challenging, and achieving them would require a substantial effort, but the scale and urgency of the threat demands no less. Success in achieving them will require focusing comprehensively on *all* the facilities that have vulnerable potential nuclear bomb material, not just those that happen to be operating civilian research reactors, or whose nuclear material happens to be Russian-supplied or U.S. supplied. Success will require flexible and creative tactics, with approaches—including incentives to give up the nuclear material—targeted to the needs of each facility and host country. It will also require the United States to convert and adequately secure its own HEU-fueled research reactors, not only to remove such threats from inside U.S. borders but also enable U.S. leadership in convincing others to do the same.

¹⁴ A similar listing was first proposed in International Panel on Fissile Materials, *Global Fissile Material 2006: Report of the International Panel on Fissile Materials* (Princeton, N.J.: Program on Science and Global Security, Princeton University, 2006).

A Comprehensive Approach

GTRI was explicitly intended to take a comprehensive approach to the problem of insecure nuclear material around the world. GTRI has established an “emerging threats” sub-program which is intended to cover what GTRI refers to as “gap materials” — those materials that fell through the cracks in pre-existing programs. To its credit, the DOE has prepared and revised a list of the facilities around the world where weapons-usable nuclear materials exist, to provide the basis for a comprehensive approach, though DOE officials report that as further visits to particular sites are conducted, new facilities using HEU are still being identified.¹⁵

Chapter 3 described in detail some of the gaps that still need to be filled: tons of U.S.-origin HEU abroad not covered by the current U.S. take-back offer (representing some two-thirds of the U.S.-origin HEU that was still abroad when the take-back offer was renewed in 1996); many HEU-fueled reactors (in fact, nearly half of the reactors still using HEU fuel around the world) not yet slated for conversion or shut-down, particularly critical assemblies and pulse reactors, which often have huge quantities of weapons-usable material on-site; reactors for medical isotope production; HEU-fueled reactor types not yet covered by GTRI at all, such as ice-breaker and submarine reactors; and HEU that does not come from either the United States or Russia, and hence is not covered by either the U.S. or Russian fuel take-back efforts.¹⁶

¹⁵ Interviews with DOE officials, February, April, and December 2005.

¹⁶ See also Matthew Bunn and Anthony Wier, *Securing the Bomb 2005: The New Global Imperatives* (Cambridge, Mass., and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, 2005; available at http://www.nti.org/e_research/report_cnwmupdate2005.pdf as of 6 May 2006); Alexander Glaser and Frank N. von Hippel, “Global Cleanout: Reducing the Threat of HEU-Fueled Nuclear Terrorism,” *Arms Control Today* (January/February 2006; available at http://www.armscontrol.org/act/2006_01-02/JAN-FEB-heuFeature.asp as of 8 June 2006); Frank von Hippel, “A Comprehensive Approach to Elimination of Highly-Enriched Uranium from All Nuclear Reactor-Reactor Fuel Cycles,” *Science and Global Security* 12, no. 3 (November 2004).

Civil plutonium and the Global Nuclear Energy Partnership. In addition to these categories of HEU, the proliferation risks of separated plutonium must be addressed as well. Small quantities of separated plutonium associated with research activities around the world should be addressed by GTRI, removing material from vulnerable sites wherever possible, and ensuring that materials that remain are effectively secured. But plutonium is in civil use on a far larger scale than HEU; it is not just a matter of kilograms or tens of kilograms at research facilities, but tens of tons being separated, stored, processed, and used around the world as fuel for large power reactors. This material is weapons-usable, and it is essential that security and accounting commensurate with post-9/11 threats be maintained throughout all stages of that process.¹⁷

www.nti.org/e_research/report_cnwmupdate2005.pdf as of 6 May 2006); Alexander Glaser and Frank N. von Hippel, “Global Cleanout: Reducing the Threat of HEU-Fueled Nuclear Terrorism,” *Arms Control Today* (January/February 2006; available at http://www.armscontrol.org/act/2006_01-02/JAN-FEB-heuFeature.asp as of 8 June 2006); Frank von Hippel, “A Comprehensive Approach to Elimination of Highly-Enriched Uranium from All Nuclear Reactor-Reactor Fuel Cycles,” *Science and Global Security* 12, no. 3 (November 2004).

¹⁷ Any state or group that could make a bomb from weapon-grade plutonium could also make a bomb from reactor-grade plutonium. For an official discussion, 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; available at <http://www.osti.gov/bridge/servlets/purl/425259-CXr7Qn/webviewable/425259.pdf> as of 12 February 2006), pp. 35-39. For a brief discussion of the civilian plutonium problem, 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/overview/report.asp as of 1 February 2006), p. 128. For a disturbing recent analysis of security for transport of separated plutonium in France

The large investments in plutonium separation facilities that have already been made make it unlikely that proposals for an immediate moratorium on plutonium reprocessing will be adopted.¹⁸ But the Bush administration should renew the effort to negotiate a U.S.-Russian moratorium on separating weapons-usable plutonium (a 20-year moratorium was nearly agreed at the end of the Clinton administration, which would have ended the accumulation of over a ton of weapons-usable separated plutonium each year at Mayak). Over the long term, civilian use of separated plutonium should be phased out, in favor of fuel cycles that do not use weapons-usable separated plutonium.

In announcing its proposed Global Nuclear Energy Partnership (GNEP), which it hopes will ease nuclear waste management and thus contribute to the growth of nuclear energy, the Bush administration agreed that traditional reprocessing approaches that fully separate plutonium pose substantial proliferation risks.¹⁹ Un-

(authored by an engineer with long experience in physical protection at DOE, though commissioned by Greenpeace), see Ronald E. Timm, *Security Assessment Report for Plutonium Transport in France* (Paris: Greenpeace International, 2005; available at <http://greenpeace.datapps.com/stop-plutonium/en/TimmReportV5.pdf> as of 6 February 2006).

¹⁸ Perkovich et al., *Universal Compliance: A Strategy for Nuclear Security*.

¹⁹ Specifically, U.S. Secretary of Energy Samuel Bodman stated, "we all would agree that the stores of plutonium that have built up as a consequence of conventional reprocessing technologies pose a growing proliferation risk that requires vigilant attention." See Samuel Bodman, *Carnegie Endowment for International Peace Moscow Center: Remarks as Prepared for Secretary Bodman* (Moscow: U.S. Department of Energy, 2006; available at <http://energy.gov/news/3348.htm> as of 17 March 2006). Critics argue that the waste management approaches proposed in GNEP will undermine rather than promoting the future of nuclear energy, asserting that the future of nuclear energy will be brightest if it is made as cheap, simple, safe, proliferation-resistant, and terrorism-resistant as possible, and

fortunately, while the Bush administration argues that its proposed new approach, known as UREX+, would be proliferation-resistant, since plutonium would not be separated in pure form, but would remain mixed with some of the higher actinides and perhaps the lanthanide fission products as well, studies have suggested that this would offer only a very modest proliferation-resistance benefit.²⁰ And it seems very likely that a decision by the United States, with the largest number of nuclear power plants in the world, to move toward reprocessing will make it more difficult to convince states such as South Korea and Taiwan not to do likewise. (The administration argues that by building a commercial consortium that would offer guaranteed fresh fuel and spent fuel management to countries willing to forego enrichment and reprocessing facilities of their own, they will reduce, not increase, the incentives for countries to build their own reprocessing plants. This is a promising approach, but it does not require reprocessing in the United States, which seems much more likely to convince other states to consider reprocessing than to convince them not to do so.)

A Creative and Flexible Set of Tactics for Addressing the Problem

Rapidly convincing facilities and countries all over the world to stop using

that reprocessing using past technologies or those proposed in GNEP points in the wrong direction on every count. See, for example, testimony of Matthew Bunn in Committee on Science, Subcommittee on Energy, *Nuclear Fuel Reprocessing*, U.S. House of Representatives, 109th Congress, 1st Session (16 June 2005; available at <http://www.house.gov/science/hearings/energy05/june15/index.htm> as of 5 July 2006).

²⁰ Jungmin Kang and Frank Von Hippel, "Limited Proliferation-Resistance Benefits from Recycling Unseparated Transuranics and Lanthanides from Light-Water Reactor Spent Fuel," *Science and Global Security* 13, no. 3 (2005).

potential nuclear bomb material and allow the material they have to be removed will be an immense challenge. The task will require considerable tactical creativity, flexibility, and perseverance. Several additions to the set of policy tools currently being applied to the problem seem likely to be essential.

Packages of incentives targeted to the needs of each country or facility. Substantial incentives will be needed to convince the operators of research reactors to convert their facilities to LEU (or shut them down), and give up their HEU.²¹ The United States and its international partners should offer packages of incentives that make it unambiguously in the interest of the facility or the country that operates it to get rid of the HEU at vulnerable sites. Such packages could include help with converting to LEU; help with improvements that would make the reactor function even better after conversion than before; help with shutting and decommissioning a reactor; contracts for other research by the scientists at a site after agreement is reached to shut the site's reactor, including shared use of reactors at other sites; help with managing the wastes from a research reactor; and other steps, many of which will not even be thought of until a particular case arises.²² It appears that additional incentives are also likely to be needed to convince facilities to return even that portion of the U.S.-supplied

²¹ For a discussion of some of the incentives packages that worked in past cases of HEU removals, see Philipp C. Bleek, *Global Cleanout: An Emerging Approach to the Civil Nuclear Material Threat* (Cambridge, Mass.: Project on Managing the Atom, Harvard University, 2004; available at http://bcsia.ksg.harvard.edu/BCSIA_content/documents/bleek-globalcleanout.pdf as of 13 April 2006).

