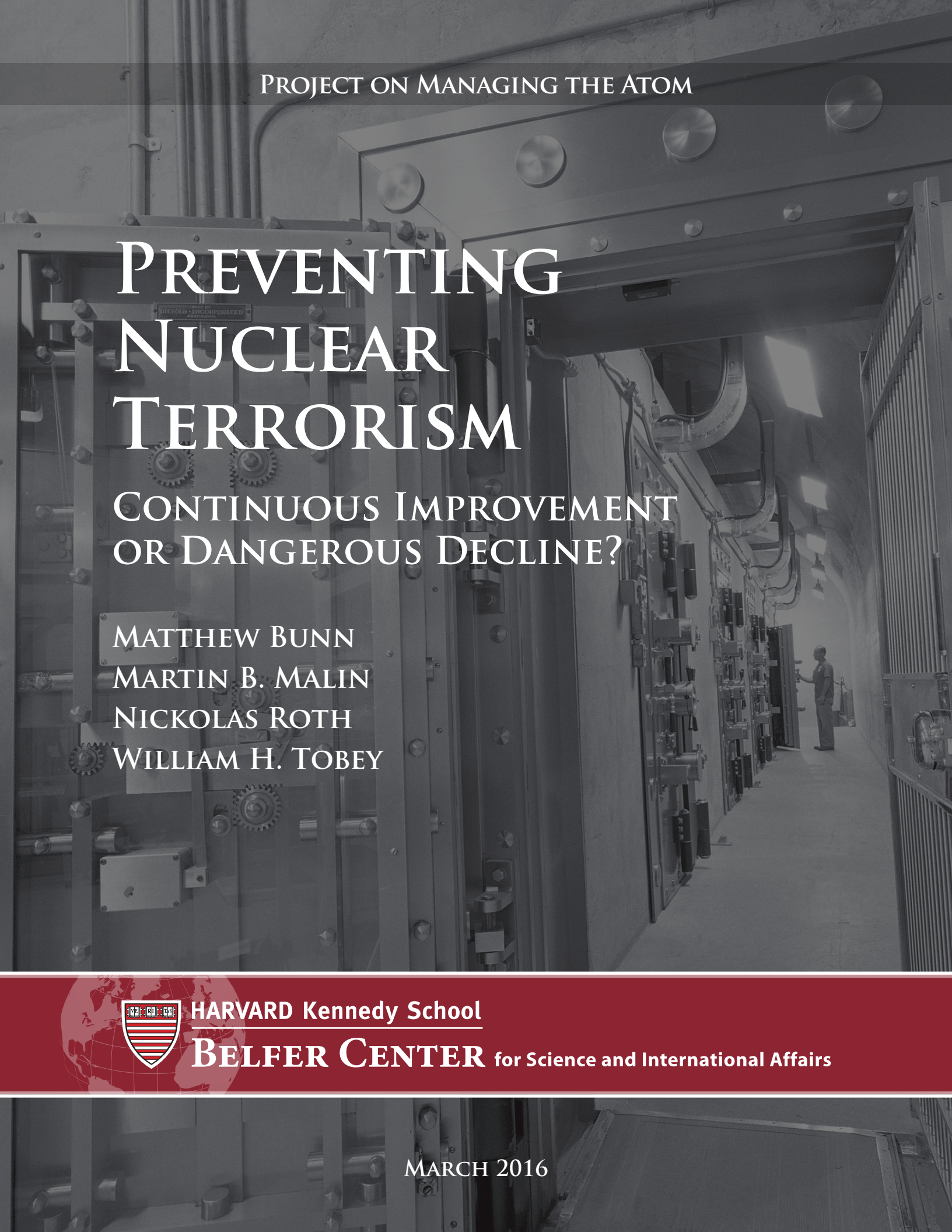

Project on Managing the Atom

Preventing Nuclear Terrorism

Continuous Improvement or Dangerous Decline?

Matthew Bunn
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Report

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The "Tunnel Vault" nuclear materials storage facility at Technical Area 41, Los Alamos National Laboratory, as seen in October, 1964. (Los Alamos Archive).

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Executive Summary

The risk of nuclear terrorism remains very real. Measures to secure nuclear weapons and the materials needed to make them are the most effective tools for reducing this risk. Terrorist threats are constantly changing—as the dramatic rise of the Islamic State in 2014 makes clear. The job of improving security for nuclear weapons and weapons-usable nuclear materials is never "done"—security must constantly evolve as the threat changes, technologies shift, and new vulnerabilities are revealed. In the two years since the last nuclear security summit, security for nuclear materials has improved modestly—but the capabilities of some terrorist groups, particularly the Islamic State, have grown dramatically, suggesting that in the net, the risk of nuclear terrorism may be higher than it was two years ago.

Visions for the Future of Nuclear Security

The 2016 Nuclear Security Summit represents an important crossroads, which will help determine whether nuclear security continues to improve or stalls and begins to decline. Several very different futures are possible. At one extreme, on a high-security path, all nuclear weapons and weapons-usable nuclear material worldwide would be effectively and sustainably protected against the full range of plausible threats that terrorists and thieves might pose; the number of locations where such stocks exist would be drastically reduced; steps would be taken to build understanding of the threat, to strengthen security culture, and combat complacency; and nations would continue an effective dialogue on next steps in nuclear security after the summit process ended. That pathway would lead to continuous improvement in nuclear security, in a never-ending quest for nuclear security excellence—and a drastically reduced risk of nuclear terrorism.

At the other extreme, on a low-security path, many stocks would remain dangerously vulnerable; few further actions would be taken to minimize the number of locations where nuclear weapons and their essential ingredients exist; complacency about the threat and weak security cultures would increasingly be the norm; and what little international discussion of nuclear security continued after the summit would be mired in political disputes and bureaucratic obstacles. On that pathway, nuclear security progress would stall and eventually reverse—and the risks of nuclear terrorism would grow.

The Evolving Threat of Nuclear Terrorism

The world has entered an age of mass casualty terrorism, in which certain adversaries seek and have the capability to inflict maximum possible carnage to achieve their ends. Making a crude nuclear bomb would not be easy, but is potentially within the capabilities of a technically sophisticated terrorist group, as numerous government studies have confirmed. The main barrier is getting hold of the needed nuclear material—but there are multiple cases in which kilogram quantities of plutonium or highly enriched uranium (HEU) have been stolen. The nuclear material for a bomb is small and difficult to detect, making it a major challenge to stop nuclear smuggling, or to recover nuclear material after it has been stolen. The consequences of detonation of even a crude terrorist nuclear bomb would be severe, turning the heart of modern city into a smoldering radioactive ruin and sending reverberating economic and political aftershocks around the world.

At least two terrorist groups—al Qaeda and the Japanese terror cult Aum Shinrikyo—have made serious efforts to get nuclear weapons, and there is suggestive evidence of Chechen terrorist interest as well (including incidents of terrorist teams carrying out reconnaissance at Russian nuclear weapon storage sites). Al Qaeda had a focused nuclear weapons program and repeatedly attempted to buy stolen nuclear bomb material and recruit nuclear expertise. Al Qaeda went as far as carrying out crude tests of conventional explosives for their nuclear bomb program in the Afghan desert.

To date, there is no publicly available evidence that the Islamic State is pursuing a similar focused nuclear weapons effort. But the group's apocalyptic rhetoric, envisioning a final war between itself and the "crusader" forces, suggests a need for very powerful weapons, and recent incidents such as the in-depth monitoring of a senior official of a Belgian facility with substantial stocks of HEU are worrying indicators of possible nuclear intent. If the Islamic State does turn to seeking nuclear weapons, it has more money, controls more territory and people, and enjoys a greater ability to recruit experts globally than al Qaeda at its strongest ever had.

Terrorist use of nuclear weapons may not be a high probability—but the global economic, political, and social consequences would be so severe that even a low probability should be enough to motivate an intense focus on steps such as nuclear security to reduce the risk.

Assessing Progress and Gaps

Nuclear security around the world has improved dramatically over the past quarter century. Egregious weaknesses—gaping holes in fences, lack of any equipment to detect if someone tried to carry plutonium or HEU out in a briefcase—have been fixed at scores of sites around the world. More than half of all the countries in the world where weapons-usable nuclear material once existed have eliminated it. Security rules and procedures have been tightened in essentially every country where these materials continue to exist.

But significant weaknesses remain, and a great deal remains to be done to ensure that nuclear weapons and the materials needed to make them are effectively and sustainably protected in the face of evolving threats. As this report documents, progress has slowed in recent years, with U.S.-Russian nuclear security cooperation largely suspended, fewer nuclear security improvements completed, and weapons-usable nuclear material eliminated from fewer sites. Meanwhile, the U.S. government has been reducing the funding available to help countries make nuclear security progress. Our assessments of progress and remaining gaps are broken into several categories, below.

Committing to Stringent Nuclear Security Principles

There has been significant progress in recent years in states making commitments to nuclear security, but gaps remain:

- As of mid-March 2016, 93 states had ratified the 2005 amendment to the physical protection convention, which extends the convention's coverage to domestic material and to sabotage, and outlines fundamental principles of physical protection. Nine more are needed for the amendment to enter into force—18 years after it was first proposed.
- At the 2014 Nuclear Security Summit, 35 states joined together in a "strengthening nuclear security implementation" initiative, in which they pledged to meet the objectives of International Atomic Energy Agency (IAEA) security recommendations and accept regular reviews of their nuclear security arrangements. In 2016, Jordan joined the initiative. Unfortunately, however, major holders of weapons-usable nuclear material such as Russia, China, Pakistan, and India are not yet participants.
- The IAEA has significantly strengthened its nuclear security recommendations, including both the 2011 revision of its broad physical protection recommendations and specific guidance in a wide range of areas.

- A number of countries have made domestic commitments in recent years by strengthening nuclear security regulations, most notably Belgium's decisions to expand protections against insiders and deploy armed personnel to protect nuclear facilities.

To date, however, the global nuclear security framework remains a patchwork, and does not include any agreed standards that specify what levels of security are needed for nuclear weapons and weapons-usable nuclear materials, or any verification of commitments or even self-reporting in a consistent format.

Implementing Effective and Sustainable Nuclear Security

Implementation of nuclear security on the ground is also a story of significant progress, combined with important remaining gaps:

- Russia has the world's largest nuclear stockpiles, spread in the world's largest number of buildings and bunkers. Nuclear security in Russia has improved dramatically since the 1990s, but significant weaknesses remain, and threats from widespread corruption, organized crime, and spreading Islamic extremism pose worrisome risks. The end of most U.S.-Russian nuclear cooperation and the substantial budget pressures facing the Russian government (including a 10 percent cut for the nuclear agency's budget) suggest that nuclear security measures may erode.
- Pakistan has a small but rapidly growing nuclear arsenal, shifting toward deployment of tactical nuclear weapons, coupled with some of the world's most capable terrorist groups. Repeated terrorist attacks on heavily guarded facilities in Pakistan—often appearing to have insider help—highlight the ongoing risk. U.S.-Pakistani cooperation is ongoing, but it is not clear how extensive or effective this cooperation can be in the future.
- India also faces significant terrorist risks, though not as extreme as those in Pakistan. India has taken significant measures to protect its nuclear sites, but recent reports suggest some nuclear security weaknesses, and U.S.-Indian nuclear security cooperation has so far been limited to a modest number of workshops.
- Research reactors using HEU as fuel or isotope-production targets continue to pose important risks, particularly at sites with only minimal security measures in place. All of the sites in non-nuclear-weapon states with enough high-quality HEU for the

simplest type of terrorist nuclear bomb, however, have either been eliminated or have had substantial security upgrades completed.

- Some countries with weapons-usable nuclear materials still have nuclear security measures not likely to provide protection against the full spectrum of plausible adversary threats.

Consolidating Nuclear Weapons and Weapons-Usable Materials

There has been significant progress in consolidating nuclear weapons usable material:

- Thirty of the 57 countries that have had weapons-usable nuclear material on their soil have eliminated it, in nearly all cases with U.S. help. All HEU has been eliminated from scores of sites around the world.
- Since reactor conversion efforts began in 1978, 65 HEU-fueled research reactors have converted to low-enriched fuel, and well over 100 have shut down.
- There has been substantial progress in recent years in developing means to produce medical isotopes without HEU, and it should soon be possible to meet global demand without the use of HEU.

But here, too, there is more to be done:

- Current U.S. plans for HEU removals would leave tons of U.S.-origin HEU in foreign countries (primarily in Europe).
- There have been dramatic delays in developing high-density fuels to convert research reactors from HEU fuel to less dangerous low-enriched uranium, and conversion efforts have slowed. Roughly half of the world's remaining HEU-fueled research reactors are in Russia, which is no longer participating in U.S.-funded conversion efforts.
- Global stocks of civilian separated plutonium are immense, but few current efforts are targeted either on minimizing these huge stocks or reducing the number of locations where they are stored and handled.
- Few initiatives are under way to consolidate nuclear weapons or military stocks of weapons-usable nuclear material.

Strengthening Security Culture and Combating Complacency

A number of programs sponsored by countries, international organizations, and others have been targeted on strengthening nuclear security culture in recent years, but a great deal remains to be done:

- Officials and nuclear managers in many countries still tend to dismiss the threat of nuclear terrorism. Many have little awareness of the specifics of past terrorist nuclear ambitions and activities or of real incidents of nuclear theft and sabotage.
- Most organizations handling nuclear weapons, HEU, or separated plutonium do not have specific programs focused on strengthening security culture.

Building Confidence in Effective Nuclear Security

Countries legitimately regard the specifics of how they guard their nuclear stocks as secret. There is, however, increasing acceptance that states should provide some information about their approaches to nuclear security, and some states are taking actions that build greater confidence, such as hosting nuclear security review missions led by the IAEA. The participants in the "strengthening nuclear security implementation" initiative agreed to accept regular reviews of their nuclear security arrangements. Beyond that initiative, however, there is no agreed approach to building confidence that effective nuclear security is in place.

Continuing an Effective Nuclear Security Dialogue After the Summits

The nuclear security summits raised the issue of nuclear security to a high political level; increased awareness of the nuclear terrorism threat; provided a regular forum for high-level dialogue on next steps; created deadlines for action; and provoked new interagency discussions within governments. The end of the nuclear security summit process with the 2016 summit will leave a substantial gap. The 2016 summit is expected to announce action plans to strengthen five existing institutions, from the IAEA to the Global Initiative to Combat Nuclear Terrorism, to help fill part of that gap. But how effective the international dialogue will be after the summit process ends remains uncertain.

Nuclear Security Funding

Nuclear security spending is a cost-effective investment in U.S. security, reducing the danger of a nuclear terrorist attack on the United States for less than two parts in a thousand of U.S. national security spending. U.S. spending on international nuclear security programs has declined from over $800 million in fiscal year (FY) 2012 to just over $500 million in FY 2016, a 38 percent decline, and the Obama administration proposes to cut it a further 24 percent for FY 2017, to less than $400 million. "International Nuclear Security," the particular program most directly focused on helping other countries improve nuclear security, would be cut by two-thirds from last year, to levels not seen since the program's earliest days in the 1990s. Much of these reductions are the result of security upgrades being completed or work in Russia being suspended—but these reductions have also led to slowing and postponing of some important nuclear security work. Current projections call for spending substantially less on nuclear security every year for the next five years than the government was projecting only one year ago. These spending reductions, if approved by Congress, would further slow nuclear security progress, undermining President Obama's otherwise impressive nuclear security legacy.

Formidable Obstacles to Nuclear Security Progress

A range of obstacles slows nuclear security progress, and must be addressed if the world is to get on to the high-security path. Most important is complacency: many officials believe that nuclear terrorism is not a serious threat, or that their own country's security measures are more than sufficient. Political disputes, bureaucratic procedures, organizational incentives, and technical and cost concerns also delay progress. The secrecy surrounding nuclear security poses a major barrier of its own, and often adds to the other barriers.