²² Where necessary, this should include help paying for the cost of new LEU fuel (especially in cases where a reactor otherwise would not buy new LEU fuel because it already has HEU that will last for many years, or for the lifetime of the reactor).

HEU abroad that is covered by the current U.S. take-back offer.²³

Putting together such packages of incentives will require some broadening of current thinking, and an expansion of current budgets (which do not include any funding for incentives going beyond paying the costs of conversion to LEU). Currently, for example, GTRI is willing to help research reactors convert to LEU, so that conversion does not represent a substantial new cost to the reactor operator—but it is generally not willing to make research reactors *better* off than they were before conversion, even if doing so would carry modest cost while being crucial to gaining agreement to convert. This policy should be reversed. GTRI program managers do not want to drive up the price that reactor operators demand for their cooperation, and that is a legitimate issue. But within reason, price should not be allowed to stand in the way of success. U.S. taxpayers would be better served by an \$800 million cleanout effort that succeeded in convincing all of the world's most vulnerable sites to give up their weapons-usable material than they would by a \$400 million effort that left dozens of vulnerable sites with HEU still in place.

Providing incentives for shutting HEU-fueled reactors, in addition to conversion. Most of the world's research reactors are aging and unneeded. The best answer for many of them is to provide incentives to shut them down. Unlike conversion, shut-down need not wait for the development of new fuels; it can be pursued immediately. For most of

²³ U.S. Congress, Government Accountability Office, *Nuclear Nonproliferation: DOE Needs to Consider Options to Accelerate the Return of Weapons-Usable Uranium from Other Countries to the United States and Russia*, GAO-05-57 (Washington, D.C.: GAO, 2004; available at <http://www.gao.gov/new.items/d0557.pdf> as of 2 February 2006).

the more than 130 HEU-fueled research reactors not currently on the target list for conversion, the shut-down option would be quicker, less costly, and more likely to succeed than conversion. There is good evidence that such an approach can work, as even in the absence of any effort to provide shut-down incentives, far more HEU-fueled reactors have shut down since 1978, when the effort to convert reactors to LEU began, than have successfully converted.²⁴ Indeed, IAEA experts have estimated that of the more than 270 research reactors still operating in the world (both HEU-fueled and otherwise), only 30-40 are likely to be needed in the long term.²⁵

No research reactor operator wants to shut his or her facility. Convincing sites to shut down their reactors is likely to require substantial packages of incentives. In some cases, the best route will be through national governments, which may be growing tired of the drain on the budget imposed by subsidizing these reactors, and may be more willing to negotiate over these reactors' fate than the operators themselves.

Helping reactors see the virtues in shutting down will take considerable care, as no approach perceived by the world's reactor operators as anti-science or anti-nuclear is likely to succeed. Indeed, it is quite possible that such an effort should be undertaken separately from the conversion effort, so that those pursuing conversion will not be "tainted" in the

minds of research reactor operators as people seeking to shut them down. As part of such an effort, the international community should help establish a smaller number of more broadly shared research reactors—the same direction that high-energy particle accelerators went long ago. Scientists at sites whose reactors are shutting down should be given funding and access to conduct experiments at other reactors (as is already routinely done in many countries). The best approach might be for the United States and other interested countries to work with the IAEA to launch an IAEA-led "Sound Nuclear Science Initiative," the goal of which would be to get the best science at the lowest cost by getting the research, testing, training, and isotope production the world needs from the minimum number of research reactors.

Security upgrades, in advance of material removals. Removing nuclear material from the world's most vulnerable sites should be done as quickly as possible, but it cannot happen overnight. Therefore efforts to remove nuclear material should go in parallel with programs to upgrade security at the sites where the material now resides. The international community should not be shy about investing to provide effective security at a site where the material will be removed in a few years; such an investment avoids leaving a weak link in nuclear security during the critical time before removal takes place. Through GTRI or whatever other rubric is most appropriate, the United States should assist countries around the world in strengthening security at small, vulnerable sites with weapons-usable nuclear material, and should work with states to put in place nuclear security rules requiring that every facility with significant quantities of weapons-usable material on hand have security measures sufficient to defeat plausible terrorist and criminal threats. (The cost of complying with such

²⁴ Iain Ritchie, "IAEA Presentation on Threat Reduction Activities," paper presented at The Global Threat Reduction Initiative International Partners' Conference, Vienna, Austria, 18-19 September 2004.

²⁵ International Atomic Energy Agency, "New Life for Research Reactors? Bright Future but Far Fewer Projected" (Vienna: IAEA, 2004; available at <http://www.iaea.org/NewsCenter/Features/ResearchReactors/reactors20040308.html> as of 22 March 2006).

regulations will provide a strong incentive to facilities to eliminate the nuclear material they have on hand.) In particular, those remaining research reactors that are still genuinely needed and cannot convert to available LEU fuels without a substantial degradation of their scientific performance should be effectively secured for now, and given incentives to convert when development of new, higher-density LEU fuels is completed—which is not likely to occur until early in the next decade.

High-level, high-priority diplomacy.

In the past, conversion of research reactors to LEU, and removal of HEU from vulnerable sites, have in most cases been handled by program managers and technical experts, not by cabinet or subcabinet national security officials. They have been treated, in essence, as “nice to do” nonproliferation initiatives, not as urgent national security priorities deserving of attention from the highest levels. In part as a result, discussions with many reactors around the world have dragged on for years, often with the hope that agreement to convert the reactor is just around the corner, but with the final deal never quite getting done. If the United States is now to succeed in drastically increasing the pace of HEU removals around the world, the issue will likely need to be on the agenda of senior officials, as one critical element of the global effort to keep nuclear bomb material out of terrorist hands and therefore a high priority for U.S. diplomacy.

Getting the United States’ Own House in Order

If the United States wants to convince other countries to convert their research reactors to use fuels that cannot be used in nuclear weapons, to put rules in place requiring high security for those facilities

where HEU is still present, and to ensure stringent security for all potential nuclear bomb material, whether in military or in civilian use, it needs to be willing to do the same itself. In particular, the United States should convert all U.S. HEU-fueled research reactors to LEU as soon as possible—a worthwhile move on its own, but also one likely to be an essential element of convincing foreign reactors to convert. The Nuclear Regulatory Commission (NRC) should require U.S. HEU-fueled research reactors to maintain effective security, phasing out the exemption from most NRC physical protection requirements for quantities of more than five kilograms of U-235 in HEU that research reactors now enjoy, while DOE should modify its definitions of which materials require high security, dropping the rules that put all HEU that is less than 50% enriched and all nuclear material that is less than 10% by weight fissile material (such as most research reactor fuel) in a lower-security category.²⁶ The U.S. government should substantially increase the radiation level considered self-protecting against theft (to take into account the new reality of suicidal terrorists).²⁷ Finally, NRC

²⁶ For the specifics of categorizing different types of material, current DOE orders still refer back to U.S. Department of Energy, *Guide to Implementation of DOE 5633.3b, “Control and Accountability of Nuclear Materials”* (Washington, D.C.: DOE, 1995).

²⁷ Currently, in both NRC regulations and IAEA guidelines, material is considered self-protecting if it emits more than 100 rad/hr at 1 meter. Calculations by one U.S. nuclear laboratory suggest that terrorists stealing nuclear material would receive a radiation dose roughly equal to the hourly radiation rate at one meter, divided by the number of terrorists who divided up the task. Thus if five terrorists stole the material, they might each get a dose of 20 rads. A dose of 400 rads will kill roughly half of those exposed, over the course of days or weeks after exposure—it takes substantially higher doses still to be acutely disabling. For discussion, see Edwin Lyman and Alan Kuperman, “A Re-Evaluation of Physical Protection Standards for Irradiated HEU Fuel,” in *The 24th International Meeting on Reduced Enrichment for Research and Test Reactors*,

should require that all domestic civilian use of separated plutonium, including in the form of mixed oxide (MOX) fuel, have security measures in place with a demonstrated ability to defend against the full design basis threat for nuclear theft (contrary to recent NRC rulings that held that sites with MOX fuel need have no more security than other power reactor sites).²⁸ If the United States is unwilling to phase out its own civilian use of HEU, and provide stringent security for all uses of HEU and separated plutonium, there is little likelihood that it will be able to convince others to do so.

APPROACH 1: STRENGTHENING THE SENSE OF URGENCY AND COMMITMENT

The three initiatives described above, if they succeeded, could drastically reduce the risk of nuclear terrorism. If they are to succeed, five underlying approaches will be essential.

The single most essential ingredient of success in ensuring security for nuclear stockpiles around the world is convincing political leaders and nuclear managers around the world that the threat of nuclear terrorism is real, and that improvements in nuclear security are critical to their own national security and deserving of their own resources. If the leaders of all the key states and nuclear facilities around the world were convinced of those two points, they would be likely to take

Bariloche, Argentina, 5 November 2002 (Argonne, Ill.: Argonne National Laboratory, 2002; available at <http://www.rertr.anl.gov/Web2002/index.html> as of 16 May 2006).

²⁸U.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; available at <http://www.nrc.gov/reading-rm/doc-collections/commission/orders/2004/2004-29cli.pdf> as of 29 March 2006).

the actions needed to keep these stockpiles out of terrorist hands. But if they are not convinced—as many of them are not today—there is little chance that they will assign sufficient resources, impose stringent security rules, take political risks to allow sensitive nuclear cooperation with foreigners, or take the other actions needed to achieve and sustain security levels sufficient to defend nuclear stockpiles against demonstrated terrorist and criminal threats. In maintaining a strong safety system, it is sometimes said that the most important element is “never forgetting to be afraid.”²⁹ The same is even more true for nuclear security.