Recommendations: Getting to Continuous Improvement in Nuclear Security

This report makes recommendations in six areas intended to put the world on the high-security nuclear path.

1. Commit to Stringent Nuclear Security Principles

Countries with nuclear weapons and weapons-usable nuclear material should join in making a political commitment to provide effective and sustainable protection for such stocks against the full range of plausible adversary capabilities and tactics—including, at a minimum, a modest group of well-armed and well-trained outsiders; a well-placed insider; and both outsiders and an insider working together. The commitment should also include specific elements needed to achieve this objective, from well-equipped, well-trained on-site armed guard forces to accounting systems able to detect any substantial theft and identify when and where it happened and who had access to the material at that time. Leaders of these countries should publicly accept that they have a responsibility for nuclear security that cannot be delegated to others. Interested states should also push for broader participation in less far-reaching but still important commitments, including ratification of the nuclear security treaties and participation in the 2014 nuclear security implementation initiative.

2. Revitalize Programs to Implement Effective and Sustainable Nuclear Security

Organizations handling nuclear weapons and weapons-usable nuclear material should take a range of actions to ensure that nuclear security is effective and sustainable, including establishing the goal of continuous improvement in nuclear security, providing adequate resources, building strong security cultures, and undertaking regular assessments and realistic tests of nuclear security performance. They should pay particular attention to reducing some of the highest risks—those from insider theft; at facilities that handle weapons-usable nuclear material in bulk; and from cyber threats.

- ***Strengthen international nuclear security cooperation.*** The chances for achieving and sustaining nuclear security excellence worldwide will be far higher if countries work together. But nuclear security cooperation is moving into a new era, focused less on donor states providing equipment and training and more on convincing (and helping) states to do more themselves. The United States should seek to expand nuclear security cooperation with Pakistan, India, and China, and should undertake nuclear security discussions and good practice exchanges with all of the countries where nuclear weapons or weapons-usable nuclear materials exist, including both developed and developing countries.

- ***Rebuild nuclear security cooperation with Russia, based on a new approach.*** Russia has the world's largest stocks of nuclear weapons and weapons-usable nuclear materials in the world's largest number of buildings and bunkers. Despite tensions over Ukraine and other issues, the United States and Russia should agree to a package of cooperation that includes both nuclear energy initiatives (of particular interest to Russia) and nuclear security initiatives (of particular interest to the United States). Cooperation should no longer be based on a donor-recipient relationship but on an equal partnership with ideas and resources coming from both sides.
- ***Establish funds to finance unexpected nuclear security needs.*** States should consider two possibilities for new funds that could help pay for nuclear security needs, such as those that arose after the collapse of the Soviet Union or the discovery of plutonium left over in nuclear test tunnels in Kazakhstan. One approach, focused on civil materials, would be a revolving fund at the IAEA, from which states could draw for a nuclear security investment, and then repay over time. Another approach, which could cover both civil and military materials, would be a U.S.-Russian fund, with a group of experts from both sides determining which projects would be funded.

3. Expand Efforts to Strengthen Security Culture and Combat Complacency

The countries with nuclear weapons or weapons-usable nuclear material should launch a new nuclear security culture initiative, in which the participating countries would work to ensure that each operator handling these stocks has a targeted program in place to assess and strengthen security culture, and all nuclear managers and security-relevant staff receive regular information, appropriate to their role, on evolving threats to nuclear security. At the same time, interested countries should launch a number of initiatives designed to build understanding of the threat and combat complacency, including: a shared database of security incidents and lessons learned; detailed reports and briefings on the nuclear terrorism threat, with some information public and more detailed information reserved for confidential discussions among states; discussions among intelligence agencies, which most governments rely on for information about the threats to their country; an expanded program of nuclear theft and terrorism exercises; and an "Armageddon Test," in which an intelligence team would seek to penetrate illicit markets and see if it could get information on nuclear materials available for sale.

4. Broaden Nuclear Consolidation Efforts

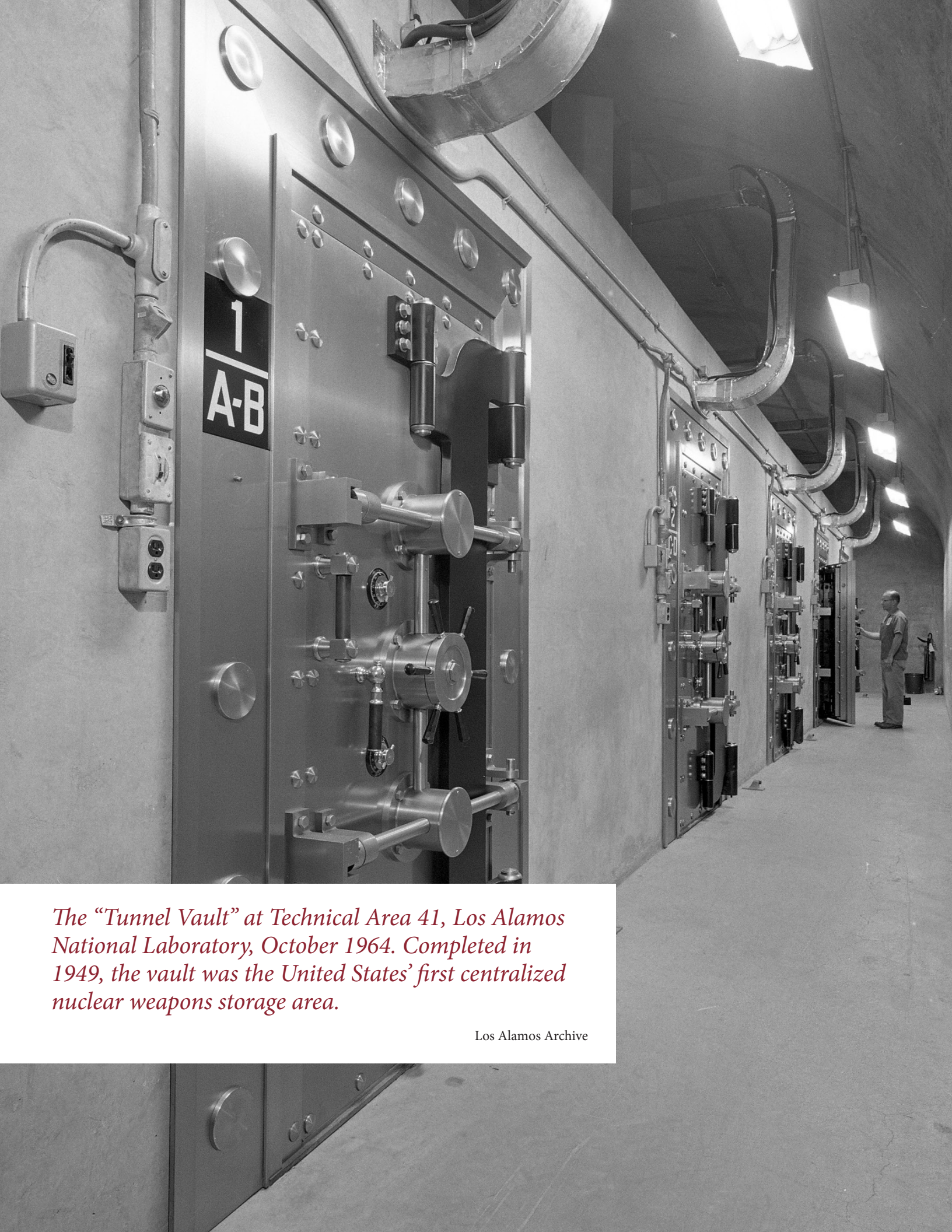
The United States and other interested countries should take a broader approach to consolidating nuclear material at fewer locations, encompassing more categories of material and additional policy tools. Each country with nuclear weapons, HEU, or separated plutonium should undertake a review of each site where these materials exist, eliminating any site whose continued benefits are outweighed by its costs and risks. The U.S. government should have a blanket policy that wherever plutonium or HEU exists in the world, it will either take it back to be secured in the United States, help arrange its disposition elsewhere, or work to ensure that it has sustainable security that will protect it from the full range of plausible threats while it stays where it is. Countries should ensure that stringent requirements for security for HEU and separated plutonium give managers an incentive to reduce security costs by eliminating these materials where they are not needed. The United States and other interested countries should add incentives for unneeded HEU-fueled research reactors to shut down as a complementary policy tool to converting research reactors away from HEU fuel. The United States and other interested countries should seek to ensure that plutonium and HEU bulk processing facilities do not spread to other countries or expand in number or scale of operations, and that no more plutonium is reprocessed each year than is used, bringing global plutonium stocks down over time. Russia and the United States, in particular, as the countries whose nuclear stockpiles are dispersed at the largest number of buildings and bunkers with nuclear weapons or weapons-usable material, should each develop a national-level plan for accomplishing their military and civilian nuclear objectives with the smallest practicable number of locations with nuclear weapons or weapons-usable material.

5. Develop Approaches to Confirm That Effective Nuclear Security Is in Place

Insecure nuclear material anywhere is a threat to everyone, everywhere—and all countries have a national security interest in seeing that all countries with nuclear weapons or weapons-usable nuclear materials protect them effectively. The United States and other interested states should establish an experts group to work out approaches to providing assurances that would build real confidence in nuclear security without unduly compromising sensitive information, ranging from permitting international peer reviews to publishing detailed information on how nuclear security systems are assessed and tested, the fraction of sites that have gotten high marks in such assessments, and how weaknesses or problems were found and fixed.

6. Continue an Effective Nuclear Security Dialogue After the Summits End

As nuclear security must continue to evolve in the face of a changing threat, it is essential to establish an effective ongoing dialogue on nuclear security after the summits come to an end. While the IAEA and the ministerial-level meetings on nuclear security it plans to hold every three years will play a central role, the IAEA focuses on civilian material and there is likely to be a need for more informal and flexible groupings to supplement the IAEA's work. In particular, senior officials of interested states should continue to meet, as they have been between summits, to oversee implementation of commitments already made and suggest ideas for additional steps, and the member states of the Global Initiative to Combat Nuclear Terrorism should establish a working group on nuclear security, as a forum for ongoing nuclear security discussion and cooperation.



The "Tunnel Vault" at Technical Area 41, Los Alamos National Laboratory, October 1964. Completed in 1949, the vault was the United States' first centralized nuclear weapons storage area.

Los Alamos Archive

1. Introduction

Two years ago, when the last nuclear security summit occurred, the Islamic State (IS) was one of many small Islamic extremist groups.[1] Within months, the IS had seized major portions of Syria and Iraq and declared a global caliphate, making its global ambitions clear. Today, the IS governs wide swathes of Iraq and Syria, is recruiting from around the globe, has demonstrated a desire and capability to strike far beyond its borders, and has stated its ambition to launch major attacks on the United States. As the IS's dramatic rise makes clear, it is impossible to predict what the terrorist threat will look like five, ten, or twenty years into the future – making it all the more essential to ensure that future terrorists can never acquire the essential ingredients of nuclear bombs.

To make a nuclear bomb, a terrorist group would have to have separated plutonium or highly enriched uranium (HEU)—materials that do not occur in nature and are likely beyond the ability of terrorists to produce. Hence, if all the world's nuclear weapons and weapons-usable nuclear materials can be locked down and kept out of terrorist hands, terrorists can be prevented from ever getting a nuclear explosive. There are many steps that should be taken to reduce the risk of nuclear terrorism, but securing nuclear stockpiles is the single most important chokepoint blocking the terrorist pathway to the bomb.

Despite significant progress over the past two decades, some nuclear weapons materials remain dangerously vulnerable to theft—and incidents such as an IS operative's intensive monitoring of a senior official of a Belgian facility with significant stocks of HEU highlight the continuing threat. In the two years since the last nuclear security summit, security for nuclear materials has improved modestly—but the capabilities of some terrorist groups, particularly the IS, have grown dramatically, suggesting that in the net, the risk of nuclear terrorism may have increased.

1 For example, in Director of National Intelligence James Clapper's testimony to the Senate Select Committee on Intelligence in January 2014, the Islamic State is not listed as a terrorist threat. See "Worldwide Threat Assessment of the US Intelligence Community" (Washington, D.C.: Senate Select Committee on Intelligence, January 29, 2014), http://www.dni.gov/files/documents/Intelligence%20Reports/2014%20WWTA%20%20SFR_SSCI_29_Jan.pdf (accessed March 17, 2016). The Islamic State is sometimes known by the acronym ISIS (for the Islamic State of Iraq and Syria, or Iraq and al-Sham, depending on the translation from the Arabic) or ISIL (for the Islamic State of Iraq and the Levant). In the Middle East, the group is often known as Daesh, the Arabic acronym for its name.

Given these ever-changing terrorist capabilities, it is critical to ensure that all nuclear weapons, and all materials that could be used to make them, wherever they may be in the world, are effectively protected against a wide spectrum of plausible adversary capabilities and tactics. Policymakers can never be satisfied that the work of nuclear security is "done." Nuclear security approaches must focus on continuous improvement in the face of an ever-evolving threat, changing technologies, and newly discovered vulnerabilities. Nuclear security that is not getting better is probably getting worse.

Yet the nuclear security summit that will occur on March 31–April 1, 2016—the fourth in a series—will likely be the last.[2] The end of the summit process will leave a substantial gap in global nuclear security governance that must be filled. The crucial question is whether the summit participants will agree on steps that will "keep this process alive and effective" after 2016, as President Obama put it at the last nuclear security summit.[3] As this report will document, nuclear security has improved substantially around the world in the last two decades, substantially reducing the risk of nuclear terrorism compared to what it would otherwise have been. But an ongoing effort focused on excellence is needed to achieve and sustain effective security for all the world's stocks of nuclear weapons and weapons-usable nuclear materials.

The year 2016 will be pivotal for nuclear security for reasons going well beyond the end of the nuclear security summit process. Actions in Syria, Iraq, Afghanistan, Pakistan, and elsewhere will affect the shape of the terrorist threat for years to come. The United States, long the leader of nuclear security initiatives, will be electing a new president, who may or may not make nuclear security a priority. The United States and Russia, the countries with the two largest nuclear stockpiles and a special responsibility for nuclear security, may or may not find ways to revitalize their cooperation in this vital area, most of which has been suspended in the wake of escalating U.S.-Russian tensions over Ukraine and other issues. The policy framework and resources that support nuclear security is also changing. The Global Initiative to Combat Nuclear Terrorism (GICNT), still co-chaired by the United States and Russia, will be celebrating its tenth anniversary, and considering ideas for its future role. The 2005 amendment to the Convention on Physical Protection may finally gain enough adherents to come into force. The U.S. Congress will be considering whether to approve administration proposals to scale back spending on nuclear security

2 The leaders have agreed that the 2016 summit will be the last for now. It is possible, however, that at some point in the future, an interested country could again invite others to a summit focused on nuclear security.

3 Barack Obama, "Remarks by President Barack Obama in Prague As Delivered," White House Press Release, April 5, 2009, https://www.whitehouse.gov/the-press-office/remarks-president-barack-obama-prague-delivered (accessed February 11, 2016).

programs. And late in the year, a ministerial-level meeting hosted by the International Atomic Energy Agency (IAEA) will help to plan the IAEA's nuclear security work for the next three years.

Plan of the Report

Following every pivot is a new path and a new set of challenges. As the era of nuclear summits ends, what progress has been made and what gaps remain? As we look beyond the horizon to the future, will the danger of nuclear terrorism continue to increase or decrease? What measures should we be taking now to create a world in which nuclear terrorism is at most a minor concern? These are the questions this report seeks to answer.