But today, many of the key players are not afraid. They believe, with Pakistani President Musharraf, that the United States is “overly concerned” about the possibility of nuclear terrorism. Several key steps should be taken to try to build the sense of urgency and commitment among political leaders, nuclear managers, and all key personnel involved in nuclear security.

Joint Threat Briefings

A series of briefings for political leaders of particular countries participating in the global coalition (and their U.S. counterparts, for political symmetry), given jointly by nuclear experts from the United States and each of the countries where the briefings took place, could outline in detail the terrorist desire for nuclear weapons, their proven efforts to get nuclear weapons, and the very real possibility that terrorists could make at least a crude nuclear bomb if they got the needed nuclear materials. The briefings could also highlight the likely global economic and political effects if a terrorist bomb

²⁹James Reason, *Managing the Risks of Organizational Accidents* (Aldershot, UK: Ashgate Publishers, Ltd., 1997).

were to be detonated in a major city, along with the significant reductions in this risk that could be achieved through improved nuclear security measures and other steps.

Fast-Paced National Surveys of Nuclear Security Vulnerabilities

In the aftermath of the 9/11 attacks, DOE dispatched a team of security experts to urgently review security measures at all key DOE nuclear sites and make recommendations for improvement. A similar approach of sending out a trusted team for an urgent review had been undertaken several times in the past as well; one particularly extensive effort in the mid-1980s was code-named Operation Cerberus, after the mythological guardian of the gates of hell. These reviews have typically identified a wide range of vulnerabilities requiring correction.

President Bush should seek to convince the leaders of key states with nuclear stockpiles to pick teams of security experts they trust to conduct fast-paced assessments of potential vulnerabilities and to develop recommendations for fixing them at all sites with nuclear weapons or weapons-usable nuclear material in their countries. These reviews could ask whether the security measures in place are really good enough to defeat, for example, one to three well-placed insiders conspiring to steal nuclear material, or two teams of well-armed and well-trained outside attackers attempting to break in, who might have help from one or more insiders. In many countries, any thorough review would conclude that for some facilities, the answer is decidedly “no.” Such reviews could give these leaders an unvarnished, independent assessment, going around those with an incentive to tell them that everything is secure. No U.S. personnel need take part, so there need be no revelation to the

United States or other foreigners of any specific security vulnerabilities. But the United States should share, in general terms, the experiences it has had in performing such rapid initial assessments, it should provide training in vulnerability assessment and testing techniques, and it should offer to help cover the cost of any security upgrades the reviews recommend.

Realistic Security Performance Tests

A regular system of realistic testing of security performance, where “red teams” playing the roles of outside attackers or insider thieves attempt to overcome the system, can be a critical part of convincing non-expert political leaders that more resources are needed for security. Short of real thefts, nothing demonstrates more convincingly that there is a problem than spectacular failures of defense systems to protect nuclear items in realistic tests. Moreover, if done properly, such tests can help convince guards and other security personnel of the plausibility of the threat, provide important training, and help them find and fix problems that may not have been obvious in paper studies. Such performance testing has been a critical part of improved nuclear security over the past two decades in the United States.³⁰

The United States should work with key countries participating in the global coalition to convince them to institute regular realistic testing of nuclear security, briefing them on the U.S. experience, providing training in testing techniques, and offering to cover part of the cost of conducting such tests. In cases like Russia’s

³⁰ For a good account of part of this experience, see Oleg Bukharin, “Physical Protection Performance Testing: Assessing U.S. NRC Experience,” *Journal of Nuclear Materials Management* 28, no. 4 (Summer 2000).

where cooperation with U.S. experts is particularly extensive, the United States should seek to help establish joint security testing teams, which could train together, share their techniques, and perhaps carry out joint tests at a few non-sensitive facilities. For each country this would provide greatly increased understanding of the other side's approach to testing security. Having the two sides then exchange limited summaries of the results of tests done by purely national personnel would generate higher confidence that these tests had been performed realistically and that effective security was in fact in place.

Nuclear Terrorism Wargames

Wargames and similar exercises have been effective in getting policy-makers in a number of countries to understand at intellectual, emotional, experiential levels the urgent challenges they face. A wargame or series of wargames for Russia's national security policy-makers, focused on nuclear theft and terrorism (similar to an exercise recently conducted in Europe) could help convince participants that more needs to be done to secure nuclear stockpiles.³¹

Shared Threat Incident Databases

Most nuclear managers and staff—even those whose jobs are critical to security—do not receive regular information about terrorist attempts to acquire nuclear materials or nuclear weapons, or other security incidents from which lessons can and should be drawn about the kinds of threats nuclear facilities must be defended

³¹ The Center for Strategic and International Studies and the Nuclear Threat Initiative (NTI) organized the "Black Dawn" war game in Europe and recently completed a similar wargame in Moscow. These are very promising first steps; more such games should be conducted, for key officials and facility managers in countries around the world.

against. In 2003, for example, a Russian court case revealed that a Russian businessman had been offering \$750,000 for stolen weapon-grade plutonium for sale to a foreign client, and had made contact with residents of the closed nuclear city of Sarov in an attempt to get such material.³² While he did not succeed, the fact that a Russian was offering what was then roughly a century of the average nuclear worker's salary for such material is surely a relevant fact of which security managers should be aware. No Russian nuclear expert or security manager with whom we have discussed this case had ever heard of it before.³³ Similarly, most nuclear security managers around the world would probably be amazed to hear that there really has been a case in the past of more than a dozen heavily armed terrorists overpowering the armed guards at a nuclear facility and seizing complete control of the facility—a type of threat that is sometimes dismissed as unrealistic.³⁴

In organizational systems for safety (as opposed to security), keeping track of all such incidents and "near-misses" and the lessons learned from them has proved to be absolutely critical. It is a key part of

³² Matthew Bunn, "Anecdotes of Insecurity," 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, 2004; available at http://www.nti.org/e_research/cnwm/threat/anecdote.asp as of 6 June 2006).

³³ Interviews, May, July, and October 2005.

³⁴ This was at the Atucha Atomic Power Station in Argentina in 1973. The facility was under construction at the time, and had no nuclear material on-site. The terrorists departed as a response force arrived, after a brief shoot-out with the responders. Konrad Kellen, "Appendix: Nuclear-Related Terrorist Activities by Political Terrorists," in *Preventing Nuclear Terrorism: The Report and Papers of the International Task Force on Prevention of Nuclear Terrorism*, ed. Paul Leventhal and Yonah Alexander (Cambridge, Mass.: Lexington Books for the Nuclear Control Institute, 1987).

convincing staff of the need to take safety seriously. Indeed, extensive studies have concluded that “the two characteristics most likely to distinguish safe organizations from less safe ones are, firstly, top-level commitment and, secondly, the possession of an adequate safety information system.”³⁵ In the United States, the Institute for Nuclear Power Operations (INPO, the U.S. arm of WANO) distributes detailed analyses of all safety-related incidents to all plants, with accompanying “lessons learned” to avoid such problems in the future. It later inspects each plant’s program for reviewing these incidents and implementing the lessons learned.³⁶

Although security matters face the constraints of secrecy, in many cases a similar approach can and should be taken for nuclear security. The United States should work with its international partners to establish a shared database of verified information on important security-related incidents and related lessons for the future. Rules could then be put in place requiring facilities to review these incidents and implement the applicable lessons. The incidents included should go beyond the nuclear industry itself. Incidents that confirm the ways that terrorists and thieves have used tactics such as bribing or blackmailing insiders (for example by kidnapping their families), deception (such as fake uniforms and IDs), unusual vehicles, tunnels into secure vaults, attacks with substantial force and heavy armament, and the like would be important for nuclear security managers around the world to be aware of.³⁷ Many

³⁵ Reason, *Managing the Risks of Organizational Accidents*, p. 113.

³⁶ Rees, *Hostages of Each Other: The Transformation of Nuclear Safety since Three Mile Island*, pp. 128-150.

³⁷ For a discussion of a selection of incidents involving such tactics, see Bunn and Wier, *Securing the Bomb: An Agenda for Action*, pp. 14-15.

of these specifics of past incidents are not classified, and could be included in a database that was available to nuclear facilities around the world. Creating such a threat incident database and ensuring that it was regularly updated and widely used could do a great deal to increase security awareness and strengthen security culture. Such a threat incident database, like many of the other commitment-building steps suggested here, could potentially be implemented by an industry-led security initiative such as the proposed WINS.

A description of the 1992 theft of 1.5 kilograms of 90% enriched HEU from the Luch Production Association in Podolsk, Russia, for example, might note that the thief stole the material in small quantities at a time, to avoid detection by the crude accounting system in place at the time at the facility; that the facility had no portal monitors in place at the time to detect HEU being carried out the door; and that the thief was motivated by fear that the hyperinflation in Russia at the time would make him unable to provide for his family.³⁸ There are several lessons to be learned from just this one case. Facilities should first of all ensure that effective portal monitors were in place to detect any removal, and that there are no means of getting material out of a facility without going through a portal monitor (such as passing it out a window). To prevent thefts like this example, facilities should ensure that portal monitors provide their data not only to a guard by the portal monitor (who might be bribed or threatened to ignore a signal), but also to a remote location. Facilities should put in place accounting systems capable of detecting significant removals of nuclear

³⁸ For an interview with the thief describing the crime, see “Frontline: Loose Nukes: Interviews” (Public Broadcasting System, 1996; available at <http://www.pbs.org/wgbh/pages/frontline/shows/nukes/interviews/> as of 22 March 2006).

material, or at least measures to compensate if the accounting system was not sensitive enough to do that job in a timely way. Finally, facilities would be wise to monitor the financial status of employees with access to nuclear material, perhaps removing from access to nuclear material employees identified as financially desperate.

Threat-Focused Training

Ongoing training for nuclear security personnel should highlight the urgency of maintaining high security, ideally in graphic terms that get to the heart, as well as the head. As a related example, as part of the safety training program for all of those involved in building and maintaining U.S. nuclear submarines so that they will not leak, key personnel are required every year to listen to a several-minute audiotape of a submarine that failed, killing everyone aboard.³⁹ Presentations to policymakers and key nuclear security officials of images from Hiroshima and Chernobyl might similarly highlight, in an emotionally gripping way, the scale of the catastrophe that could occur if nuclear security measures failed and terrorists succeeded in detonating a nuclear bomb or sabotaging a major nuclear facility. The United States and Russia should work together, for example, to develop a training video for nuclear personnel highlighting terrorists' ongoing hunt for nuclear material for nuclear weapons and the possibility that particularly sophisticated terrorist groups might be capable of constructing at least a crude nuclear bomb.

³⁹ See testimony of Rear Admiral Paul E. Sullivan, Naval Sea Systems Command, in Committee on Science, *NASA's Organizational and Management Challenge*, U.S. House of Representatives (29 October 2003).

APPROACH 2: SUSTAINED HIGH-LEVEL LEADERSHIP

A second essential approach is sustained leadership from the highest levels of government, focused on overcoming obstacles and moving these programs forward as rapidly as possible. The job of keeping nuclear weapons and their essential ingredients out of terrorist hands requires broad international cooperation affecting some of the most sensitive secrets held by countries around the globe. A maze of political and bureaucratic obstacles must be overcome—quickly—if the world's most vulnerable nuclear stockpiles are to be secured before terrorists and thieves get to them.

The U.S.-Russian interagency nuclear security committee established by the Bratislava summit, co-chaired by Secretary of Energy Samuel Bodman and his Russian counterpart, Rosatom chief Sergei Kirienko, represents a major step in the right direction. This committee has succeeded in reaching agreement on a plan for completing upgrades at all but a few Russian nuclear weapon and weapons-usable material sites by the end of 2008, and a plan for returning most Soviet-origin HEU to Russia by the end of 2010. And with a requirement to report to President Bush and President Putin every six months, the group has provided a regular mechanism that could be used to bring key issues forward for presidential decision (though it does not appear to have been used for that purpose to date).

But the reality is that the necessary programs stretch across multiple branches of government—in the United States, in Russia, and in other essential participants in the global coalition described above. Many of the obstacles are not ones that a secretary of energy or a Rosatom chief can realistically overcome; for better or

for worse, neither of these agencies are at the center of decision-making on matters of security, diplomacy, or secrecy and counter-intelligence in their respective governments. Agencies such as these must inevitably take the lead on implementation, but they need sustained help from the centers of political power in overcoming the obstacles to implementation and seizing new opportunities as they arise.

To ensure that this work gets the priority it deserves, President Bush should appoint a senior full-time White House official, with the access needed to walk in and ask for presidential action when needed, to lead these efforts, and keep them on the front burner at the White House every day. That official would be responsible for finding and fixing the obstacles to progress in the scores of existing U.S. programs scattered across several cabinet departments of the U.S. government that are focused on pieces of the job of keeping nuclear weapons out of terrorist hands—and for setting priorities, eliminating overlaps, and seizing opportunities for synergy. Despite the creation of a Department of Homeland Security, President Bush rightly considered it essential to continue to have a senior official in the White House focused full-time on homeland security—to ensure that the issue continued to get the needed sustained White House attention, and to use the power of the White House to overcome the obstacles to progress and cut through the disputes between the many departments and agencies that continue to play essential roles. Much the same logic applies in this case.

As part of this sustained leadership from the top, nuclear security needs to be moved much closer to the front of the diplomatic agenda. Despite myriad statements about the priority of the issue, there

is little public indication that the subject of preventing nuclear terrorism—and in particular urgent steps to secure nuclear stockpiles around the world—has been a focus of any of President Bush's post-Bratislava meetings with foreign leaders, or of Secretary of State Condoleezza Rice's meetings with any of her counterparts. The subject was entirely absent from the U.S.-India nuclear deal, despite the fact that DOE experts had been attempting to engage India on nuclear security cooperation for years. No public discussion of Chinese leader Hu Jintao's April 2006 visit to Washington mentioned the subject, even though DOE has placed high priority on trying to extend nuclear security cooperation with China, but has not yet succeeded in getting Chinese agreement to expand beyond the civil sector. In the lead-up to the G8 summit in St. Petersburg in July 2006, there is a good deal of public discussion of nonproliferation, but none of securing nuclear stockpiles.

If an effective global coalition to prevent nuclear terrorism is to be forged, this has to change. The leaders of the critical states need to hear, at every opportunity, that action to ensure nuclear security is crucial to their own security and to a positive relationship with the United States. The United States can no longer afford to let the issue languish when obstacles are encountered, or to leave the discussion to specialists. The U.S. government should make nuclear security a central item on the diplomatic agenda with all of the most relevant states, an item to be addressed at every opportunity, at every level, until the job is done.⁴⁰

⁴⁰ The experience in Russia has been that cooperation has proceeded best when either (a) it was allowed to go forward "under the radar screen," with technical experts communicating directly with each other with relatively modest intervention from central governments, or (b) at the other extreme, when action was taken at the presidential level to push the cooperation forward and over-

Nuclear security and nuclear terrorism also have to be moved to the top of the intelligence agenda. Since 9/11, the level of U.S. intelligence focus on trying to figure out what terrorists might be doing related to weapons of mass destruction has increased substantially. But short of success in penetrating a cell working on weapons of mass destruction, it will always be very difficult to know what individual terrorist groups may be doing relating to weapons of mass destruction.⁴¹ Other kinds of information that is critical for policy-makers working this problem, and is quite easy to get, have not yet been given priority for collection and assessment (either by intelligence agencies or by policy and implementation agencies): how much are the workers paid, for example, at civilian research reactors with HEU? Is there corruption among them? What are the conditions for the guard forces (if any)? What kind of terrorist and criminal activity has there been in the areas where these facilities are located, and what might that suggest about the threats that security at these facilities should be designed to cope with? This kind of information could be critical in assessing risks and setting priorities. The U.S. government should

come obstacles. When the discussion was lodged at levels in between those extremes, officials who wanted to raise objections were able to do so, and officials who wanted to sweep aside these obstacles did not have the power to do so. Matthew Bunn, "Cooperation to Secure Nuclear Stockpiles: A Case of Constrained Innovation," *Innovations* 1, no. 1 (2006; available at http://bcsia.ksg.harvard.edu/BCSIA_content/documents/INNOV0101_CooperationtoSecureNuclearStockpiles.pdf as of 4 April 2006). In the case of countries such as Pakistan, India, and China, however, it appears likely that nuclear security cooperation will be so sensitive and so closely monitored by conservative government security agencies, that the "under the radar screen" approach may not be possible.

⁴¹ Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction, *Report to the President* (Washington, D.C.: WMD Commission, 2005; available at <http://www.wmd.gov/report/> as of 5 April 2006).

immediately develop and implement an interagency plan for collecting and analyzing the information most critical to assessing the risks of nuclear theft at sites throughout the world. In doing so, the U.S. government should be extraordinarily careful not to turn the experts attempting to build nuclear security partnerships with foreign colleagues into spies (or make them perceived to be spies), as that would destroy any hope of building the real partnerships that will be essential to success.

APPROACH 3: BUILDING GENUINE NUCLEAR SECURITY PARTNERSHIPS

Gaining both the in-depth cooperation required to improve security for all the vulnerable nuclear stockpiles around the world and the buy-in of national experts crucial to long-term sustainability will require approaches based on genuine partnership. Experts from the countries where these stockpiles are located will need to play key roles in working with foreign partners in the design, implementation, and evaluation of the entire effort.⁴² Indeed, data from a wide range of other types of international assistance efforts make clear that the success rate is far higher when assistance recipients are deeply involved in project design and implementation than when this is not the case.⁴³ Moreover, whatever transparency

⁴² For discussions of such partnership approaches to nuclear security in the Russian context, see Oleg Bukharin, Matthew Bunn, and Kenneth N. Luongo, *Renewing the Partnership: Recommendations for Accelerated Action to Secure Nuclear Material in the Former Soviet Union* (Washington, D.C.: Russian American Nuclear Security Advisory Council, 2000; available at http://bcsia.ksg.harvard.edu/BCSIA_content/documents/mpca2000.pdf as of 10 March 2006); Bunn, "Building a Genuine U.S.-Russian Partnership for Nuclear Security."

⁴³ See, for instance, World Bank, *Assessing Aid: What Works, What Doesn't, and Why* (Oxford, United Kingdom: Oxford University Press, 1998).

a country is willing to provide about the size and management of its nuclear stockpiles, that country's experts will inevitably know more about those stockpiles, the specific approaches used to secure them, their security, and the agencies charged with ensuring that security than American experts ever will.

For proud and secretive countries such as China, India, and Pakistan, nuclear security cooperation that is portrayed as an opportunity for them to join in a co-equal partnership with the leading nuclear states to address a global security problem will be far more appealing than being seen as needing foreign assistance because they are too poor or uninformed to adequately secure their own nuclear stockpiles. The specific tactics and sets of incentives needed to move cooperation forward will vary with national and cultural contexts. But in broad terms, approaches based on genuine partnership will work better than attempting to impose "made in America" nuclear security approaches.