The purpose of this report, the most recent in a series, is to propose a vision for nuclear security for the future; assess progress thus far to achieving that vision; and then offer recommendations that provide a roadmap for getting to the goal.[4] We begin by laying out two scenarios for the nuclear security future—a desirable path toward sustainable excellence in nuclear security, and a complacent path on which many serious risks would remain unaddressed and progress already achieved might erode. Next, we focus on the threat, offering an account of the nuclear terrorism dangers still posed by al Qaeda, the IS, and other terrorist groups. That threat assessment is followed by an assessment of what has been achieved in various elements of the effort to improve nuclear security around the world. We examine the obstacles to further progress and the reasons why continuous improvement in nuclear security is difficult. Finally, we offer recommendations for action, intended to help put the world on the high-security path, avoiding the dangers of the low-security path.

4 The previous report in the series is Matthew Bunn, Martin B. Malin, Nickolas Roth, and William H. Tobey, *Advancing Nuclear Security: Evaluating Progress and Setting New Goals* (Cambridge, MA.: Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, March 2014), http://belfercenter.ksg.harvard.edu/files/advancingnuclearsecurity.pdf (accessed March 1, 2016). Earlier reports in the portion of the series titled Securing the Bomb are available at http://www.nti.org/about/projects/Securing-bomb/.

Three Types of Nuclear or Radiological Terrorism

The three types of nuclear and radiological terrorism each pose different risks:

- Detonation of an actual nuclear bomb, either a nuclear weapon acquired from a state's arsenal or an improvised nuclear device made from stolen weapons-usable nuclear material;[1]
- Sabotage of a nuclear facility causing a large release of radioactivity; and
- Use of a radiological dispersal device or "dirty bomb" to spread radioactive material and create panic and disruption.[2]

Use of an actual nuclear explosive, while the most difficult for terrorists to accomplish, would be by far the most devastating, as described in the threat assessment below. The radiation from a dirty bomb, by contrast, might not kill anyone—at least in the near term—but could impose billions of dollars in economic disruption and cleanup costs. The effects of sabotage of a nuclear facility would depend heavily on the specific nature of the attack, but would likely range between the other two types of attack in severity. The difficulty of achieving a successful sabotage is also intermediate between the other two. This report focuses primarily on the danger that terrorists might get and use an actual nuclear bomb—the form of nuclear terrorism whose consequences would be most catastrophic. (Short boxes briefly discuss dirty bombs and sabotage. See "Reducing the Risks of Radiological Dirty Bombs," p. 110, and "Protecting Against Nuclear Sabotage," p. 126.)

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i In this report, we refer to HEU, plutonium separated from spent fuel, and the other rare isotopes that could be used to make a nuclear bomb as "weapons-usable materials." This term, as we use it, includes materials that would require some chemical processing to prepare them for use in a bomb, but it does not include uranium that would require further enrichment, or material so radioactive that it could not practically be processed for use in a bomb without complex remote-handling equipment. This is the same set of materials the International Atomic Energy Agency refers to as "unirradiated direct use materials." See International Atomic Energy Agency, *IAEA Safeguards Glossary* (Vienna: IAEA, 2001), http://www-pub.iaea.org/MTCD/publications/PDF/nvs-3-cd/PDF/NVS3_prn.pdf (accessed February 16, 2016), p. 33. It is important to understand that both uranium and plutonium that is much poorer quality than the level considered "weapons-grade"—typically 90 percent or more U-235 for uranium or Pu-239 for plutonium—can still be used to make devastating nuclear explosives, and hence is still weapons-usable.

ii One early account distinguishes between use of stolen nuclear weapons manufactured by a state and improvised nuclear devices terrorists made themselves, creating four categories rather than three. See Charles D. Ferguson, William C. Potter, with Amy Sands, *The Four Faces of Nuclear Terrorism* (New York: Routledge, 2005).

2. Nuclear Security in 2030: Two Visions of the Future

In what direction will the events of 2016 lead? Looking beyond the immediate horizon, how strong will global nuclear security efforts be in 2030? With sufficient action and effective processes in place to continue the momentum, the world could be on track to achieve and sustain effective security for all weapons-usable nuclear material and nuclear facilities and a very low risk of nuclear terrorism. But with inadequate steps and no genuinely effective means to continue high-level discussion after the summit, there is a real danger that complacency will return, recent gains in nuclear security will erode, and the world will be faced with an unacceptably high—and growing—danger of nuclear terrorism.

While a number of pathways between these extremes are also possible, it is worthwhile outlining the positive and negative scenarios in more detail, to highlight what the international community should be seeking to achieve, and to avoid. We will call the upper pathway the "high-security" scenario and the lower pathway the "low-security" scenario.

The High-Security Scenario

Achieving the high-security scenario would require steps to: build commitment to stringent nuclear security principles; implement those commitments effectively and sustainably; build security culture and combat complacency; consolidate nuclear weapons and materials to fewer locations; build confidence that effective nuclear security steps really had been taken; and continue an effective dialogue after the end of the nuclear security summits.

A Strong Commitment to Nuclear Security Principles

In the high-security scenario, by 2030:

- States with nuclear weapons and weapons-usable nuclear material (or nuclear facilities whose sabotage could cause a major catastrophe), and organizations operating facilities or transports handling these items and materials, are committed to:
    - » Providing effective protection against the full spectrum of plausible adversary threats. At a minimum, such stocks and facilities should be protected against a

modest group of well-armed and well-trained outsiders, able to operate as more than one team; a well-placed insider; and both the outsiders and insider working together, using a broad range of possible tactics. Facilities or transports in countries facing more substantial adversary threats should provide more extensive protection.

  - » Undertaking regular, realistic tests and in-depth independent reviews of their nuclear security.
  - » Having systems in place to detect, assess, delay, and respond to outsider intrusions, capable of providing high confidence of defeating a broad range of potential adversary tactics.
  - » Providing on-site armed guard forces that are well equipped, well trained, professional, and have capabilities sufficient to defeat adversary threats.
  - » Having a comprehensive suite of measures to protect against insider threats.
  - » Implementing material control and accounting systems adequate to detect and localize any theft of weapons-usable nuclear material.
  - » Having protection against cyber threats that is strong and fully integrated with other nuclear security measures.
  - » Prioritizing responsibility for security at all levels throughout the organization, and having programs in place to assess and strengthen their security culture.
  - » Reviewing and updating, on a regular basis, their nuclear security requirements and approaches in the face of changing technology, accumulating experience, and the evolving threat.

- Heads of government and state, like their chief executive officer counterparts in the private sector, recognize their undelegatable responsibility for nuclear security.

Implementing Effective and Sustainable Nuclear Security

In the high-security scenario, by 2030:

- All organizations managing facilities or transports with nuclear weapons or weapons-usable nuclear materials, or nuclear facilities whose sabotage could cause a major catastrophe:

    - » Have put in place measures to meet the commitments above.
    - » Have resources and plans in place to achieve and sustain effective nuclear security and accounting.
    - » Are staffed by personnel who have been trained to be, and certified as, competent to carry out their assigned duties.
    - » Are implementing good nuclear security practices and participating in good practice exchanges and lessons learned programs, such as those of the World Institute for Nuclear Security.
    - » Have built effective organizational cultures that focus on achieving the highest standards of safety, security, and successful operations, seeing each of these elements as essential to the organization's success.
- Vibrant nuclear security cooperation is underway among the countries with the most substantial nuclear stockpiles—including, among others, the United States, Russia, the United Kingdom, France, China, India, Pakistan, and Japan—ranging from exchanges of best practices to technical exchange visits to nuclear facilities to joint R&D on improved nuclear security and accounting technologies.
- The role and capabilities of the IAEA and other relevant international organizations in supporting nuclear security have been substantially strengthened, with adequate resources provided to fulfill those roles.

Major Progress on Consolidating Nuclear Weapons and Weapons-Usable Materials

In the high-security scenario, by 2030:

- The number of sites and transports with nuclear weapons, plutonium, or HEU, has been greatly reduced compared with the number in 2016, and the civil use of HEU has been eliminated (or the last few sites with civil HEU have definite plans to eliminate it at fixed dates within a few years).
- The number of facilities processing weapons-usable nuclear material in bulk has declined compared with 2016, and these facilities have not spread to additional countries.

- All states have stopped producing fissile material for weapons; all production of HEU for any purpose has ceased; stocks of nuclear weapons, HEU, and separated plutonium are decreasing; reprocessing of spent nuclear fuel for civilian purposes has not spread to additional countries, and/or increased in scale; and, to the extent HEU is still used for naval fuel, this HEU is accorded the same security given to nuclear weapons and other military stocks of HEU.

Building Confidence in Effective Nuclear Security

In the high-security scenario, by 2030:

- Nearly all relevant countries are regularly reporting non-sensitive information on their nuclear security progress and challenges, and accepting some form of international review, to build international confidence that effective security genuinely is in place and to help identify issues that may require further action.

An Effective and On-Going Nuclear Security Dialogue After the Summits

In the high-security scenario, by 2030:

- Senior decision-makers from countries possessing weapons-usable material use an effective process to regularly gather to share information on threat trends, report on national programs to provide effective nuclear security, and make cooperative decisions on next steps in nuclear security.

Related Steps

In the high-security scenario, by 2030:

- Pakistan and India have capped their nuclear arsenals and agreed to confidence-building measures or other steps that greatly reduce the probability of crises that would lead to the dispersal of nuclear weapons to front-line forces.
- North Korea's nuclear weapons program has been verifiably eliminated or capped at a low level, pending elimination.

- Iran's nuclear program is entirely civilian, does not involve HEU or separated plutonium, and is managed in a way that poses only modest breakout concerns; and no other countries have established nuclear programs that are seen as posing substantial nuclear proliferation risks.
- All of the most plausible source, transit, and target states for nuclear smuggling have: established counter-nuclear smuggling teams trained and equipped to handle nuclear smuggling cases; established effective cooperation with other countries' intelligence and law enforcement agencies to share information on nuclear and radioactive smuggling; put in place effective nuclear forensics capabilities or arrangements to rely on those of another country; and have effective border controls and radiation detection to increase the difficulties and risks nuclear and radioactive smugglers would face.
- Radioactive sources whose use in a "dirty bomb" would result in large-scale economic disruption have been provided with effective low-cost security measures (such as equipment designs that make the sources extremely difficult to remove without special equipment, alarms, and security cameras), in storage, use, and transport; all large cesium chloride sources have been replaced with other technologies; and other large sources have also been replaced with non-radioactive technologies wherever technically and economically practical.

If the high-security scenario were achieved, and other measures were taken to (a) degrade or defeat the highest-capability terrorist groups that have the most potential to engage in nuclear terrorism, and (b) make it as difficult as possible for nuclear thieves, smugglers, and terrorists to connect with one another and smuggle nuclear and radioactive material, then the risk of nuclear terrorism could be reduced to a very low level, greatly improving all countries' security. Moreover, the cooperation needed to achieve this level of reduced risk could improve political relations and cooperation in other areas.

There are real opportunities to reach the goals of the high-security scenario, if countries commit at the 2016 summit to continue moving forward on nuclear security and establish effective processes for doing so, and if the next U.S. president and other national leaders take effective action. The cost and difficulty of reaching these goals are tiny by comparison with the costs countries are routinely accustomed to paying to protect their security, as the steps that need to be taken have only a modest effect on only a small number of facilities in any given country. But the non-monetary barriers posed by complacency, bureaucracy, and excessive concerns for secrecy and sovereignty are substantial, and will take sustained leadership to overcome (see "Formidable Obstacles to Nuclear Security Progress" p. 87)

The Low-Security Scenario

By contrast, in the low-security scenario, most of these goals have not been achieved. In the low-security scenario, by 2030:

A Weakening Global Commitment to Nuclear Security Principles

- Few states or organizations are committed to stringent nuclear security principles.
- Heads of state and government have not accepted their responsibility for nuclear security.

Ineffective and Unsustainable Nuclear Security Programs

- A substantial fraction of the organizations operating facilities or transports with nuclear weapons or weapons-usable nuclear material, or whose sabotage would cause a major catastrophe:
    - » Have security systems inadequate to protect against the full spectrum of adversary threats that exist in their country, and some have systems whose effectiveness is declining as complacency increases.
    - » Are not subject to regular realistic tests or in-depth independent reviews of their nuclear security.
    - » Have not taken steps to ensure that their personnel have been trained to be, and certified as, competent to carry out their assigned duties.
    - » Do not have systems in place to detect, assess, delay, and respond to outsider intrusions that would be capable of handling a full range of adversary tactics.
    - » Continue to rely on off-site forces for armed response, or on-site forces without the numbers, training, equipment, and motivation needed to provide effective response.
    - » Have only weak measures in place to counter insider threats, along with material control and accounting systems that would not be adequate to detect and localize some types of nuclear thefts.

  - » Have taken only weak steps to ensure cybersecurity, inadequate to the evolving threat, and have in most cases not explored the potential connections between cybersecurity and physical security.
  - » Have weak norms prioritizing responsibility for security at all levels, and have no programs in place to assess and strengthen their security culture.
  - » Have few resources or plans in place to sustain effective nuclear security and accounting.
  - » Rely on a static security approach that is not regularly reviewed or updated.
- Little bilateral or multilateral nuclear security cooperation is underway, and the nuclear security programs of the United States, Russia, China, India, and Pakistan, among other countries, are proceeding largely in isolation.
- Little, if anything, has been done to strengthen the nuclear security role and capabilities of the IAEA or other relevant international organizations, and these groups face substantial challenges in getting adequate funding for their activities.

No Progress on Consolidating Nuclear Weapons and Weapons-Usable Materials

The number of sites and transports with nuclear weapons, plutonium, or HEU, remains similar to today (or has even increased), and civil use of HEU is ongoing, with few conversions or shut-downs of HEU-fueled research reactors, continued use of HEU for medical isotope production, and no end in sight. The number of reprocessing and bulk handling facilities for plutonium and HEU is equal to or larger than the number today, as is the annual scale of bulk processing of these materials.

- States are continuing to produce plutonium and HEU for weapons; reprocessing and enrichment have spread to additional countries; stocks of civil plutonium have continued to expand (now amounting to over 300 tons of separated plutonium); more countries are building or planning plutonium-fueled fast breeder reactors.

Eroding Confidence in Effective Nuclear Security

- Nuclear security is still considered highly secret, and very little information about this topic is being exchanged, beyond bland assurances that offer little basis for confidence or for identification of weak points requiring action.

Ineffective Nuclear Security Dialogue

- Over time, processes for driving international decisions on next steps in nuclear security have atrophied. No genuinely effective new mechanisms for bringing high-level policy makers together to advance the field have emerged.

Related Steps

- India and Pakistan continue to expand their nuclear arsenals, now numbering many hundreds of weapons, and are continuing to rely on doctrines likely to lead to early dispersal of those weapons in the event of a crisis.
- North Korea continues to expand its arsenal, to well over 100 nuclear weapons by this time; Iran is scaling up its enrichment program as the constraints of the Joint Comprehensive Plan of Action expire, and has announced plans to begin producing HEU for submarine fuel, which it will eventually remove from IAEA safeguards as it moves into the military sphere, as permitted by the nuclear Non-Proliferation Treaty (NPT); other countries are establishing nuclear programs seen as posing significant proliferation risks.
- Few measures have been taken to increase the risks nuclear and radioactive smugglers would face.
- Many dangerous radioactive sources still have only minimal, if any, security measures in place, and little progress has been made in substituting other technologies for the most dangerous radiological sources.

Unfortunately, just as there are real opportunities to reach the goals of the high-security scenario, there are real dangers that the world will slide downward toward the low-security scenario. The seeds of complacency are already planted in many countries, and may begin to grow.

Of course, the risk of nuclear terrorism in 2030 will be determined not just by the nuclear security measures in place but also by other factors, such as the evolution of the terrorist threat. No one knows what will happen to the IS, al Qaeda, the broader jihadist movement, or other terrorist threats by 2030. Either the high-security or the low-security scenario could occur in concert with high or low future terrorist threats in 2030. But it is precisely because of this uncertainty, and the real risk that terrorists in 2030 will still be capable and bent on mass destruction, that it is so important to ensure that all the world's potential nuclear bomb material is secure and that we can account for it.