How would a real, and not just rhetorical, shift from assistance to partnership actually be different? In the case of cooperation in Russia, both the United States and Russia would have to change some of their past approaches. Russia would have to assign more of its own resources to the effort, reversing the past habit, in many areas, of cutting Russian funding for activities the United States is willing to help pay for. It would also need to be willing to openly discuss key issues for the joint effort, such as how nuclear security arrangements are and will be funded, or how good security performance by managers, guards, and workers is and will be rewarded. The United States would have to be willing to bring Russian experts more fully into the process by which decisions are made on what security upgrades will be done.

Strategic plans, timetables, and milestones should be developed jointly by the country where the nuclear stockpiles in question exist and its foreign partners, using both the country's own funds and foreign funds. They should not be developed in Washington alone, without consulting with the agencies which actually control those stockpiles, as has sometimes been the practice in the past. Similarly, guidelines for the kinds of upgrades to be put in place and the standards of security needed should be discussed and agreed wherever possible. In the past, the United States has often decided what kinds of security measures to tell its teams to put in place in Russia without consulting Russian experts—keeping those experts from seeing those guidelines even as they were used as the basis to reject security upgrade projects that Russian experts proposed. Progress should be reviewed by experts from both sides working together, replacing the past U.S. practice of having U.S.-only evaluation teams assess progress of each project and recommend changes. Key personnel should lead the effort at particular sites for extended periods of time, so they can build the site-level relationships needed for a real partnership to grow.

A partnership approach does not necessarily mean putting U.S.-funded projects under management from the country where the nuclear stockpiles are located—an arrangement that might well slow projects down rather than speeding them up. A good example of how the kind of partnership recommended here works in practice can be found in the case of the work to improve security and accounting for the nuclear warheads and materials of the Russian Navy. In that case, a small, stable U.S. team has been leading the effort for years, building confidence with Russian counterparts over time. A Russian team at the Kurchatov Institute has taken the lead in overseeing

much of the work. With a daily on-the-ground presence in Moscow and Russian security clearances, the Kurchatov team has been able to overcome obstacles far more effectively than remote U.S. managers would have been able to do. Finally, a highly committed Russian Navy team has been willing to make the hard decisions needed to move forward and has provided Navy resources for sustaining the new security and accounting equipment once installed.⁴⁴

With the world's largest nuclear stockpiles, a growing cadre of specialists with experience in modern security and accounting techniques, and political relationships with a range of countries unlikely to be willing to cooperate with experts from the United States, Russia is in an excellent position to make a major contribution to a global coalition. As envisioned in the Bush-Putin Bratislava statement, U.S.-Russian nuclear security cooperation should extend beyond Russia's borders to improve nuclear security around the world. Even at U.S. facilities, as part of the ongoing discussion of "best practices," when Russian experts visit, the United States should actively solicit their suggestions for security improvements and should make a conscious effort to adopt in the United States any Russian equipment, software, or procedures that may be useful. Few steps could more quickly dispel the perception of Russia as a passive recipient of U.S. assistance than well-publicized U.S. adoption of an innovative piece of Russian equipment or a Russian procedure superior to U.S. approaches for improving security at U.S. nuclear facilities.

⁴⁴ For an account, see, for example, Morton Bremer Maerli, "U.S.-Russian Naval Security Upgrades: Lessons Learned and the Way Ahead," *Naval War College Review* 56, no. 4 (Autumn 2003; available at <http://www.nwc.navy.mil/press/Review/2003/Autumn/pdfs/art2-a03.pdf> as of 18 April 2006).

Such genuine partnerships cannot be built in a political vacuum. Today, while President Bush and President Putin have a good relationship, much of the Russian security establishment is deeply suspicious of cooperation with the United States—and much of the U.S. political establishment is becoming more and more suspicious of cooperation with a Russia seen as sliding back toward authoritarianism and seeking to dominate its neighbors.⁴⁵ Similarly, many in the U.S. and Chinese nuclear establishments are deeply suspicious of the other side, with each country seeing the other as bent on stealing nuclear secrets. Much the same is true of India and Pakistan—though the specifics of the suspicions vary in each case. A key focus of the top-level leadership needed to secure the world's nuclear stockpiles must be to find the means to overcome these suspicions and build the partnerships needed to move forward.

In many cases, a willingness to cooperate in other areas important to partner countries will be key to building an effective partnership. Though nuclear security was left out of the U.S.-India agreement, the U.S. willingness to lift nuclear sanctions on India undoubtedly increases the chances that nuclear security cooperation with India will finally move forward. The recent U.S. decision to invite Russia to join in the Generation IV International Forum, and to ask Russia to join in GNEP, is a step in the right direction—though the United States will have to be careful to ensure that this does not lead to these initiatives promoting fuel cycle strategies

⁴⁵ John Edwards and Jack Kemp, *Russia's Wrong Direction: What the United States Can and Should Do*, ed. Stephen Sestanovich, *Independent Task Force Report No. 57* (New York: Council on Foreign Relations, March 2006; available at http://www.cfr.org/content/publications/attachments/Russia_TaskForce.pdf as of 17 May 2006).

that increase rather than decreasing proliferation risks.⁴⁶

This step should be followed with immediate negotiation of a civil nuclear cooperation agreement, which would make it possible for Russia to import spent fuel over which the United States has veto rights (that is, fuel that came from the United States or was irradiated in reactors with key components from the United States). Establishing a functioning spent fuel import enterprise is potentially a central element of the effort, proposed by President Bush and now incorporated into GNEP, to create a consortium that would offer assured fuel supply and spent fuel management to countries willing to agree not to pursue enrichment and reprocessing of their own. The leverage created by U.S. veto rights over U.S.-obligated spent fuel around the world—representing more than three-quarters of the plausible market for Russian spent fuel imports—should be used to ensure that a portion of the revenue from such imports is set aside for sustaining effective security throughout the Russian nuclear establishment.⁴⁷ An explicit set-aside for security would serve as a type of insurance against the type of “security Chernobyl” discussed above that, were it to occur,

⁴⁶ “Russia Invited to Join 4th Generation Nuke Reactors Consortium,” *ITAR-TASS World Service*, 10 March 2006.

⁴⁷ Matthew Bunn et al., *Interim Storage of Spent Nuclear Fuel: A Safe, Flexible, and Cost-Effective near-Term Approach to Spent Fuel Management* (Cambridge, Mass.: Project on Managing the Atom, Harvard University, and Project on Sociotechnics of Nuclear Energy, Tokyo University, 2001; available at http://bcsia.ksg.harvard.edu/BCSIA_content/documents/spentfuel.pdf as of 18 May 2006), pp. 57-85. See also Thomas B. Cochran, “The Nonproliferation Trust Proposal: Managing Spent Fuel and Nuclear Waste in Russia,” paper presented at MIT Security Studies Program Technical Seminar, Cambridge, Mass., 31 October 2002 (available at http://docs.nrdc.org/nuclear/nuc_02103101a_220b.pdf as of 17 May 2006).

would dramatically chill the prospects for nuclear energy expansion that Russia is hoping to exploit.

A U.S.-Russian nuclear cooperation agreement would also enable broader U.S.-Russian cooperation in developing new reactor and fuel cycle technologies under the GNEP rubric. Such a step would help to counter the perception in the Russian nuclear industry that the United States is attempting to freeze Russia out of world markets and is not willing to engage in a genuine partnership.⁴⁸

Overcoming the suspicions and political tensions standing in the way of effective nuclear security partnerships with all the critical states will require a sustained diplomatic effort. Doing so is nonetheless an essential ingredient of success in reducing the threats of nuclear terrorism. As part of that effort, the United States should undertake a substantially increased public diplomacy effort to build support for cooperation to secure, consolidate, and eliminate nuclear stockpiles, in Russia and around the world. The United States should sponsor articles, workshops, briefings, and the like that emphasize such matters as how much has been accomplished that serves the security interests of Russia and the other states where this cooperation is taking place; how limited the access to sensitive sites the United States has requested really is, and how few nuclear secrets are actually revealed; how willing the United States has been to give parallel access at its own sites; how much of the equipment that is being installed is produced by local manufacturers, in systems designed and installed by local experts, not American ones; and how beneficial to the local public’s safety

⁴⁸ For a recent bipartisan recommendation to complete such an agreement, see Edwards and Kemp, *Russia’s Wrong Direction: What the United States Can and Should Do*.

and security this cooperation has been. Expanded efforts should be pursued to build support through engaging the legislatures, the press, non-government organizations, and the rest of civil society in the countries where such cooperation is taking place.

APPROACH 4: COOPERATING WITHOUT COMPROMISING NUCLEAR SECRETS

Disputes over access to sensitive sites and protection of nuclear secrets have delayed a wide range of cooperative nuclear security upgrade efforts, in Russia and elsewhere—sometimes for years at a time. To ensure that taxpayers' funds are spent appropriately, the United States has often demanded that U.S. personnel be allowed access to the sites where U.S. money was to be spent on security upgrades. But some sites in Russia have simply been too sensitive for Russia to allow foreigners to visit—and this is likely to be even more true in countries such as Pakistan, India, and China, where the very existence of some of the important sites (such as war-head storage sites) are closely guarded secrets.

The United States and other donor countries should take a flexible approach to these issues, working creatively to find ways to cooperate to improve nuclear security within the constraints of what partner states are willing to accept. In the end, it is more important to make progress in ensuring that nuclear stockpiles are secure than it is to keep track of every dollar of U.S. funds.

Approaches developed in the course of U.S.-Russian cooperation can be used in some cases. For example, in a number of cases, the U.S. government has taken the view that if it was only providing

equipment to be installed by the partner country at its own expense, U.S. personnel did not need to visit, or even know the location of, the places where the equipment was installed. For particularly sensitive sites, U.S. and Russian laboratory experts worked out approaches that can provide good assurance that U.S. funds are spent appropriately without access by U.S. personnel, such as photographs and videotapes of installed equipment, certification of installation by facility directors, and operational reports on the equipment's use. Another innovative approach that has been implemented in some cases is reliance on "trusted agents"—personnel who are citizens of the recipient country with security clearances from that country, who can visit relevant sites and certify that work has been done appropriately, but who are employed by a U.S. contractor.

There are a wide variety of other steps that can be taken cooperatively to improve nuclear security without compromising nuclear secrets. These include: training experts in vulnerability assessment, physical protection system design, material accounting, nuclear security regulation, and other areas of expertise critical to an effective nuclear security and accounting system; discussions of "best practices" and means to find and fix nuclear security vulnerabilities; and joint exercises and demonstrations of equipment and procedures, carried out at non-sensitive facilities.

APPROACH 5: ENSURING SUSTAINABILITY AND STRONG SECURITY CULTURES

The billions spent on nuclear security upgrades will not do the job if the security and accounting equipment is all broken

and unused five years after U.S. assistance comes to an end. Nor will modern security and accounting equipment provide high levels of security if security personnel do not take security procedures seriously, and do not use the equipment as intended. As U.S.-Russian cooperative security upgrade programs race toward a 2008 deadline for completing upgrades, the questions of how to ensure “sustainability” and strong “security cultures” are among the most difficult remaining policy challenges facing these efforts—not only in Russia, but everywhere where cooperation to improve nuclear security will proceed around the world. Sustaining for the long haul the enhancements to security made possible by one-time international investments in security systems will require countries to indigenously finance, manage, and maintain their own security systems. Therefore, working with partner countries to ensure that high levels of security will be sustained for the long haul and that all personnel give security the priority it deserves are absolutely essential if the risk of nuclear terrorism is going to be substantially reduced for an extended period.⁴⁹

⁴⁹ For a recent discussion of steps toward ensuring security for the long haul in Russia (which they called “indigenization” rather than “sustainability”) by a committee of the National Academy of Sciences, see Committee on Indigenization of Programs to Prevent Leakage of Plutonium and Highly Enriched Uranium from Russian Facilities, Office for Central Europe and Eurasia, National Research Council, *Strengthening Long-Term Nuclear Security: Protecting Weapon-Usable Material in Russia* (Washington, D.C.: National Academy Press, 2005; available at <http://fermat.nap.edu/catalog/11377.html> as of 4 April 2006). For an earlier discussion of sustainability in Russia and steps to achieve it, see Bukharin, Bunn, and Luongo, *Renewing the Partnership: Recommendations for Accelerated Action to Secure Nuclear Material in the Former Soviet Union*. For a good discussion of the security culture issue in Russia, 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; available at <http://www.uga.edu/cits/documents/pdf/Security>

These are genuine concerns. Achieving sustainability will require a much higher commitment to modern security and accounting measures, and far more resources for them, than has been forthcoming from the Russian government or Russian facility managers to date. Similar issues are certain to arise elsewhere as well. While many types of equipment are being installed in cooperative nuclear security programs, substantial portions of the equipment have expected lifetimes averaging around 5-15 years—meaning that some 10% of it might have to be replaced in an average year. In Russia alone, the average annual cost of these replacements—to say nothing of routine operations and maintenance, salaries and other costs for guards and other security and accounting personnel, and other security costs—is likely to come to over \$100 million per year (if one considers both the equipment for nuclear material sites and the equipment for nuclear warhead sites). The current sums allocated for nuclear security and accounting equipment by the Russian government and by individual facilities are not publicly known, but are clearly far below this figure. (As noted in Chapter 2, one leading Russian expert estimated in 2005 that spending on physical protection comes to only 30% of the need.) And resources are not the only issue: sustaining high levels of nuclear security requires a high level of commitment to doing so throughout a country’s nuclear infrastructure.

Similarly, while some sites appear to have stronger security cultures in place than others, there continue to be reports of guards patrolling with no ammunition in their guns,⁵⁰ staff propping open security doors

%20Culture%20Report%2020041118.pdf as of 18 February 2006).

⁵⁰ This practice, and many other issues that raise serious concerns about the effectiveness of the guard forces at Seversk (one of Russia’s largest plutonium

for convenience,⁵¹ and guards turning off intrusion detectors when they become annoyed by the false alarms.⁵² These events suggest that there is a good deal of work to do to achieve the level of commitment by all security-relevant staff needed for a truly effective nuclear security system.

DOE has recognized the challenge of ensuring sustainability and strong security cultures. With respect to sustainability, DOE is working to build up Russia's capability to sustain effective nuclear security. To provide the human capital needed to maintain an effective MPC&A system, it is providing extensive training programs. It is letting contracts to cover operations and maintenance costs for several years after new U.S.-funded equipment has been installed. DOE is also working to build up the infrastructure of firms and experts available for designing, building, installing, and maintaining nuclear security and accounting equipment in Russia. In addition to these efforts, DOE is helping Russia write and enforce effective nuclear security and accounting regulations, which, in principle, will still be forcing sites to take effective security measures long after U.S. assistance has come to an end. In one innovative and important

and HEU facilities) is described in 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; available at <http://www.pircenter.org/data/publications/yk4-2003.pdf> as of 28 February 2006). At the time of the article, Goloskokov was the security chief for the Siberian Chemical Combine, the nuclear facility at Seversk.

⁵¹ This is reported, with a photograph, in U.S. Congress, General Accounting Office, *Weapons of Mass Destruction: Additional Russian Cooperation Needed to Facilitate U.S. Efforts to Improve Security at Russian Sites*, GAO-03-482 (Washington, D.C.: GAO, 2003; available at <http://www.gao.gov/new.items/d03482.pdf> as of 4 March 2006).

⁵² A number of Russian experts have reported this kind of incident to U.S. colleagues.

move, DOE has negotiated contracts under which Russian facilities estimate their costs to maintain good nuclear security and accounting systems and lay out their plans for doing so.⁵³ Under the Bodman-Kirienko committee established at the Bratislava summit, DOE and Rosatom are now developing a joint sustainability plan, which explicitly includes the premise that U.S. resources devoted to nuclear security in Russia will decline year by year and will be replaced by increasing Russian resources. As of the spring of 2006, however, that plan was not yet complete and agreed.⁵⁴ DOD is also planning a program to help ensure that the security measures it is financing at Russian nuclear warhead sites will be sustained, but this effort appears to be much smaller in scope, and public information about it is limited.

To build security culture, DOE and its Russian partners have included a focus on security culture in training programs. At a few Russian sites, they have also put in place "culture coordinators" on a pilot basis; these culture coordinators are comparable in some ways to the security awareness coordinators at DOE sites. These security culture efforts are slowly expanding. In addition, DOE is sponsoring an "MPC&A Operations Monitoring" (MOM) project, in which security cameras are installed to monitor how personnel are doing their jobs at key locations, such as where staff are screened for nuclear material as they exit the building. These data provide site management (and potentially regulators) insights into the strengths and weaknesses of actual operations of the security systems. Awareness that they are being monitored gives personnel strong

⁵³ For a brief discussion of DOE's current sustainability work, see U.S. Department of Energy, *2006 Strategic Plan: Office of International Material Protection and Cooperation, National Nuclear Security Administration* (Washington, D.C.: DOE, 2006).

⁵⁴ Interview with DOE officials, April 2006.

incentives to implement security procedures correctly. In some cases, the United States can even receive data from this monitoring—edited to remove any sensitive information—that give U.S. program managers additional insights on how systems are being operated and sustained. The post-Bratislava workshops on security culture, and on “best practices” in nuclear security and accounting, raised the U.S.-Russian dialogue on these subjects to a higher level. But there is still a great deal more to be done.

Sustainability

Steps like those taken thus far to improve sustainability and the security culture are essential, but are not likely to be sufficient. To achieve sustainability, two sets of recommendations above are likely to be especially important. Genuinely partnership-based approaches are essential: only if the experts at the sites using this equipment see it as having been in significant part their idea are they likely to have the necessary commitment to using, maintaining, and replacing it over time. Steps to convince political leaders and facility managers of the reality and urgency of the threat are equally critical, for those managers are only likely to devote the resources and sustained attention needed to maintain high levels of security if they genuinely believe that the threat is severe enough to require such measures.

Several additional steps are likely to be needed to get partner states to put in place the *resources, organizations, and incentives* essential to sustaining nuclear security for the long haul.

Resources. As a follow-up to the successful Bratislava summit initiative on nuclear security, President Bush should seek an explicit commitment from President Putin that he will assign sufficient resources

from the Russian budget to ensure that security and accounting measures sufficient to defeat the threats that terrorists and thieves have demonstrated they can pose in Russia will be sustained after U.S. assistance phases out. Such a commitment should include some mechanism for following through, such as a specific line-item for nuclear security in the Russian state budget.

The possibility of creating a special fund for sustaining nuclear security should also be considered.⁵⁵ One possible mechanism would be for the United States and other partner countries to provide funding for sustainability projects that could only be used if matched by dedicated, transparent funds provided from the Russian state budget. At first an exact one-to-one match might not be necessary, but over time, the ratio of donor matching funds to indigenous Russian funding should shift to reflect the increasing ability of Russia to secure its own nuclear warheads and materials against the threats terrorists have demonstrated they can pose. Such a matching fund would require mechanisms to show that work paid for was actually being completed.