The future growth and spread of nuclear energy is another important factor not addressed in detail in this report. Choices about the nuclear fuel cycle—particularly whether fuel cycles that involve large-scale reprocessing and handling of separated plutonium become widespread—will affect the number of locations where weapons-usable nuclear material could be stolen.[5] Fortunately, the economics of reprocessing is poor, and most nuclear power plants today use low-enriched uranium (LEU) fuel that cannot be used to make a nuclear bomb without technologically demanding further enrichment. More nuclear reactors of that kind would not offer more opportunities for terrorists to get nuclear bomb material, but it would mean more opportunities for nuclear sabotage. Either of the scenarios described here could feature large or small growth of nuclear energy. We would argue, however, that the high-security scenario would offer a higher chance of large-scale nuclear energy growth, as it would leave a much lower risk of the nuclear industry being devastated by a Fukushima-scale radioactive release resulting from terrorist action.

The low-security scenario, given the possibility of highly capable terrorists in 2030, would lead to an unacceptably high risk of nuclear terrorism. Indeed, in the low-security scenario, there would be a very real possibility that by 2030, a nuclear sabotage causing a "security Fukushima"; a dirty bomb attack forcing the evacuation of many blocks of a major city; or even the incineration of the heart of a major city in a terrorist nuclear blast would already have occurred. The dangers of the low-security scenario are real, and affect every country—though some (particularly the United States) are clearly more likely to be targeted than others. The countries of the world must continue to work together to stay off the low-security path and move toward the high-security one.

5 For a recent review of the history, current status, and prospects for reprocessing, see *Plutonium Separation in Nuclear Power Programs: Status, Problems, and Prospects of Civilian Reprocessing Around the World* (Princeton, N.J.: International Panel of Fissile Materials, 2015), http://fissilematerials.org/library/rr14.pdf (accessed March 17, 2016).

3. The Evolving Threat of Nuclear Terrorism

Statesmen, intelligence analysts, and academics have all assessed the threat of nuclear terrorism in recent years. Today, Republican and Democratic Party leaders in the United States and the heads of state or government from dozens of countries in the international community—including Presidents Putin[6] and Obama[7]—recognize that the threat of nuclear terrorism is real, urgent, and commands action. Yukiya Amano, Director General of the International Atomic Energy Agency (IAEA) summarized the present danger, saying, "the threat of nuclear terrorism is real, and the global nuclear security system needs to be strengthened in order to counter that threat."[8] Director-General Amano's statement, made before the rise of the Islamic State (IS), is even truer today than it was when he made it in 2013.

Making a crude nuclear bomb would not be easy, but is potentially within the capabilities of a technically sophisticated terrorist group, as numerous government studies have confirmed.[9] The main barrier is getting hold of the needed nuclear material – but there are multiple cases in which kilogram quantities of plutonium or highly enriched uranium (HEU) have been stolen (see "Empirical Evidence of Insecure Nuclear Material," p. 24). The nuclear material for a bomb is small and difficult to detect, making it a major challenge to stop nuclear smuggling, or to recover nuclear material after it has been stolen.

Moreover, the potential consequences of successful nuclear terrorism would be immense. The heart of a major city could be reduced to a smoldering radioactive ruin, leaving tens

6 George W. Bush and Vladimir Putin, "Joint Statement by U.S. President George Bush and Russian Federation President V. V. Putin Announcing the Global Initiative to Combat Nuclear Terrorism" (Washington, D.C.: The White House, July 15, 2006), http://georgewbush-whitehouse.archives.gov/news/releases/2006/07/20060715-2.html (accessed February 6, 2016).

7 Obama, "Remarks in Prague."

8 Anthony Chibarirwe, "IAEA Chief Warns of the Threat of Nuclear Terrorism," *theTrumpet.com*, July 7, 2013, https://www.thetrumpet.com/article/10787.19.0.0/world/terrorism/iaea-chief-warns-of-threat-of-nuclear-terrorism (accessed February 16, 2016). There are many assessments of the nuclear terrorism threat in the public literature. For an updated U.S.-Russian assessment—which was the briefing on the threat provided to the Sherpas before the 2014 Nuclear Security Summit—see William H. Tobey and Pavel S. Zolotarev, "The Nuclear Terrorism Threat," paper presented at Meeting of the 2014 Nuclear Security Summit Sherpas, hosted by the Thai Ministry of Foreign Affairs Pattaya, Thailand, 2014, http://belfercenter.ksg.harvard.edu/publication/23879 (accessed February 9, 2016).

9 See Matthew Bunn and Anthony Wier, "Terrorist Nuclear Weapon Construction: How Difficult?," *Annals of the American Academy of Political and Social Science*, Vol. 607, September 2006, pp. 133–149.

or hundreds of thousands of people dead, and countless more injured.[10] Terrorists—either those who committed the attack or others—would probably claim they had more bombs already hidden in other cities (whether they did nor not), and the fear that this might be true could lead to panicked evacuations, creating widespread havoc and economic disruption. In what would inevitably be a desperate effort to prevent further attacks, traditional standards of civil liberties would likely be jettisoned, and the country attacked might well lash out militarily at whatever countries it thought might bear a portion of responsibility.[11] In 2005, then-UN Secretary-General Kofi Annan warned that the reverberating global economic effects would push "tens of millions of people into dire poverty," creating "a second death toll throughout the developing world."[12] Terrorist use of nuclear weapons may not be a high probability—but the consequences would be so severe that even a low probability should be enough to motivate an intense focus on steps such as nuclear security to reduce the risk.

As described in an appendix to this report, perceptions of the danger of nuclear terrorism have evolved during the nuclear age. In the 1970s and 1980s—long before the Internet, with the detailed information on nuclear weapons now available—intelligence agencies assessed that terrorists might well be able to make a crude nuclear bomb if they got the needed materials. But they also suggested that such large-scale violence would not serve terrorists' political objectives, and was therefore very unlikely.

The attacks of September 11, 2001, eliminated the complacent belief that terrorists would avoid mass slaughter, making clear—as the Japanese terror cult Aum Shinrikyo's nerve

10 There have been many assessments of the impact of such an attack, though they usually focus narrowly on the death and destruction the explosion itself would cause, rather than the reverberating economic and political aftershocks. In a 2003 report, the present author and two co-authors estimated that if terrorists detonated a 10-kiloton bomb (that is, one with the explosive power of 10,000 tons of TNT, somewhat smaller than the bomb that obliterated Hiroshima) at Grand Central Station in Manhattan on a typical workday, the attack could kill half a million people and cause roughly $1 trillion in direct economic damage. See Matthew Bunn, Anthony Wier, and John Holdren, *Controlling Nuclear Warheads and Materials: A Report Card and Action Plan* (Cambridge, MA, and Washington, D.C.: Project on Managing the Atom, Harvard University, and Nuclear Threat Initiative, 2003), http://www.nti.org/media/pdfs/controlling-nuclear-warheads-and-materials-2003.pdf?_=1322768605 (accessed February 9, 2016). This was a rough estimate based on a relatively crude analysis. For more detailed recent analyses (though often focusing on attacks in areas and times with much lower population density than Midtown Manhattan on a workday) see, for example, U.S. Homeland Security Council, *National Planning Scenarios: Final Version 21.3* (Washington, D.C.: U.S. Homeland Security Council, March, 2006), https://www.llis.dhs.gov/sites/default/files/NPS-LLIS.pdf (accessed July 19, 2014) ; Charles Meade and Roger C. Molander, *Considering the Effects of a Catastrophic Terrorist Attack* (Washington, D.C.: RAND, 2006), http://www.rand.org/pubs/technical_reports/2006/RAND_TR391.pdf (accessed July 7, 2015); Ira Helfand, Lachlan Forrow, and Jaya Tiwari, "Nuclear Terrorism," *British Medical Journal*, Vol. 324 (February 9, 2002), http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1122278/ (accessed May 27, 2015), pp. 356–358.

11 For a useful scenario of the swirl of decision-making in the immediate aftermath of such an attack, see Brian M. Jenkins, *Will Terrorists Go Nuclear?* (Amherst, N.Y.: Prometheus, 2008), pp. 323–353.

12 Kofi Annan, "A Global Strategy for Fighting Terrorism: Keynote Address to the Closing Plenary," *The International Summit on Democracy, Terrorism and Security* (Madrid: Club de Madrid, 2005), http://www.un.org/press/en/2005/sgsm9757.doc.htm (accessed February 9, 2016).

gas attack in the Tokyo subway had years before—that the world had entered an age of mass casualty terrorism, in which certain adversaries seek and have the capability to inflict maximum possible carnage to achieve their ends. Indeed, both al Qaeda and Aum Shinrikyo have made serious efforts to get nuclear weapons, and there is suggestive evidence of Chechen terrorist interest as well (including incidents of terrorist teams carrying out reconnaissance at Russian nuclear weapon storage sites).[13] Within weeks after the 9/11 attacks, the U.S. intelligence community was assessing that making a crude nuclear bomb was "well within" al Qaeda's capabilities if it could obtain the needed nuclear material—separated plutonium or HEU.[14] Over the next two years, a special CIA team evaluating al Qaeda's nuclear, chemical, and biological activities found that al Qaeda had a focused nuclear weapons program under the leadership of "nuclear CEO" Abdel Aziz al-Masri, which reported directly to Ayman al-Zawahiri (then the group's second-in-command, now its leader); that a Pakistani network that included leading Pakistani nuclear scientists and a former commander of Pakistan's feared Inter-Services Intelligence (ISI) spy agency had been working to assist al Qaeda's nuclear and biological efforts; that bin Laden and al-Zawahiri had met with two leading Pakistani nuclear weapons scientists to discuss nuclear weapons at length in the weeks leading up to the 9/11 attacks; and that al Qaeda's effort had proceeded as far as carrying out crude but sensible tests of conventional explosives for the nuclear weapons program in the Afghan desert.[15] In 2002–2003, long after the loss of their Afghan sanctuary, al Qaeda attempted to buy three objects it thought were Russian nuclear weapons in Saudi Arabia, and commissioned a *fatwa,* or religious ruling, authorizing the use of nuclear weapons against American civilians.[16]

Since then, core al Qaeda has suffered serious blows, including the death of Osama bin Laden, and the capture or killing of many of his subordinates. The organization has, however, proved resilient, and some of its regional affiliates have expanded their capabilities.

13 See discussion in Matthew Bunn, Yuri Morozov, Rolf Mowatt-Larssen, Simon Saradzhyan, William Tobey, Viktor I. Yesin, and Pavel S. Zolotarev, *The U.S.-Russia Joint Threat Assessment of Nuclear Terrorism* (Cambridge, MA: Belfer Center for Science and International Affairs, Harvard Kennedy School, and Institute for U.S. and Canadian Studies, 2011), http://belfercenter.ksg.harvard.edu/publication/21087/ (accessed February 9, 2016).

14 Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction, *Report to the President* (Washington, D.C.: WMD Commission, 2005), http://www.gpo.gov/fdsys/pkg/GPO-WMD/pdf/GPO-WMD.pdf (accessed February 9, 2016), pp. 272, 277.

15 For overviews of this intelligence, see Rolf Mowatt-Larssen, *Al Qaeda Weapons of Mass Destruction Threat: Hype or Reality* (Cambridge, MA: Belfer Center for Science and International Affairs, January 2010), http://belfercenter.ksg.harvard.edu/files/al-qaeda-wmd-threat.pdf (accessed February 9, 2016); George Tenet, *At the Center of the Storm: My Years at the CIA* (New York: HarperCollins, 2007), pp. 259–280; and Bunn et al., *The U.S.-Russia Joint Threat Assessment of Nuclear Terrorism*.

16 For accounts of this episode, see Tenet, *At the Center of the Storm*, p. 272; Mowatt-Larssen, *Al Qaeda WMD Threat*, pp. 22, 26–27.

With IS dominating the world's headlines, al Qaeda may feel pressure to carry out a spectacular attack to demonstrate that it is still at the forefront of the violent jihadist movement.

Will the Islamic State Pose a Nuclear Threat?

Even more important, perhaps, is the rise of the IS, out of the ashes of what was once al Qaeda in Iraq. In 2014 in particular, IS seized major portions of Iraq and Syria, including the cities of Mosul and Raqqa, and declared an Islamic caliphate.[17] IS now has substantial territory and access to financial assets and ongoing revenues in Iraq, Syria, and Libya.[18] Some 43 groups in Europe, Asia, or Africa have sworn allegiance or support for IS, multiplying its personnel and financial resources.[19] Though its gains in Syria and Iraq have been eroded in recent months, the group has demonstrated a penchant for carrying out or associating itself with operations outside of its core region. Since October 2015, IS attacks in Ankara, Beirut, Paris, Tunis, and on the Sinai Peninsula have killed over 500 people.[20]

The case of Ilyass Boughalab—who left his position working in the vital areas of a Belgian nuclear power plant to fight for terrorists in Syria—makes clear that the risk of IS inspiring individuals working at sensitive facilities is not hypothetical (see box, "Insider Sabotage and a Terrorist in a Belgian Nuclear Power Plant," p. 29). Russia too, may face a growing risk of IS-inspired threats. According to a recent report from the Carnegie Moscow Center, "The ethnic composition of the Ural region is changing as a result of an influx of migrants from Central Asia and the Caucasus, occasionally causing tensions between migrants and locals... A number of Muslims from the Ural Federal District have participated in terrorist acts in Central Asia and the Caucasus or have gone to fight for the

17 For IS's caliphate declaration—which is also a summary of the group's ideology and ambitions—see Islamic State, *This is the Promise of Allah* (Al Hayat Media Center, 2014), https://ia902505.us.archive.org/28/items/poa_25984/EN.pdf (accessed February 9, 2016). For a useful description of the group's ambitions and apocalyptic vision, see Graeme Wood, "What ISIS Really Wants," *The Atlantic,* March, 2015, http://www.theatlantic.com/features/archive/2015/02/what-isis-really-wants/384980/ (accessed February 9, 2016).

18 Sergio Pecanha and Derek Watkins, "ISIS' Territory Shrank in Syria and Iraq This Year," *The New York Times*, interactive display, December 22, 2015, http://www.nytimes.com/interactive/2015/12/18/world/middleeast/Where-ISIS-Gained-and-Lost-Territory-Islamic-State.html?_r=0 (accessed January 3, 2016).

19 "Islamic State's 43 Global Affiliates Interactive World Map," *IntelCenter*, http://intelcenter.com/maps/is-affiliates-map.html#gs.WvTOr0I (accessed December 15, 2015).

20 Beatrix Immenkamp, "ISIL/Daesh and Nonconventional Weapons of Terror" (Brussels: European Parliamentary Research Service, December 2015), p. 1.

self-proclaimed Islamic State in the Middle East."[21] Unlike the Caucasus region, the Ural Federal District encompasses some of Russia's largest nuclear weapons-related facilities.

IS's capabilities are substantial. If the group were to pursue nuclear weapons, it has more money, controls more territory and people, and enjoys a greater ability to recruit experts globally than al Qaeda at its strongest ever had. Moreover, unlike many terrorist groups, IS has demonstrated an ability to manage implementation of large-scale, long-term projects.[22]

IS's intentions with respect to nuclear terrorism remain more obscure. There is no publicly available evidence of a significant IS nuclear weapons effort. The group's apocalyptic ideology, however, envisions a final war between its forces and those of the United States and the West (the "Crusaders"), which the group expects ultimately to win. For taking on the world's leading superpower and its allies, nuclear weapons would surely be extremely useful. The group's documented indiscriminate mass casualty attacks and horrific individual acts of cruelty and mayhem demonstrate a significant willingness to inflict destruction on a wide scale and disregard for the Islamic prohibition on the slaughter of innocents.