Another source of revenue could be generated if, as part of negotiating arrangements for Russian commercial import of foreign spent fuel subject to U.S.

⁵⁵ For a proposal for one particular approach to such a fund, see Committee on Indigenization of Programs to Prevent Leakage of Plutonium and Highly Enriched Uranium from Russian Facilities, *Strengthening Long-Term Nuclear Security*. For other approaches, see, for example, Matthew Bunn, John P. Holdren, and Anthony Wier, *Securing Nuclear Weapons and Materials: Seven Steps for Immediate Action* (Cambridge, Mass., and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, 2002; available at http://www.nti.org/e_research/securing_nuclear_weapons_and_materials_May2002.pdf as of 1 February 2006).

veto rights, the United States insisted that an agreed portion of the revenue be put into a fund to support nuclear security. This would be Russia's own money, not U.S. taxpayer funds, and thus could be spent at highly sensitive sites and on other purposes for which the United States is not willing to allocate funds (such as actually paying the salaries of guards at nuclear sites)—but an agreed arrangement should be worked out to provide enough transparency to offer some confidence that the funds are indeed being spent on nuclear security.

As sustainability is not only a Russia problem, similar funding approaches should be considered with other partner countries with large-scale nuclear programs. For countries with only one or two nuclear facilities requiring high levels of security, more limited approaches to ensuring resources for sustainability are more likely to suffice.

Organizations. It will be extremely difficult to sustain effective nuclear security unless the organizations responsible have the personnel, expertise, resources, and authority to do so. The United States should work with Russia and other partner countries to ensure that every organization responsible for facilities with nuclear weapons or weapons-usable nuclear materials has a dedicated organization charged with ensuring effective security and accounting for those stockpiles, and that every facility where these stockpiles are located has sufficient personnel, with sufficient resources and authority, dedicated to this mission.

The United States should put very high priority on working with partner countries to ensure that all nuclear regulatory bodies have the personnel, expertise, resources, and authority to write and enforce effective nuclear security and accounting rules.

In some cases, this will mean going beyond providing training or equipment to regulatory bodies, to working with political leaders of partner countries to convince them to give their nuclear regulatory bodies enhanced authority or budgets. In the case of Russia, it will mean not only working to strengthen Rostekhnadzor (the regulator for all civilian nuclear activities in Russia) and Rosatom's internal regulation, but also working with the Ministry of Defense (MOD) regulatory group that in principle regulates security for all MOD nuclear activities and for those Rosatom activities involving nuclear weapons and components. Given the prominent role of the NRC in regulating nuclear security and accounting in the United States, NRC should be given the authority and budget to play a significant role in working with partner countries to set and enforce effective nuclear security and accounting rules.

Incentives. Every dollar a facility manager invests in security is a dollar not spent on something that would bring in revenue or accomplish the facility's core mission. It is essential to create strong incentives for nuclear security to counteract this obvious incentive to cut corners. Most facility managers simply will not make substantial investments in improving and maintaining security and accounting measures unless they have to. In many cases, "they have to" means that otherwise an inspector is going to come and find out that they have not done so, and the result may be a fine, temporary closure, or something else they want to avoid. Hence, there could hardly be any subject more important to this entire agenda than effective nuclear security and accounting rules, effectively enforced. As noted above, a broad range of other steps can and should be taken to create and strengthen incentives for nuclear security.⁵⁶

⁵⁶ Bunn, "Incentives for Nuclear Security."

Consolidation. Finally, consolidating stockpiles of both nuclear warheads and weapons-usable nuclear materials into a much smaller number of sites (and a smaller number of buildings within those sites) is likely to be crucial to sustainability, because it will make it possible to achieve higher security at lower cost. While Russian warheads are stored in significantly fewer sites today than they were in Soviet times, and some buildings and sites have had their weapons-usable nuclear material removed, in general consolidation in Russia has lagged. The pace has been slow in part because neither Rosatom nor MOD appears to have been willing to focus on the difficult decisions of closing bases or sites or of forcing them to give up their weapons-usable nuclear material. Sustaining high security would be a far easier task with a much smaller number of sites to secure. The United States should increase the priority it devotes to consolidation, and raise the matter with Russia at higher political levels; it should also provide detailed briefings on its own consolidation efforts, and how much it expects to save from, for example, the closure of the Rocky Flats plutonium facility.

Security Culture

As with sustainability, the steps above to build genuine nuclear security partnerships and to convince political leaders and facility managers of the urgency of the threat are likely to be absolutely central to building effective security cultures. As already noted, the most fundamental element of an effective security culture is never forgetting to be afraid: the reality of the threat to be defended against needs to be inculcated constantly—in initial training, annual training, regular security exercises, and by any other means managers can think of. Convincing the top managers (and top security managers) of nuclear facilities is particularly important, for a strong security culture at a facil-

ity is only likely to get built if the facility management makes it a top mission to do so. Promoting an ongoing awareness of security incidents and trends around the world is also key, as only by being confronted with real data on ongoing incidents will people really be convinced about the scope and nature of the threats they need to defend against. Indeed, as noted above, tracking and forcing participants to confront such data on problems and near-misses, and the lessons drawn from them, has proven to be absolutely crucial to building effective *safety* cultures in industries throughout the world. As noted earlier, in the safety arena, management commitment and a good system for collecting and learning from such near-miss data are thought to be the two most important factors in achieving high levels of safety. Much the same is likely to be true for security.

OPTIONS FOR THE U.S. CONGRESS

The U.S. Congress has a crucial role to play in furthering global efforts to lock down nuclear stockpiles—making the priority of these efforts clear, exerting performance-based oversight, enabling and authorizing key steps while removing legal constraints, and mandating particular steps where necessary. Congress took the lead in initiating the Nunn-Lugar effort in the early 1990s, expanded the effort with the Nunn-Lugar-Domenici legislation in the late 1990s, and played a key role in encouraging and authorizing the establishment of GTRI in 2003-2004. The steps Congress should take can be grouped in several categories.

Authorizing and Removing Obstacles

First, Congress should act to remove obstacles it has created in the past. Congress has imposed a range of requirements

that the president certify that recipient countries are meeting particular standards before threat reduction funds can be spent. When President Bush declined to certify Russia's compliance with all of its arms control obligations, crucial threat reduction programs ground to a halt for months, until Congress passed waiver authority and President Bush issued a waiver. While Congress extended President Bush's waiver authority last year, the reality is that the continuing need to get presidential sign-off each year on a waiver of particular requirements, with a detailed justification provided to Congress, takes up a substantial amount of the time of senior officials working on the program, which could better be used overcoming various obstacles to implementing threat reduction programs around the world. Delays in making the required waiver can lead to months-long interruptions in work that is critical to U.S. and world security. The time has come to eliminate the certification requirements entirely, as Senator Richard Lugar (R-IN), chairman of the Senate Foreign Relations Committee and co-author of the original Nunn-Lugar legislation, has proposed.⁵⁷

Congress should also authorize the administration to expend threat reduction funds from DOE, DOD, and the State Department on a global effort to help states around the world put in place the effective controls on weapons of mass destruction

⁵⁷ For instance, see United States Senate, *Nunn-Lugar Cooperative Threat Reduction Act of 2005*, 109th Congress, S. 313 (2005; available at <http://thomas.loc.gov/cgi-bin/bdquery/z?d109:s.00313>; as of 22 March 2006). As submitted, Lugar's legislation would also authorize threat reduction funds to be spent anywhere in the world they are needed, without limit, and authorize such programs to be carried out "notwithstanding any other provision of law," making it possible, for example, to carry out threat reduction programs in states that are otherwise under sanctions, if necessary.

and related materials and technologies mandated by UNSCR 1540.⁵⁸

Finally, Congress should authorize the use of the Mayak Fissile Material Storage Facility to store any separated plutonium or HEU that could otherwise pose a threat to the United States, rather than limiting its use only to material that fits essentially arbitrary definitions of "weapons-grade."

Appropriating Budgets

Congress has been generally supportive of most threat reduction budgets. For large parts of these programs, money is not the limiting factor, and simply appropriating another \$100 million or \$1 billion would not have a dramatic effect on what could be done unless key bureaucratic and political obstacles to cooperation were resolved simultaneously.

But there are specific areas where targeted increases to the administration's budget request could make a real difference; Congress should consider offering such increased appropriations.⁵⁹ First,

⁵⁸ Senator Richard Lugar and Senator Barack Obama have co-sponsored a bill that would authorize the president to cooperate with countries worldwide specifically on improving capabilities to interdict weapons of mass destruction-related transfers, one key aspect of UNSCR 1540. See United States Senate, *Cooperative Proliferation Detection, Interdiction Assistance, and Conventional Threat Reduction Act of 2006*, 109th Congress, S. 2566 (2006; available at <http://thomas.loc.gov/cgi-bin/bdquery/z?d109:s.02566>; as of 6 June 2006).

⁵⁹ Because this report focuses only on nuclear weapons and materials, we do not discuss here the broader budget picture for cooperative threat reduction. A case can be made that additional funds are needed for chemical weapons dismantlement in Russia and related infrastructure and local support; for improved security for chemical and biological sites, and for sustaining high security levels over time; and for dismantlement of chemical weapons in Libya, among other purposes. As noted earlier, some of these purposes have been major areas of

a good case can be made for adding approximately \$50 million to the requested budget for GTRI, divided among several important activities. Additional funding could quicken the pace in addressing the substantial quantities of material and substantial numbers of HEU-fueled reactors not yet covered by GTRI sub-programs (currently approximately \$6 million is requested for the entire “Emerging Threats” line in GTRI that is intended to address such “gap materials”). Increased funding would make it possible to provide targeted packages of incentives to convince states and facilities to convert from HEU to LEU fuels, and allow their HEU stocks to be removed—an effort specifically endorsed by the House Armed Services Committee in the 2005 legislative session; such incentives would receive almost no funding under the requested budget. Additional funding could dramatically accelerate and broaden the program to upgrade security at civilian nuclear sites in non-nuclear weapons states with weapons-usable nuclear material (which would receive only \$1 million under the proposed budget, though GTRI hopes to get additional funds from other DOE programs). Finally, additional funding for GTRI would support maintaining an adequate pace for securing and consolidating overseas radiological sources (an area whose budget would be cut in the proposed request from \$25 million in FY 2005 to just over \$18 million in FY 2007).

Second, as noted above, it is important to provide adequate resources to the IAEA office devoted to prevention of nuclear and radiological terrorism. There are in fact many things the IAEA can do better than the U.S. government, including: overseeing the development of international standards for nuclear security; working with states that may be suspi-

investment by non-U.S. donors participating in the Global Partnership.

cious of U.S. intentions; managing the international database on nuclear and radiological trafficking, to which many countries report; providing international training courses and workshops; and coordinating international peer reviews of nuclear security. An additional \$5-10 million in the U.S. voluntary contribution in this fiscal year, coupled with an effort to convince other IAEA member states to increase their funding for this office and ultimately make its cost part of the IAEA’s assessed budget, would be money well spent. Such funds could come from the international assistance budget (where the bulk of the U.S. contribution to the IAEA resides) or from DOE’s budget (both the International Material Protection and Cooperation program and GTRI have contributed to the IAEA Office of Nuclear Security in the past).

Third, to help countries around the world put in place the controls mandated by UNSCR 1540, budgets for DOE, DOD, and State Department programs to interdict nuclear smuggling and DOE and State Department programs to help countries improve export controls should be significantly increased.⁶⁰ The reality is that today, there are 191 states that have a legal obligation to put in place effective export controls, border controls, and transshipment controls, but the United States and other donor countries still have assistance programs targeted on a few dozen countries.

Fourth, it appears that additional funding may be needed for programs to help

⁶⁰ Senator Richard Lugar and Senator Barack Obama have co-sponsored a bill which would have the effect of significantly increasing funds available for cooperation with states to improve their ability to interdict transfers of weapons of mass destruction and related technologies. See *Cooperative Proliferation Detection, Interdiction Assistance, and Conventional Threat Reduction Act of 2006*.

ensure that partner states can and will sustain effective nuclear security. This may be particularly true in the case of nuclear warheads, where DOD's planned budgets for site security appear to focus less on sustainability than DOE's out-year budget plans do. Congress should also consider whether sustainability measures for nuclear sites should be consolidated in one department, rather than having DOE and DOD each fund somewhat different approaches.

Fifth, to create an opportunity for substantially accelerating the destruction of dangerous HEU, Congress should consider making a conditional appropriation in the range of \$200-300 million to finance accelerated blend-down of HEU in Russia, should U.S. and Russian negotiators be able to reach agreement on such an accelerated blend-down.⁶¹

Sixth, there are opportunities to make some additional progress in ensuring sustainable re-employment for Russian nuclear weapons experts with some additional funding beyond the budget request. The request was drafted at a time when the government-to-government agreement on the Nuclear Cities Initiative (NCI) had long since expired. But with the liability language issue resolved, DOE has now received authority to negotiate a new agreement, and expects to be able to do so rapidly, paving the way for addi-

tional projects in the closed nuclear cities if there were additional funding to pay for them. Similarly, the Russian institutes and U.S. firms participating in the Initiatives for Proliferation Prevention (IPP) program are developing new proposals, which would require additional funds. Adding approximately \$10 million to the requested budget for the Global Initiatives for Proliferation Prevention (GIPP, incorporating both NCI and IPP) would bring the budget back in line with previous budgets, and make it possible to seize some of these opportunities.

Mandating and Directing New Actions

Congress can also launch new programs or require the administration to take particular actions. Having been initiated by congressional action in 1991, the entire Nunn-Lugar cooperative threat reduction effort is a perfect example. Congress could consider passage of broad legislation mandating fast-paced efforts to secure nuclear stockpiles and interdict nuclear smuggling worldwide, including removing potential nuclear bomb material from as many sites as possible. Such legislation might also provide important direction and authorities for such efforts, and require the president to take a number of specified actions to accelerate and strengthen efforts to lock down all the world's nuclear stockpiles. These could include requirements that the president:

- Seek to establish a global coalition to prevent nuclear terrorism, with the goals described above;
- Appoint a deputy national security advisor with full-time responsibility for measures to prevent nuclear terrorism;
- Develop and implement a comprehensive, prioritized plan for

⁶¹ For discussion of this approach, see Bunn, Wier, and Holdren, *Controlling Nuclear Warheads and Materials: A Report Card and Action Plan*, pp. 154-156. While Russia did not agree to any large-scale accelerated blend-down in the official discussions that followed the May 2002 Bush-Putin summit statement on accelerated disposition, at the same time Russia agreed with the non-government Nuclear Threat Initiative to study the feasibility and costs of a variety of rapid blend-down options in detail. That study is now nearly complete, and a follow-on study to optimize the approaches and reduce their costs is underway.

preventing nuclear terrorism, with: clear designations of responsibility and accountability for each element of the plan; specified ultimate goals, with measurable metrics of progress, estimated schedules, and specified milestones to be achieved; estimates of the budget and other resources required for each year for each element of the plan; a strategy for diplomacy and incentives to convince other states to cooperate in the accomplishment of each element of the plan; and a process for adapting the plan as circumstances change.

- Seek to gain agreement with other countries on effective global nuclear security standards, as described above;
- Undertake new steps as described above to accelerate removals of weapons-usable material around the world, including programs to provide substantial incentives to sites to give up their HEU, and for HEU-fueled research reactors to either convert or shut down (as appropriate for the particular site);
- Seek to ensure that all stockpiles of nuclear warheads and weapons-usable nuclear materials worldwide are secure and accounted for, to effective agreed standards, as rapidly as that objective can be achieved, and establish measurable milestones and targets for achieving it;
- Take specified new measures to ensure that cooperative security upgrades will be sustained, and to build strong security cultures, as just described;
- Take new steps to upgrade the security levels required of U.S. nuclear material exported abroad, and encourage other nuclear states to do likewise.
- Develop and implement a comprehensive plan for interdicting nuclear smuggling, including not only border detectors but steps to ensure that each potential source or transit state has at least one unit of the national police trained and equipped to deal with nuclear smuggling cases, and that all other jurisdictions know to call them, and new steps to encourage informers to provide information on conspiracies in progress relating to nuclear materials or other weapons of mass destruction.
- Negotiate arrangements with Russia to accelerate and expand the blend-down of HEU, with the additional LEU produced kept in monitored stores until the market is ready for its sale.
- Refocus U.S. nuclear intelligence, directing the intelligence community to give high priority to collecting data on security for nuclear material and nuclear weapons worldwide (including such matters as pay and morale of personnel at remote facilities with weapons-usable material).
- Redouble efforts to build police and intelligence cooperation with other states to identify and disrupt potential nuclear terrorist groups, interdict nuclear smuggling, and identify high-risk nuclear facilities requiring security upgrades or material removals.

Exercising Performance-Based Oversight

Congress should set clear goals, and insist that the executive branch prepare coherent plans for achieving them, including measurable milestones. It should then hold the executive branch accountable for performance in achieving these goals. At the same time, Congress should give the executive branch considerable flexibility

in how these goals are achieved, making it possible to seize opportunities and adapt approaches as circumstances change.

To exercise such flexible, performance-based oversight, Congress will need to delve into the progress and problems of these efforts in detail, learning both the good news and the bad news. For that purpose, in-depth hearings on the threat and what is being and could be done to address it will be essential—possibly complemented with staff investigations. It is crucial that such hearings include testimony from independent witnesses. If it hears only from the government officials managing these efforts—as has almost always been the case in recent years—Congress will rarely hear either the bad news or new ideas for accelerated and expanded progress.

A LONG ROAD YET TO TRAVEL

Real and important progress has been made in securing nuclear stockpiles in recent years, particularly in Russia. But there is more to be done there, and the effort in much of the rest of the world is just beginning. The steps recommended above could lead the way toward a faster, more effective, and more comprehensive effort to lock down the world's nuclear stockpiles before terrorists and criminals can get to them. President Bush and President Putin, working with other world leaders, have the power to take actions that would transform the global effort to secure nuclear stockpiles and interdict nuclear smuggling. Between them, they have an historic opportunity to leave behind, as a lasting legacy, a world in which the danger of nuclear terrorism has been drastically reduced.

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ABOUT THE PROJECT ON MANAGING THE ATOM

The Project on Managing the Atom (MTA) at Harvard University brings together an international and interdisciplinary group of scholars and government officials to address key issues affecting the future of nuclear weapons and nuclear energy, particularly where these futures intersect.

MTA 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. Much of the project's work is international in nature. MTA hosts research fellows from a variety of countries, and its members engage collaborative projects with colleagues around the world.

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- Jeffrey Lewis, Executive Director, Project on Managing the Atom
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- Hui Zhang, Research Associate, Project on Managing the Atom
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