In November 2015, Belgian police discovered that some IS operatives involved in the Paris attacks had taken hours of surveillance video at the home of a senior official of SKN-CEN, a Belgian nuclear research center with a substantial amount of HEU on-site. Investigators have not managed to confirm what the terrorists were seeking to accomplish through this monitoring. One possibility—and it is only a possibility—is that they envisioned kidnapping the official or his family in an effort to force him to help them gain access to the nuclear facility and its materials.[23] This focused, extended monitoring of a nuclear official at a sensitive site is the most worrying indicator of IS nuclear intent to date.

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21 Alexey Malashenko and Alexey Starostin, *The Rise of Nontraditional Islam in the Urals* (Moscow: Carnegie Moscow Center, September 30, 2015), http://carnegie.ru/2015/09/30/rise-of-nontraditional-islam-in-urals/iie6 (accessed January 3, 2016), p. 1.

22 For a discussion of how central this capability is to terrorist nuclear, chemical, or biological efforts, see Kathleen Vogel, *Looming Menace or Phantom Danger? A New Framework for Assessing Bioweapons Threats* (Baltimore: Johns Hopkins University Press, 2013). For a discussion of how difficult management challenges are for most terrorist groups, see Jacob N. Shapiro, *The Terrorist's Dilemma: Managing Violent Covert Organizations* (Princeton, N.J.: Princeton University Press, 2013).

23 See, for example, Milan Schreuer and Alissa J. Rubin, "Video Found in Belgium of Nuclear Official May Point to Bigger Plot," *New York Times,* February 18, 2016, http://www.nytimes.com/2016/02/19/world/europe/belgium-nuclear-official-video-paris-attacks.html (accessed March 11, 2016); Patrick Malone and R. Jeffrey Smith, "A Terrorist Group's Plot to Create a Radioactive 'Dirty Bomb'," *Center for Public Integrity,* February 29, 2018, http://www.publicintegrity.org/2016/02/29/19376/terrorist-group-s-plot-create-radioactive-dirty-bomb (accessed March 11, 2016); "140 Militairen Gaan Nucleaire Sites Bewaken," (in Dutch), *De Morgen,* March 4, 2016. Contrary to the Malone and Smith piece, there is no clear evidence one way or the other as to whether the monitoring related to a desire to obtain radiological materials for a "dirty bomb," get HEU for a nuclear explosive, sabotage the facility, or some other motive.

Other publicly available indicators of nuclear intent are little more than suggestions. In May of 2015, *Dabiq*—the IS English-language propaganda organ—published an article purportedly written by John Cantlie, a hostage who may have turned propagandist for the group, which had a paragraph fantasizing about the group buying a nuclear weapon from corrupt officials in Pakistan.[24] The article offered no evidence that such a plan existed or had been acted upon, much less that the weapons were available in Pakistan. The *New York Times* reported that IS was actively seeking to purchase "red mercury"—a mythical material believed by some to be useful in nuclear weapons, which has been the center of countless nuclear smuggling scams—over a period of more than a year.[25] That might be a signal of nuclear intent, but it is also a signal of a lack of any real nuclear expertise, at least on the part of those involved in that particular effort.

In short, while there is as yet no publicly available evidence of a focused IS nuclear effort of the kind al Qaeda once had, over the long term IS may be as motivated to carry out dramatic mass-casualty operations as al Qaeda, and may be more capable of pulling together the needed capabilities. The rise of IS clearly raises the threat of nuclear terrorism. The full magnitude of the increase in threat is uncertain. It can be mitigated by increased security, as well as by a range of efforts to degrade and defeat IS.

24 Heather Saul, "ISIS Claims it Could Buy Its First Nuclear Weapon from Pakistan Within a Year," *Independent*, May 22, 2015, http://www.independent.co.uk/news/world/middle-east/isis-claims-it-could-buy-its-first-nuclear-weapon-from-pakistan-within-12-months-10270525.html (accessed January 3, 2016).

25 C.J. Chivers, "The Doomsday Scam," *New York Times Magazine,* November 19, 2015, http://www.nytimes.com/2015/11/22/magazine/the-doomsday-scam.html?_r=0 (accessed March 5, 2016).

Growing Cyber Security Risks

Cyberattacks pose a growing threat to nuclear facilities and materials.[i] While the Stuxnet virus that damaged Iran's Natanz centrifuge facility is the best-known example, many other incidents have occurred, from the insider placement of a virus in the computers of the Ignalina nuclear power plant in 1992 to the December 2014 hacking of the computer systems of the South Korean nuclear plant operator (not including the reactor control systems).[ii] A number of incidents have taken place at U.S. nuclear power plants as well, including some that rendered systems important to safety inoperable for hours.[iii]

Three main forms of cyberattack are particularly significant for nuclear security. First, a cyberattack might be used to sabotage a nuclear facility, as Stuxnet reportedly did. Second, a cyberattack might contribute to a physical theft or sabotage attempt—for example, by confusing or disabling alarm and assessment systems, unlocking doors, or altering material accounting systems. Third, adversaries might use cyber weaknesses to get access to sensitive nuclear information. Beyond items such as the facility blueprints and employee personal data hacked in South Korea, cyber means could be used to gain information ranging from nuclear weapon designs to details on nuclear security systems and their weaknesses.

Several trends are increasing the risk of cyberattack in nuclear facilities. First, these facilities are in the process of replacing their analog technology with digital systems, which are more vulnerable to cyber intrusions. Second, not all of these new systems are designed with effective protections against cyber intrusions. Third, the inclusion of new technology linking systems together may reduce the effective level of backups and

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i Caroline Baylon, with Roger Brunt and David Livingstone, *Cyber Security at Civil Nuclear Facilities: Understanding the Risks* (London: Chatham House, September 2015), https://www.chathamhouse.org/sites/files/chathamhouse/field/field_document/20151005CyberSecurityNuclearBaylonBruntLivingstoneUpdate.pdf (accessed March 13, 2016).

ii For a description of these episodes, see, for example, Baylon, *Cyber Security at Civil Nuclear Facilities,* pp. 3–5. In the Ignalina case, the employee who introduced the virus reportedly did so to highlight the threat and be rewarded for detecting the malware. In the South Korean case, the South Korean government later accused North Korea of being behind the hacking. See "South Korea Accuses North of Cyber-attacks on Nuclear Plants," *Security Week,* March 17, 2015, http://www.securityweek.com/south-korea-accuses-north-cyber-attacks-nuclear-plants (accessed February 18, 2016); Sohee Kim and Meeyoung Cho, "South Korean Prosecutors Investigate Data Leak at Nuclear Power Plants," *Reuters,* December 21, 2014, http://www.reuters.com/article/us-southkorea-nuclear-idUSKBN0JZ05120141221 (accessed February 18, 2016).

iii Baylon, *Cyber Security at Civil Nuclear Facilities,* pp. 3–5.

redundancies. Fourth, nuclear security technology itself is increasingly digital, from alarm systems to access control. Fifth, while many systems at nuclear sites are "air-gapped"—not connected to the broader Internet—it is quite common for this air-gapping to be compromised by connecting laptops or other systems to them as part of equipment and software maintenance and testing.

The threat is not limited to civilian nuclear facilities. A 2013 Defense Science Board report warned that most U.S. nuclear command and control systems "have not been assessed (end-to-end)" against the most sophisticated potential state-level attacks.[iv] Then head of U.S. Strategic Command (STRATCOM) General C. Robert Kehler told a March 2013 Senate hearing that he was "very concerned with the potential of a cyber-related attack on our nuclear command and control and on the weapons systems themselves."[v] We do not know how vulnerable nuclear states with less advanced cyber capabilities may be.

More and more countries are addressing the cyber threat to nuclear facilities. The IAEA and the World Institute for Nuclear Security (WINS) have both published guidance on protecting against cyber threats to nuclear security.[vi] In 2015, the IAEA held a major international conference on cybersecurity for nuclear facilities, and has since launched a five-year plan to enhance understanding of cyber threats.[vii] Since 2012, at least 17 states have incorporated cybersecurity into their nuclear security laws and regulations. But the 2016 edition of the *NTI Nuclear Security Index* found no publicly available evidence that 15 of the 23 states with a kilogram or more of nuclear material had yet put requirements in place for their nuclear facilities to protect against cyberattacks.[viii]

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iv Defense Science Board, *Resilient Military Systems and the Advanced Cyber Threat* (Washington, D.C.: Department of Defense, Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, January, 2013), http://www.acq.osd.mil/dsb/reports/ResilientMilitarySystems.CyberThreat.pdf (accessed February 18, 2016).

v Timothy Farnsworth, "Study Sees Cyber Risk for U.S. Arsenal," *Arms Control Today,* April 2, 2013, https://www.armscontrol.org/act/2013_04/Study-Sees-Cyber-Risk-for-US-Arsenal (accessed February 18, 2016).

vi See *Effectively Integrating Physical and Cyber Security* (Vienna, Austria: World Institute for Nuclear Security, May 2015) and International Atomic Energy Agency, *Computer Security at Nuclear Facilities*, IAEA Nuclear Security Series No. 17 (Vienna: IAEA, 2011).

vii "International Conference on Computer Security in a Nuclear World: Expert Discussion and Exchange," Vienna, Austria, 1–5 June 2015.

viii Nuclear Threat Initiative and Economist Intelligence Unit, *NTI Nuclear Security Index: Building a Framework for Assurance, Accountability, and Action*, 3rd Edition (Washington, D.C.: NTI, January 2016), http://ntiindex.org/ (accessed March 11, 2016).

Growing International Consensus That the Threat is Real

In recent years, countries and international organizations around the world have joined in highlighting the importance of the nuclear terrorism threat. United Nations Secretary General Ban-Ki Moon, for example, has warned that, "Nuclear terrorism is one of the most serious threats of our time. Even one such attack could inflict mass casualties and create immense suffering and unwanted change in the world forever. This prospect should compel all of us to act to prevent such a catastrophe."[26] Two years later, Mohammed El Baradei, then Director General of the IAEA, described "an extremist group getting hold of nuclear weapons or materials" as "the gravest threat faced by the world." Classified government studies in several countries, including, among others, Russia, the United Kingdom, and Australia, have confirmed the conclusion of U.S. government studies that it is plausible that a sophisticated terrorist group could make a crude nuclear bomb if it possessed the necessary materials.

At the first Nuclear Security Summit in 2010, the assembled leaders agreed that, "nuclear terrorism is one of the most challenging threats to international security."[27] At that summit and subsequent ones, many heads of state have emphasized the threat in their remarks.

Russia, despite its decision not to participate in the 2016 Nuclear Security Summit, has clearly concluded that nuclear terrorism is a serious threat. Russia first proposed the International Convention on the Suppression of Acts of Nuclear Terrorism (ICSANT), with President Vladimir Putin warning in 2004 of the urgent need to avert "any attempts by terrorists to get hold of nuclear weapons or any other nuclear materials."[28] In 2005, Putin joined with U.S. President George W. Bush in the Bratislava nuclear security initiative, describing nuclear terrorism as "one of the gravest threats our two countries face."[29] In 2006, Bush and Putin joined in launching the GICNT, which the two countries continue to co-chair.

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26 Ban-Ki Moon, "Secretary General Welcomes Swift Entry Into Force of Nuclear Terrorism Convention, Calls on All States to Ratify Without Delay" (New York: United Nations, June 13, 2007), http://www.un.org/press/en/2007/sgsm11040.doc.htm (accessed January 17, 2016).

27 Communique of the Washington Nuclear Security Summit," The White House, Office of the Press Secretary, April 13, 2010, https://www.whitehouse.gov/the-press-office/communiqu-washington-nuclear-security-summit, (accessed February 9, 2016).

28 "Putin Eyes Nuclear Terrorism," *Moscow Times,* November 2, 2004, http://www.themoscowtimes.com/news/article/putin-eyes-nuclear-terrorism/227281.html (accessed January 17, 2016).

29 "Joint Statement by President George W. Bush and President Vladimir V. Putin: Nuclear Security Cooperation," February 24, 2005, https://www.gpo.gov/fdsys/pkg/WCPD-2005-02-28/pdf/WCPD-2005-02-28-Pg322.pdf (accessed February 9, 2016).

Senior Russian officials have offered even more alarming assessments of the threat. In 2001, for example, General Igor Valynkin, then commander of the force that guards Russia's nuclear weapons, confirmed two incidents of terrorist teams carrying out reconnaissance at nuclear weapon storage facilities (whose locations are a state secret in Russia).[30] The Russian state newspaper reported two additional incidents of terrorists carrying out reconnaissance on nuclear weapon transport trains.[31] In 2005, Russian Interior Minister Rashid Nurgaliev—in charge of the forces that guard most Russian nuclear facilities—announced that "international terrorists have planned attacks against nuclear and power industry installations" and intended to "seize nuclear materials and use them to build weapons of mass destruction for their own political ends."[32] In 2007, Anatoly Safonov, then Putin's special representative for counter-terrorism (and former deputy chief of the FSB, Russia's domestic security agency) warned that "we know for sure, with evidence and facts in hand, about this steady interest and a goal pursued by terrorists to obtain what is called nuclear weapons and nuclear components in any form."[33] In 2011, a joint report by U.S. and Russian experts summarized the threat in a way that is still relevant today:

> "Nuclear terrorism is a real and urgent threat. Urgent actions are required to reduce the risk. The risk is driven by the rise of terrorists who seek to inflict unlimited damage, many of whom have sought justification for their plans in radical interpretations of Islam; by increased availability of weapons-usable materials; and by globalization, which makes it easier to move people, technologies, and materials across the world.
>
> Making a crude nuclear bomb would not be easy, but is potentially within the capabilities of a technically sophisticated terrorist group, as numerous government studies have confirmed. Detonating a stolen nuclear weapon would likely be difficult for terrorists to accomplish, if the weapon was equipped with modern technical safeguards . . . Terrorists could, however, cut open a stolen nuclear weapon and make use of its nuclear material for a bomb of their own.

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

31 Vladimir Bogdanov, "Propusk K Beogolovkam Nashli U Terrorista," [A pass to warheads found on a terrorist], *Rossiskaya Gazeta*, November 1, 2002.

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

33 "Russian Foreign Ministry Aware of Terrorist Attempts to Obtain Nuclear Weapons—Diplomat," *Interfax*, September 27, 2007.

Empirical Evidence of Insecure Nuclear Material

Assessments of the nuclear terrorism threat must include an element of imagination, as a terrorist attack with nuclear explosives has never occurred. One realm of hard, empirical data, however, is direct and empirical evidence of the risk that terrorists might be able to get weapons-usable nuclear material—incidents involving the seizure of such material outside of authorized control.

The IAEA tracks such incidents, and in 2015 the Agency reported:

> In the 1993-2014 period, group 1 [illegal possession, sale, or movement of nuclear material] confirmed incidents included highly enriched uranium (13), plutonium (3), and plutonium beryllium neutron sources (5). Some of these incidents involved attempts to sell or traffic these materials across international borders.
>
> A small number of these incidents involved seizures of kilogram quantities of potentially weapons usable material, but the majority involved gram quantities. In some of these cases, there were indications that the seized material was a sample from a larger unsecured stockpile.
>
> Incidents involving attempts to sell nuclear or other radioactive material indicate that there is a perceived demand for such material. The number of successful transactions is not known and therefore it is difficult to accurately characterize an 'illicit nuclear market'. Where information on motives is available, it indicates financial gain to be the principal incentive behind the majority of events. Many trafficking incidents could be characterized as 'amateur' in nature as demonstrated by ad-hoc planning and a lack of resources and technical proficiency. However, there are a few significant cases that appear more organized, better resourced, and that involved perpetrators with a track record in trafficking nuclear/radioactive material.[i]

Thus, the IAEA has reported on 16 cases, and others are known to have occurred.[ii] None of the reported seizures involved enough material to cause a nuclear detonation—though an attempted theft of 18.5 kilograms of HEU from a

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i "IAEA Incident and Tracking Data Base Fact Sheet" (Vienna: International Atomic Energy Agency, 2015) available at http://www-ns.iaea.org/downloads/security/itdb-fact-sheet.pdf (accessed February 12, 2016).

ii Bunn et al., *The Joint Threat Assessment of Nuclear Terrorism,* pp. 18–19. For a useful unclassified summary of the cases, see Lyudmilla Zaitseva, *Illicit Trafficking in Nuclear Materials: Assessing the Past Two Decades*, in Joseph F. Pilat and Nathan E. Busch, eds., Routledge Handbook of Nuclear Proliferation and Policy (New York: Routledge, 2015), pp. 440–454.

Russian nuclear facility in 1998 may have come close to that level, depending on its enrichment. Nonetheless, the incidents are important for three reasons. First, they are incontrovertible evidence of nuclear security failures. The material was found in a place where it was not supposed to be, in the possession of people who should not have had it. Second, until the details of each incident are fully understood—who stole the material? How was it removed? Where was it headed?—we cannot be confident that the leak has been plugged. Third, as noted by the IAEA, in some cases, the seized material was advertised as a sample of a larger cache for sale, which might still be outside of authorized control.

After an initial burst of activity in the 1990s, related to the parlous state of post-Soviet nuclear security, the number of incidents has remained fairly steady, with new seizures in 2003, 2006, 2010 (Georgia), and 2011 (Moldova). The Moldovan case was perhaps the most concerning of recent years, as there appears to have been a somewhat more organized criminal group involved; there was a real buyer from Sudan trying to purchase the material; the smugglers claimed to have nine kilograms of HEU for sale, and also access to plutonium; and documents at one of the smuggler's apartments listed a wide range of conventional arms for sale, from armored personnel carriers to helicopters. Moldovan police believe the ringleader, a retired Russian colonel, remains at large. The HEU appears to be very similar to the materials seized in Bulgaria in 1999 and Paris in 2001, suggesting that a stash of stolen HEU of unknown quantity has been in smuggler's hands since the 1990s.[iii]

The seizures of fissile material that have occurred are both empirical evidence of nuclear security vulnerabilities and key leads for investigating how best to redress them. Unfortunately, competing political interests among nation states—particularly between Russia, the United States, and countries where recent seizures have taken place—have so far hampered credible and comprehensive investigation of these incidents.

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iii Douglas Birch and R. Jeffrey Smith, "The Fuel for a Nuclear Bomb is in the Hands of an Unknown Black Marketeer From Russia, U.S. Officials Say," *Center for Public Integrity*, November 12, 2015, http://www.publicintegrity.org/2015/11/12/18850/fuel-nuclear-bomb-hands-unknown-black-marketeer-russia-us-officials-say (accessed March 15, 2016); Desmond Butler and Vadim Ghirda, "Nuclear Black Market Seeks IS Extremists," *Associated Press,* October 7, 2015.

> The nuclear material for a bomb is small and difficult to detect, making it a major challenge to stop nuclear smuggling, or to recover nuclear material after it has been stolen. Hence, a primary focus in reducing the risk must be to keep nuclear material and nuclear weapons from being stolen, by continuously improving their security . . ."[34]

One way to estimate the threat posed by nuclear terrorism is by thinking of it as the product of would-be perpetrators' intentions and capabilities, minus efforts by others to mitigate the danger:

> Threat = (Intentions × Capabilities) – Mitigating Actions

Today, both terrorist intentions and terrorist capabilities remain deeply worrisome. While a broad international coalition is working to defeat both IS and al Qaeda, the danger posed by large and sophisticated violent extremist organizations is likely to persist for years to come. As will be described in this report, great progress has been made in improving nuclear security, the most critical area of mitigating action. But given the scale of the threat, much more remains to be done.

34 Bunn, et al., *The U.S.-Russia Joint Threat Assessment of Nuclear Terrorism* (Cambridge, MA: Report for Belfer Center for Science and International Affairs, Harvard Kennedy School, Institute for U.S. and Canadian Studies, June 6, 2011), http://belfercenter.ksg.harvard.edu/files/Joint-Threat-Assessment%20ENG%2027%20May%202011.pdf (accessed March 13, 2016).

4. Assessing Progress and Gaps

To determine how to achieve the goals outlined in this report, it is first necessary to evaluate what has been gained and what international organizations, countries, and organizations responsible for nuclear security still need to do.

Reducing the risk of nuclear terrorism is not just about preventing theft. Countries and international organizations must also stop nuclear and radiological smuggling, strengthen emergency responses, eliminate terrorist groups pursuing nuclear and radiological weapons, prevent and deter state-sponsored terrorism, and more. But security and accounting measures to prevent terrorists and thieves from getting nuclear weapons and materials are the most important single chokepoint blocking the terrorist pathway to the bomb.

The purpose of strengthening nuclear security is to reduce the risk of nuclear theft and terrorism to the lowest possible level. Determining the correct balance of risk reduction achieved by increasing security versus the increased cost and inefficiencies that come with it is a difficult task, particularly considering that there exists no accurate measure for assessing the level of risk that exists at any given facility or how much risk reduction can be achieved with added security measures.[35]

As discussed elsewhere in this report, the goal of reducing the risk of theft and terrorism requires achieving effective and lasting security for all nuclear weapons and weapons-usable nuclear materials against the full spectrum of threats adversaries might plausibly pose at the locations where those weapons and materials exist. Assessing progress toward this goal is extremely difficult, as the specifics of nuclear security arrangements in most countries are secret. Even national governments themselves may not have a full picture of the effectiveness of their nuclear security arrangements: before the 2012 protester intrusion at Y-12, for example, nuclear security managers at U.S. Department of Energy

35 The *NTI Nuclear Security Index* provides an assessment of the overall nuclear materials security conditions in a country by looking at openly available information on indicators in five categories relevant to the risk of theft. The index is largely based on yes or no questions about whether countries have established a rule in a particular area or not, or participate in a particular treaty or initiative or not. It is not designed to assess what kinds of adversary capabilities the security systems within a country could protect against, or what the odds are that adversaries could put together enough capability to defeat the security system; hence, it does not provide an assessment of how the probability of nuclear theft varies from one country to the next. See *NTI Nuclear Security Index*, 2016. See, for example, Michelle Cann, Kelsey Davenport, and Jenna Parker, *The Nuclear Security Summit: Progress Report on Joint Statements* (Washington, D.C.: Arms Control Association and Partnership for Global Security, March 2015), https://www.armscontrol.org/files/ACA_NSS_Report_2015.pdf (accessed March 17, 2016).

(DOE) headquarters would have identified the security program at Y-12 as one of DOE's strongest.

Perhaps the best indicator of progress would be the percentage of the facilities with nuclear weapons and weapons-usable nuclear materials in the world that (a) are judged to have security measures in place that are likely to be sustained and are capable of protecting against the full spectrum of threats thought to be most plausible at that location; and (b) have demonstrated that level of performance in realistic tests, or in a thorough independent review of their security performance.

While governments with substantial amounts of information on nuclear security in other countries—such as the U.S. government—might be able to develop at least partial estimates of progress on such a measure, the data is simply not available for outside analysts to do so. Instead, in this report, we offer assessments of progress (or backsliding) in six key interrelated areas likely to be crucial to meeting the overall goal:

- Committing to stringent nuclear security principles
- Implementing effective and sustainable nuclear security
- Strengthening security culture and combating complacency
- Consolidating nuclear weapons and weapons-usable materials
- Building confidence in effective nuclear security
- Continuing an effective nuclear security dialogue after the summits

After the discussion of these six areas, a separate section analyzes the U.S. budget to support nuclear security efforts, since the United States has been the predominant donor supporting nuclear security programs around the world.

In each of these areas, a later section of the report offers recommendations to achieve additional progress toward the overall goal. Separate boxes offer recommendations to strengthen security for radiological sources; security against nuclear sabotage; and the broader set of measures needed to reduce the risk of nuclear terrorism.

Insider Sabotage and a Terrorist in a Belgian Nuclear Power Plant

Many people are unaware that a major incident of nuclear sabotage actually occurred in Belgium in August 2014. An insider at the Doel-4 nuclear power reactor in Belgium opened a locked valve, allowing all the lubricant for the plant's turbine to drain out, and rigged the valve so that it appeared to still be closed, as it should be. The turbine overheated and destroyed itself. There was never any danger of a radioactive release, as this occurred in the non-nuclear area of the plant, but the cost of replacing the turbine and buying replacement power during the months when the plant was shut down amounted to $100-$200 million, making the incident one of the most serious acts of economic sabotage of all time. As of early 2016, neither the perpetrator nor the motivation for the crime had been identified. In response, in December 2014, the Belgian nuclear regulator imposed substantial new requirements for protection against insider threats, including strengthened access controls, deployment of additional cameras to monitor activities in key areas of plants, and new two-person rule requirements forbidding anyone from being alone in specified plant areas.[i]

As investigators began exploring the incident, they found that two years before, in 2012, a contractor working at the plant, cleared for access to the vital areas (the parts of the plant where a sabotage could cause a major disaster), had left to fight for terrorists in Syria.[ii] Ilyass Boughalab worked at the plant from 2009 to 2012, inspecting welds. He passed a security clearance review for access to the plant's vital areas; his family reports that he was radicalized after the clearance process.[iii] He is not a suspect in the 2014 sabotage, having left long before, but was convicted in absentia of terrorist activities as part of an organization called "Sharia4Belgium."

In short, this plant had a budding jihadi terrorist in its vital areas—but it was a different employee, years later, who caused devastating sabotage.

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i See, for example, Noah Gale Pope and Christopher Hobbs, *Insider Threat Case Studies at Radiological and Nuclear Facilities* (London: King's College and Los Alamos National Laboratory, April 13, 2015), http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-15-22642 (accessed February 29, 2016); Erik Raspoet, "Wie is de Saboteur van Doel 4?" (in Dutch), February 11, 2015, http://www.erikraspoet.be/?p=679 (accessed March 15, 2016); Hoe Kan zo Iemand in Doel Werken?" (in Dutch), *HLN.be,* October 21, 2014, http://www.hln.be/regio/nieuws-uit-lokeren/-hoe-kan-zo-iemand-in-doel-werken-a2095802/ (accessed March 13, 2016); Malone and Smith, "A Terrorist Group's Plot"; and Robin Sayles, "Belgian Regulator Sets New Security Steps After Suspected Sabotage," *Inside NRC,* December 29, 2014.

ii Raspoet, "Wie is De Saboteur van Doel 4?" *Erik Raspoet Blog*, February 11, 2015, http://www.erikraspoet.be/?p=679 (accessed February 18, 2016).

iii See Alan Hope, "Jihad fighter previously worked at Doel nuclear plant," *Flanders Today,* October 6, 2014, http://www.flanderstoday.eu/current-affairs/jihad-fighter-previously-worked-doel-nuclear-plant (accessed February 18, 2016).

Decelerating Toward the Finish Line?

During his closing remarks at the 2014 Nuclear Security Summit, President Obama emphasized that it was "important for us not to relax, but rather accelerate our efforts over the next two years, sustain momentum so that we finish strong in 2016."[36] Nevertheless, the assessments offered in this report and in the Nuclear Threat Initiative's Nuclear Security index suggest that there has been a notable slowing of progress in the last few years. This slowing results in part from the completion of many of the efforts that were most politically and technically feasible to implement, leaving more challenging work still to come.

The picture is more impressive when judged on a longer time horizon. Nuclear security around the world has improved dramatically since the early 1990s, and particularly since the 9/11 attacks in the United States in 2001. On the ground, operating organizations are making nuclear security an increasingly important priority, far more so than was the case 20 years ago. Many of the countries with the largest quantities of weapons-usable nuclear material have made significant advances to reduce the likelihood that their nuclear material would be stolen. International norms for enhancing nuclear security are slowly being strengthened.

From 2009 to 2013, during the four-year effort to secure all vulnerable material, momentum increased further. During this time, the nuclear security summit process raised the issue to the level of presidents and prime ministers, increasing attention to the problem, building understanding of the threat, and contributing to overcoming obstacles to progress. Partly as a result, during the four-year effort:[37]

- More than a dozen countries eliminated all the HEU or separated plutonium on their soil.
- Many countries strengthened their rules and procedures for securing nuclear weapons, nuclear materials, nuclear facilities, or dangerous radiological sources.
- All of the locations in non-nuclear-weapon states where enough high-quality HEU for the simplest type of terrorist nuclear bomb existed at a single site were either eliminated or had significant security improvements put in place.

36 "Obama's Remarks at Close of Nuclear Security Summit," *The Wall Street Journal,* March 25, 2014, http://blogs.wsj.com/washwire/2014/03/25/obamas-remarks-at-close-of-nuclear-security-summit/ (accessed January 16, 2016).

37 See discussion in Matthew Bunn et al., *Advancing Nuclear Security: Evaluating Progress and Setting New Goals* (Cambridge, MA: Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, March, 2014), http://belfercenter.hks.harvard.edu/files/advancingnuclearsecurity.pdf (accessed May 11, 2014).

- Programs to identify and exchange nuclear security best practices and nuclear security training programs expanded greatly.
- Many additional states joined relevant nuclear security conventions and initiatives.
- The nuclear security role of the IAEA was significantly strengthened, as were the IAEA's recommendations on physical protection of nuclear materials and facilities.

Since then, countries have continued to make nuclear security improvements, but at a slower rate. As described below, fewer reactors have stopped using HEU fuel in the last couple of years than over comparable periods previously; less weapons-usable nuclear material has been removed; and fewer countries have substantially strengthened their nuclear security requirements and approaches. And during the same period, most U.S.-Russian nuclear security cooperation—which had driven some of the most important nuclear security improvements of the past quarter century—came to a halt, leaving only a few modest cooperative activities remaining.

Some of this slow-down results from many important nuclear security steps having already been taken. In many areas, however, there is more to be done, but less momentum to do it. [38] One of the key challenges for leaders gathering at the 2016 Nuclear Security Summit, for the next U.S. president, and for other leaders around the world, will be to find ways to build momentum toward the high-security path, avoiding the dangers of the low-security path.

38 For example, from April 2009 through March 2015, U.S. physical protection teams assessed 43 sites around the world with U.S.-obligated nuclear material. Of those 43 sites, 11 did not meet International Atomic Energy Agency guidelines for security when they were first inspected. Six of 11 sites possessed category I quantities of nuclear material. U.S. Congress, Government Accountability Office, *Nuclear Nonproliferation: DOE Made Progress to Secure Vulnerable Nuclear Materials Worldwide, but Opportunities Exist to Improve its Efforts*, GAO-15-799 (Washington, D.C.: GAO, September 2015), http://www.gao.gov/assets/680/672703.pdf (accessed December 13, 2015), pp. 26–27.

Committing to Stringent Nuclear Security Principles

To achieve the goal of effectively and sustainably protecting nuclear stocks against the full range of plausible threats, governments and operating organizations must first commit to reaching that objective. Two key indicators could be used to assess progress in that direction:

- The fraction of the sites with nuclear weapons or weapons-usable nuclear materials within countries or managed by organizations that had made a particular commitment; and
- How far toward the goal of effective and sustainable security the commitment would take these stocks, if fulfilled.

National Design Basis Threats

One key way of making such a commitment is for countries to establish a design basis threat (DBT) including a substantial array of potential adversary capabilities and tactics that operators must protect against. Progress in that respect is difficult to judge, as the specifics of DBTs are generally secret—and in some cases, legal arrangements are lacking even to exchange them confidentially between cooperating countries.[39] While the details are not known, it is clear that overall there has been substantial progress in this direction. Since 1999, when the IAEA first recommended that countries require operators to protect against a DBT, most countries have established such regulations. In a recent Harvard survey, experts from all of the 18 participating countries, representing a majority of the nations with HEU or plutonium on their soil, reported that their countries had a regulatory DBT in place, and that formal processes were in place to regularly reassess the threat.[40] The expert from only one participating country judged his country's DBT to be less capable than the published version of the U.S. Nuclear Regulatory Commission's

39 In the case of U.S.-Japanese cooperation, for example, experts on both sides have concluded that a new agreement would be needed to enable the exchange of DBT information.

40 Matthew Bunn and Eben Harrell, *Threat Perceptions and Drivers of Change in Nuclear Security Around the World: Results of a Survey* (Cambridge, MA: Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, March 2014), http://belfercenter.ksg.harvard.edu/files/surveypaperfulltext.pdf (accessed January 20, 2016), pp. 20, 26.

(NRC's) DBT for theft.[41] Here, too, however, progress appears to have slowed: the only major steps (of which we are aware) that countries have taken to strengthen their DBTs since the 2014 Nuclear Security Summit are moves to include cyber threats, or to upgrade the kinds of cyber threats that must be considered (described in more detail below).

The Nuclear Security Implementation Initiative

Another means of making such a commitment is to join in making collective commitments with other countries. Here, the most important recent step is the "implementation initiative" agreed to by 35 countries at the 2014 nuclear security summit.[42] This was perhaps the most significant result from that summit. The participating countries pledged to:

- Implement the "intent" of key IAEA nuclear and radiological security recommendations, and "realize or exceed" their objectives. (These recommendations include, among other items, requiring facilities with enough HEU or separated plutonium to be a significant fraction of a bomb to protect against a DBT based on the state's assessment of the threat.)
- Accept peer reviews (such as the International Physical Protection Advisory Service, or IPPAS) "periodically";
- Ensure that "management and personnel with accountability for nuclear security are demonstrably competent"; and
- Take a range of other particular steps, from working to strengthen nuclear security culture to exchanging good practices with other countries to bolstering cybersecurity.

The countries that made this commitment include all of the European and North American participants in the nuclear security summit process, and a number of other countries.

41 Bunn and Harrell, *Threat Perceptions and Drivers of Change*, p. 27. The exception was Australia, but as Australia has only Category II material, which under NRC rules does not need to be protected against any DBT, the Australian rule is actually more stringent than U.S. rules for equivalent material, not less. Experts from several countries judged the question to be too sensitive to answer, and several others argued that their countries' DBT was different in significant respects, but neither more nor less capable overall, when compared with the published version of the NRC DBT for theft.

42 For descriptions, see Jonathan Herbach, "The Nuclear Security Implementation Initiative: A Catalyst to Needed Action," *Arms Control Today,* June 2014, http://www.armscontrol.org/ACTdigital/June_14 (accessed March 16, 2015), pp. 8–12; Bart Dal, Jonathan Herbach, and Kenneth N. Luongo of the Nuclear Security Governance Experts Group, "The Strengthening Nuclear Security Implementation Initiative: Evolution, Status, and Next Steps," (Washington, D.C.: The Asan Institute for Policy Studies, Partnership for Global Security, and the Stanley Foundation, October 2015), https://pgstest.files.wordpress.com/2015/10/nsgeg-snsi-report.pdf (accessed February 4, 2016).

But key countries such as Russia, Pakistan, India, China, and South Africa (among others) did not agree to participate. Thus, while this initiative represents progress:

- A substantial fraction of the world's nuclear weapons and weapons-usable nuclear materials are not covered by the initiative.
- While the initiative addresses many of the elements of an effective nuclear security system, it does not commit countries to secure their stocks against the full spectrum of potential capabilities and tactics nuclear thieves and saboteurs might use.

The implementation initiative is built around a structure of previous agreements and initiatives, which also form an important part of the overall effort to build commitment to effective nuclear security. In addition to the nuclear security summit process, particularly important elements of the global framework for nuclear security include: nuclear security recommendations from the IAEA; IAEA-led meetings, reviews, training, and services, such as the IPPAS; multilateral treaties, such as the 1980 Convention on the Physical Protection of Nuclear Material (CPPNM), its 2005 amendment, and the 2005 International Convention on the Suppression of Acts of Nuclear Terrorism (ICSANT); UN Security Council Resolution (UNSCR) 1540 and its successors; and multilateral groupings such as the Global Initiative to Combat Nuclear Terrorism (GICNT), the Global Partnership Against the Spread of Weapons and Materials of Mass Destruction (GP), and Interpol. While none of these agreements or initiatives includes specific commitments to achieve high levels of nuclear security, each of them contributes to the goal of nuclear security. IAEA recommendations and the international treaties and UNSC resolutions are discussed in this section, as key elements of building commitment to nuclear security. Other elements of the global regime are discussed in additional sections below, in the areas where they have their most important effects.

IAEA Recommendations

In 1973, recognizing the need for international nuclear security guidelines, the IAEA published "Recommendations for the Physical Protection of Nuclear Material." This was the IAEA's first foray into the area of nuclear security. The Agency subsequently published a revised version as Information Circular 225 (INFCIRC/225). The fifth revision of INFCIRC/225 appeared in 2011, and over the past decade the IAEA has provided a wide range of other recommendations and guidance related to nuclear security in its "Nuclear Security Series."[43]

43 For a complete listing, see International Atomic Energy Agency, "Nuclear Security Series Publications" (Vienna: IAEA, October 15, 2015), http://www-ns.iaea.org/security/nss-publications.asp (accessed February 7, 2016).

IAEA recommendations have proven to be remarkably influential; because they provide a convenient starting point for regulators and because countries do not wish to be perceived as laggards failing to implement international guidelines, many countries base their nuclear security regulations on IAEA recommendations.

The fifth revision of INFCIRC/225 represented an important strengthening of the document, which:

- Added sections on rapid recovery of nuclear material, and mitigating sabotage;
- Included topics not previously covered, such as security culture, cybersecurity, material control and accounting;
- Strengthened recommendations for insider protection;
- Recommended force-on-force exercises for the first time, as part of evaluating security system effectiveness;[44]
- Significantly bolstered recommendations on security of nuclear material transports, including secure two-way communications and a two-person rule;
- Suggested that countries not downgrade security measures for mildly radioactive material as previously recommended (though not specified, this was based on the realization that radiation doses that would be insufficient to incapacitate nuclear thieves might not deter suicidal thieves); and
- Extended some protections previously reserved for Category I materials to Category II materials as well (such as 24-hour guards).[45]

Countries are still working to incorporate these changes into their national regulations, but there is little doubt that the long-awaited revision of INFIRC/225 represented a

44 Force-on-force exercises are tests of the ability of the protective force for a site or transport to defend against an adversary force. They help assess the overall performance of both the human and technical elements of a nuclear security system in coping with intelligent adversaries trying to find ways to defeat the system.

45 See International Atomic Energy Agency, "Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities," INFCIRC/225/Rev. 5, 2011. For an analysis by the chair of the group that drafted the revision, see Christopher Pryce, "Development of the IAEA Nuclear Security Recommendations on Physical Protection of Nuclear Materials and Nuclear Facilities (INFCIRC/225/Rev.5)," *Journal of Nuclear Materials Management*, Vol. 39, No. 3 (Spring 2011), pp. 11–17.

significant step forward—as does the expanding set of guidance in other elements of the IAEA's Nuclear Security Series.[46]

Nuclear Security Treaties

International treaties are the next key element of building a commitment to effective nuclear security. In 1980, the CPPNM—which includes provisions requiring states to criminalize nuclear theft and vague requirements for securing civilian nuclear material in international transport—was opened for signature. In 2005, the CPPNM was amended to include physical protection requirements for materials in domestic use, storage, and transport and to cover sabotage of nuclear facilities. The amendment does not include specific standards for physical protection, but rather broad "fundamental principles of physical protection," such as the responsibility of the state, and the need for countries to put nuclear security rules in place. The 2005 ICSANT also focuses primarily on criminalizing acts related to nuclear terrorism. It requires parties to "adopt appropriate measures to ensure the physical protection of radioactive materials," but does not include any specifics on what appropriate measures might be.

There has been substantial progress in broadening participation in these treaties since 2009. Only a few of the countries with weapons-usable nuclear material on their soil have not become parties to these treaties (see Table 1).

As of mid-March 2016, there were 153 parties to the CPPNM. Eight of those parties joined since 2009, four of them during the four-year effort. By the same date, 93 states had acceded to the 2005 amendment to the CPPNM; 49 of those countries did so during the four-year nuclear security effort, and 20 more since.

Nevertheless, the amendment has still not gained enough parties to enter into force—despite the participants in the 2012 nuclear security summit calling for it to come into force by 2014, and the participants in the 2014 summit pledging to work to bring it into force later in 2014. Two-thirds of the 153 parties to the convention—nine more than have ratified so far—must ratify before the amendment enters into force. Given the pace of ratifications in recent years, it seems quite plausible that the amendment might enter into force in 2016.

46 Best practice guides from the World Institute for Nuclear Security have also become increasingly important; since these are directed primarily to implementing organizations, they are discussed below in the section on implementing and sustaining effective nuclear security.

Similarly, 40 states ratified ICSANT during the four-year effort, and ten more since then, bringing the total to 102 parties, with 13 additional signatories.[47] ICSANT entered into force in 2007.

Table 1: **States with Weapons-Usable Nuclear Material That Have Not Joined Nuclear Security Treaties**

ICSANT	CPPNM
Argentina	Iran*
Ghana	North Korea*
Iran*	Syria*
Israel	**CPPNM Amendment**
Italy	Belarus
North Korea*	Iran
Pakistan*	North Korea
Syria	Pakistan
	South Africa
	Syria

Source: Based on IAEA and UN Data, January 2016
*Indicates the state has neither signed nor ratified.

In 2015, the United States finally ratified the CPPNM amendment and ICSANT. Our previous report described the years of embarrassing delays in U.S. ratification.[48] While the Senate had given its advice and consent to both treaties in 2008, Congress was unable to resolve disputes over the death penalty and wiretapping in order to pass implementing legislation for seven years thereafter. The U.S. ratifications are a very important element of progress, as some other states may have been looking to the United States, and having ratified will make it easier for the United States to push other states to follow suit. One such case in point is Pakistan, which has been slow to ratify the amendment to the CPPNM. But following a diplomatic push by the United States, Pakistan's National Command Authority has given its approval for ratification.[49]

47 International Convention for the Suppression of Acts of Nuclear Terrorism, July 7, 2007, Status available at https://treaties.un.org/pages/ViewDetailsIII.aspx?src=TREATY&mtdsg_no=XVIII-15&chapter=18&Temp=mtdsg3&lang=en (accessed March 15, 2016).

48 Bunn et al., *Advancing Nuclear Security*,p. 62.

49 "National Command Authority Expresses Satisfaction with Security of Nuclear Programme," *92 News*, February 24, 2016, http://92newshd.tv/national-command-authority-reviews-safety-mechanism-of-nuclear-program/ (accessed February 29, 2016).

UN Security Council Resolution 1540

UNSCR 1540, which was approved unanimously in 2004, obligates all UN member states to provide "appropriate effective" security and accounting for all nuclear weapons or related materials they may have; to criminalize any act that would help non-state actors acquire nuclear, chemical, or biological weapons; to institute a broad range of other nonproliferation controls; and to report to the Security Council on the steps they have taken to implement the resolution.[50] In 2011, the Security Council extended the life of the oversight committee for UNSCR 1540 for another 10 years. The committee's new, broadened mandate includes identifying "effective practices" and providing states with guidance and templates for implementation. At the direction of the Security Council, the committee charged with overseeing implementation of UNSCR 1540 is carrying out a comprehensive review of the resolution and its implementation, to be completed this year.[51]

In principle, by establishing a legal obligation to achieve "appropriate effective" security and accounting, UNSCR 1540 could be a very important tool in building commitment to stringent nuclear security principles. Unfortunately, no agreement has ever been reached on what essential elements must be in place for a nuclear security system to be considered appropriate and effective.[52]

Given its reporting requirements, UNSCR 1540 could also be an important tool for increasing transparency in nuclear security. Unfortunately, however, the quality of states' reporting varies widely, and in many cases it is very difficult to get a clear understanding of a state's approaches to nuclear security from the information presented in its UNSCR 1540 reports. Moreover, there are still a few countries that have never reported, and many more that have not answered the clarifying questions posed by the UNSCR 1540 committee. That committee has only a small staff, with few resources, and has been able to play only a very limited role in ensuring that states fulfill their UNSCR 1540 obligations.

Overall, while there is very significant progress in the area of building commitment to stringent nuclear security principles, there is much more to be done, both in expanding the commitments to additional countries and in strengthening the commitments.

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50 United Nations Security Council Resolution 1540, S/Res/1540, April 28, 2004.

51 The Security Council adopted UNSCR 1977 in 2011, stating that a review on UNSCR 1540 should be held before December 2016. See, "Comprehensive Review of the Status of Implementation of Resolution 1540," *United Nations,* http://www.un.org/en/sc/1540/comprehensive-review/general-info.shtml (accessed February 18, 2016).

52 Matthew Bunn, "'Appropriate Effective' Nuclear Security and Accounting—What is it?" Paper presented at Global Initiative/UNSCR 1540 Workshop on 'Appropriate Effective Material Accounting and Physical Protection,' Nashville, TN, July 18, 2008, http://belfercenter.ksg.harvard.edu/files/bunn-1540-appropriate-effective50.pdf (accessed June 29, 2015).

Implementing Effective and Sustainable Nuclear Security

Approaches to actually implementing effective and sustainable nuclear security are also critical. Organizations must put in place measures that really provide effective protection, and must sustain those protections for the long haul. The goal must be a culture of continuous improvement, in a never-ending search for nuclear security excellence.

To judge progress in this area, one would want to examine the fraction of the facilities and transport operations with nuclear weapons and weapons-usable nuclear materials that had made particular types of progress, and the importance to reducing the risk of nuclear theft and sabotage of the particular steps they had taken. Indicators might include:

- The fraction of facilities and transport operations with nuclear weapons and weapons-usable nuclear material that have demonstrated high nuclear security performance (e.g., through realistic test programs or in-depth independent assessments);
- The fraction of these facilities and transport operations that have implemented particular measures judged to be important (such as regular and realistic tests of nuclear security performance, or a targeted program to assess and improve nuclear security culture);
- The magnitude of the risk reduction particular nuclear security performance facilities or transport operations have achieved;
- The fraction of these facilities and transport operations participating in particular types of nuclear security cooperation or good practice exchanges, and the scale of improvements being made as a result of those programs.

Individual programs, such as training or regulatory support efforts, should be judged by how much improvement toward effective and sustainable security they achieve, and for how many facilities or transport operations they make that contribution. Here, too, while governments might be able to use such indicators, publicly available data is not sufficient to judge the quality and sustainability of nuclear security implementation around the world. Hence, rather than attempting to assess these indicators, this section offers:

- Qualitative descriptions of the strengths and weaknesses of nuclear security in Russia, Pakistan, and India, the three countries that combine significant stocks of

nuclear weapons and materials with high terrorist threats and poor ratings on indices of corruption and regulatory effectiveness; and

- Briefer descriptions of recent improvements in nuclear security implementation in other countries around the world.

Russia

More nuclear weapons, plutonium, and HEU are spread across more buildings and bunkers in Russia than in any other country.[53] While Russia has greatly improved security and accounting for these stocks, important weaknesses remain, and the end of most U.S.-Russian cooperation has drawn a curtain of opacity over ongoing nuclear security implementation and the prospects for sustainability. Moreover, the deep corruption in Russia (including in the nuclear industry and the security services that guard it), combined with an ongoing organized crime problem and growing terrorist threats, mean that Russian nuclear security systems have to cope with potentially substantial adversary threats.

Security surrounding Russia's nuclear stockpile has improved dramatically since the political turmoil that followed the collapse of the Soviet Union. The fences around facilities have been mended, staff are paid regularly, guards stand their posts, and electric bills are paid on time. Russian nuclear facilities are generally equipped with modern fences, intrusion detectors, barriers, access control systems, vaults, and nuclear material accounting and control systems. It is significantly more difficult to steal weapons-usable nuclear material in Russia than it was 20 years ago.

Russia designs its nuclear security systems to protect against a significant range of outsider and insider capabilities, although it appears that facilities with nuclear weapons have more stringent requirements than those with weapons-usable nuclear material.[54] Russia now has requirements for weapons-usable nuclear material to be kept in secure vaults when not in use (with limited access to the vaults); detailed accounting of the material in and out of each area where material is stored and handled; and the use of uniquely identifiable

53 For a previous assessment from the same authors, see Bunn et al., *Advancing Nuclear Security*, pp. 24–28.

54 Bunn and Harrell, *Threat Perceptions and Drivers of Change*, p. 27. Two of the three Russian participants judged Russian DBTs to be more capable than the published description of the NRC DBT, while the other judged them to be generally as capable. A different set of two judged that Russian DBTs had changed substantially in the years since the turn of the century, while the other judged the changes to be more moderate. Interviews with U.S. and Russian experts, 2003–2014. Much the same is true in the United States, though the particular arrangements as to which facilities face what requirements differ.

tamper-indicating devices to reveal whether a canister or a door has been opened.[55] Indeed, the United States has helped Russian regulators draft scores of new rules and regulations focused on physical protection, material control, and material accounting, intended to help protect against both outsider and insider threats.[56] Russia has taken a number of steps in recent years to address insider threats, from additional monitoring of personnel to new anti-corruption initiatives (though the latter are primarily focused on corruption at the level of senior officials steering large procurement contracts in return for bribes, rather than line workers potentially helping with a nuclear theft).[57]

Russia has also significantly reduced the number of locations with nuclear weapons, plutonium, and HEU, for example closing its last plutonium production reactors and the two major plutonium reprocessing plants associated with them, reducing the number of nuclear weapon assembly and disassembly facilities from four to two, consolidating plutonium and HEU weapons component fabrication at a single site, and greatly reducing the number of buildings with weapons-usable nuclear material at some sites.[58] Although U.S. funding for such consolidation efforts is no longer available, Russia continues with some efforts on its own, such as the removal of weapon-grade uranium metal from the BFS critical assembly at the Institute for Physics and Power Engineering (IPPE) in Obninsk.[59] In the U.S.-Russian HEU Purchase Agreement that was completed in 2013, Russia destroyed 500 metric tons of weapons-grade HEU; it destroyed another 17 tons in U.S.-funded consolidation programs, and it has also used some HEU to re-enrich European enrichment

55 A revised version of the "Basic Rules on Nuclear Material Control and Accounting" (known by its Russian acronym, OPUK) finally went into force in 2012, after years of delay.

56 For a discussion of one part of this regulatory effort—strengthening Rosatom's agency-level rules on physical protection—see Alexander Izmaylov, *et al*., *Development of Physical Protection Regulations for Rosatom State Corporation Sites under the U.S.-Russian MPC&A Program*, PNNL-21418 (Richland, WA: Pacific Northwest National Laboratory, 2012). For a broader and more conceptual approach from an earlier stage of the work, see Greg E. Davis, Lorilee Brownell, Troy Wright, John Tuttle, Mitchel Cunningham, and Patricia O'Brien, "Creating a Comprehensive, Efficient and Sustainable Nuclear Regulatory Structure: A Process Report From the U.S. Department Of Energy's Material Protection, Control and Accounting Program," *Proceedings of the 47th Annual Meeting of the Institute for Nuclear Materials Management,* Nashville, TN, July 16–20, 2016 (Northbrook, IL: INMM, 2006). Recent major Russian nuclear security regulations are described briefly in Anton Khlopkov, "Russia's Nuclear Security Policy: Priorities and Potential Areas for Cooperation" (Muscatine, IA: Stanley Foundation, May 2015), http://www.stanleyfoundation.org/publications/pab/KhlopkovPAB515.pdf (accessed February 5, 2016). Recent Russian nuclear material accounting regulations are described in Dmitry Kovchegin, "Developing a Nuclear Material Control and Accounting System in Russia" (Maryland: Center for International and Security Studies at Maryland, University of Maryland, December 2013), http://cissmdev.devcloud.acquia-sites.com/sites/default/files/papers/developing_a_nuclear_material_control_and_accounting_system_in_russia.pdf (accessed February 18, 2016).

57 For a summary of anticorruption initiatives in Russia, see D. Donnelly, D. Kovchegin, S. Mladineo, L. Ratz, N. Roth, "Corrupting Nuclear Security: Potential Gaps and New Approaches to Insider Risk Mitigation," Institute of Nuclear Materials Management, 2015.

58 Pavel Podvig, "Consolidating Fissile Materials in Russia's Nuclear Complex," *International Panel on Fissile Materials Report*, May 2009, http://fissilematerials.org/library/rr07.pdf (accessed February 18, 2016).

59 Interview with Russian laboratory expert, July 2015.

tails in past commercial deals. Overall, Russia has eliminated more than three times as much HEU as the United States, although Russia began with a much larger stock.[60]

At the same time, with U.S. funding, Russia has established a range of training centers, from facilities to provide training in particular tasks related to physical protection or material accounting to masters degree programs that have provided a network of younger professionals working in the field.

Nevertheless, Russia's nuclear security and accounting systems still have important weaknesses that determined thieves could exploit; the end of nearly all U.S. financial support for nuclear security in Russia, combined with an economic downturn and government budget reductions, raises questions about whether all the nuclear facilities in Russia will be able to finance sustaining effective nuclear security and accounting programs; and Russia's nuclear security measures face substantial threats from both insiders and outsiders.

Suspension of Most U.S.-Russian Nuclear Security Cooperation. In December 2014, Russia cut off all but a small portion of U.S.-Russian nuclear security cooperation.[61] This step came in part as a response to the U.S. cutoff of nuclear energy cooperation as one component of the sanctions over Russia's action in Ukraine, and in part over broader concerns, including the Russia government's perception that cooperation in the mode of threat reduction assistance was no longer needed and was being implemented in a way that was unequal and unfair. Congress then acted to bar funding for any new contracts for nuclear security work with Russia unless the Secretary of Energy signed a waiver certifying that the activities served U.S. national security interests—and as of early 2016, no such waiver had been approved, bringing most remaining work nearly to a halt, even work with the Russian regulator to strengthen nuclear security regulations. Russia has also refused to participate in the 2016 Nuclear Security Summit, and has been criticizing summit preparations from outside the process.[62]

60 Throughout this report, when we refer to "tons" we mean metric tons, which is approximately 2,205 pounds. As of December 2014, the United States had downblended 146.1 tons of HEU, while Russia has eliminated 517 tons. See International Panel on Fissile Materials, "Countries: United States," last edited on January 14, 2016, http://fissilematerials.org/countries/united_states.html (accessed February 9, 2016). The IPFM estimates that the United States has 599 tons of HEU remaining, while Russia has 679 tons (with an uncertainty of over 100 tons).

61 For a description of what was cut off and what remained, see Matthew Bunn, "Rebuilding U.S.-Russian Nuclear Security Cooperation," *Nuclear Security Matters*, January 22, 2015, http://nuclearsecuritymatters.belfercenter.org/blog/rebuilding-us-russian-nuclear-security-cooperation (accessed February 9, 2016).

62 TASS, "Moscow slams organizers of fourth Nuclear Security Summit," *TASS Russian Politics and Diplomacy,* January 13, 2016, http://tass.ru/en/politics/849199 (accessed February 11, 2016).

Some limited cooperation between the two countries remains. In 2014 and 2015, Russia and the United States continued to cooperate to remove HEU from third countries, including Uzbekistan, Kazakhstan, and Georgia. There is still some ongoing cooperation with Russia's civilian nuclear regulator Rostekhnadzor to strengthen nuclear security and accounting regulations. There is also some cooperation on security improvements at sites that are neither under military or Rosatom control, like the Kurchatov Institute in Moscow.[63] Russia still remains an active participant in the GICNT, which it co-chairs with the United States. But continuing funding for even limited projects within Russia will require approval of a waiver.

By the time most U.S.-Russian cooperation was suspended in 2014, U.S. programs had assisted with comprehensive security and accounting upgrades for 218 of a planned 229 buildings in Russia with weapons-usable nuclear material, and at 97 nuclear weapon storage or handling sites. These represented all but a small fraction of the material buildings and warhead sites that exist.[64]

Material Accounting and Bulk Processing. Material accounting has improved significantly over the past 20 years, but still involves significant uncertainties, and there is no requirement for facilities to analyze the trends in material accounting to see if small amounts of material are being stolen over time. Indeed, as long as their accounting systems meet regulatory rules, facilities are not required to assess how effective they are in preventing insider thefts.[65] Some facilities have thousands of canisters of HEU or plutonium built up over decades, with paper records (slowly being computerized) of what is in each one—but no one has gone back to measure each canister to be sure the material is still there. Moreover, while Russian regulations now require the use of uniquely identifiable seals, rather than the easily-faked wax or lead seals used until recently, many of these seals—like many in use elsewhere—could be readily defeated.[66] Russia continues to conduct bulk processing of weapons-usable nuclear

63 Bunn, "Rebuilding U.S.-Russian Nuclear Security Cooperation."

64 Matthew Bunn, *Securing the Bomb 2010: Securing all Nuclear Materials in Four Years* (Cambridge, MA: Project on Managing the Atom, Harvard Kennedy School, and Nuclear Threat Initiative 2010), http://www.nti.org/media/pdfs/Securing_The_Bomb_2010.pdf? (accessed March 5, 2016), pp. 31–43. For an update of the number of buildings with completed security upgrades, see U.S. Department of Energy, *FY 2015 Congressional Budget Request: National Nuclear Security Administration*, Vol. 1, DOE/CF-0096 (Washington, D.C.: DOE, 2014), http://energy.gov/sites/prod/files/2014/04/f14/Volume 1 NNSA.pdf (accessed May 25, 2014), p. 521.

65 Interview with Russian regulatory official, June 2013, and interview with Russian nuclear accounting expert, July 2015.

66 Interview with U.S. laboratory expert, 2015. One remarkable 2003 study examined 213 types of both high-tech and low-tech seals and found that all could be defeated in ways that would not be detected with the seal inspection protocols in place, using equipment available from any hardware store, with an average defeat time of 2.7 minutes. See Roger Johnston, *Tamper-Indicating Seals: Practices, Problems, and Standards* (LAUR-03-0269 (2003), http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-03-0269 (accessed June 12, 2015). Seals and their use have improved somewhat since, but the problem of widespread unrecognized vulnerabilities remains.

material—the activity that creates the most risk of covert insider theft—on a large scale, reprocessing roughly a ton of plutonium per year, fabricating HEU and plutonium weapons components, and fabricating HEU fuels.

Nuclear Security Financing and Sustainability. Effective nuclear security is something that requires constant vigilance and sustained resources. The end of cooperation has left the United States with little knowledge of how nuclear security in Russia is evolving, and raises concern that some of the improvements of recent decades could erode. One issue for Russian facilities is the end of U.S. funding. When cooperation ended, U.S. funding had been phasing down for some time, but the Obama administration requested some $100 million for nuclear security cooperation with Russia for FY 2015, the last year such a request was made. Only a portion of these supported sustaining security and accounting measures at Russian facilities, as opposed to paying for U.S. experts to work on the cooperation. The end of U.S. funding comes at a time when low oil prices and sanctions are having a serious effect on the Russian government budget. At the same time, Russian facilities' own finances are becoming increasingly tight. The Russian government plans to fire 10 percent of state employees in 2016, and Rosatom plans substantial budget cuts—which will inevitably affect the funds sites have available to pay for security.[67] Russian nuclear facilities generally do not receive separate government funding for nuclear security, but must provide the funding needed to meet regulatory requirements from their general funds. This means they have every incentive to do the minimum required by Russia's still-modest regulations, and some smaller facilities with limited revenues—such as small research reactors with HEU—may not be able to afford the costs of effective security. In past periods of substantial budget reductions, Russian regulators found that they were not permitted to cut their employees' salaries, and with salaries taking up the vast majority of their budget, they had to virtually eliminate travel costs, making it almost impossible to travel to nuclear sites for inspections.[68]

Guard Forces. Insider threats are not the only concern. To protect against outsider attacks, many weapons-usable nuclear material sites still rely in large part on Ministry of Interior (MVD) troops for guard forces. Many of these forces are poorly paid conscripts who cycle through the force rapidly, so that soon after they are fully trained they are no longer available, and many have little idea of the importance of what they are guarding.

67 Arnaud Lefevre, "Russian government cuts Rosatom funding," *Dynatom News*, September 3, 2015, http://dynatom.org/russian-government-cuts-rosatom-funding/ (accessed February 5, 2016).

68 Interview with Russian regulator, March 2009.

Moreover, the possibility of corruption or recruitment raises the possibility that guards will become "the most dangerous internal adversaries," as the security chief of the Siberian Chemical Combine once put it.[69]

Regulatory Enforcement. Russian regulators exercise far less power, have far fewer resources, and sometimes have less expertise than the agencies they are seeking to regulate. Key nuclear security requirements are spread among several layers of national, agency-level, and site-level rules, and are sometimes vague or confusing, making it difficult in some cases for working-level personnel to know how to follow the rules.[70]

Nuclear Security Culture. Russian and U.S. experts worked together to develop many of the early ideas about how to strengthen nuclear security culture. Rosatom requires all of its major sites to have programs to strengthen security culture (including a "culture coordinator" charged with overseeing the effort), and Rostekhnadzor, the Russian regulatory agency, has issued guidelines on how facilities should approach the issue.[71] Unfortunately, however, many Russian nuclear experts still tend to dismiss the threat, believing either that terrorists could not make a nuclear bomb, or that Russian nuclear security measures are fully sufficient to prevent any possible nuclear theft—the belief propagated by the Russian government as well.[72] Belief in the threat is the foundation for a strong security culture.

Terrorism and Islamic Extremism. Whatever the strengths and weaknesses of Russia's nuclear security approaches, they must protect against a substantial range of potential threats, from corrupt insiders to terrorist outsiders. Terrorists in Russia continue to pose serious dangers, though there have been few complex, sophisticated terrorist attacks since Russia's brutal crushing of the Chechen rebellion years ago. The Kavkaz Emirat, once the leading coalition of terrorist organizations in Russia, is wracked by disputes between

69 Interviews with U.S. and Russian participants in nuclear security cooperation, 2010–2014. The quote is from Igor Goloskokov, "Refomirovanie Voisk MVD po Okhrane Yadernikh Obektov Rossii [Reforming MVD troops to guard Russian nuclear facilities]," *Yaderny Kontrol*, Vol. 9, No. 4 (Winter 2003), pp. 39–50.

70 Dmitri Kovchegin, "Developing National Regulations to Support Nuclear Security: Lessons Learned from the U.S. Support to Russia, Ukraine, and Belarus," *Security Index: A Russian Journal on International Security* (December 2014), p. 4.

71 Khlopkov, "Russia's Nuclear Security Policy," pp. 3–5.

72 See, for example, Office of the Russian President, "Statement of the Russian Federation on Nuclear Security," April 13, 2010, http://news.kremlin.ru/ref_notes/520 (accessed July 6, 2015). Sergei Ivanov, then the Russian Minister of Defense, summed up a widely expressed Russian view in 2004, asserting that it was "impossible for there to be any loss" of plutonium or uranium, and that there had never been "a single case of so much as a gram being lost." (This statement was clearly false, since there had been cases where individuals had been caught and confessed to their thefts.) Russian acceptance of cooperative threat reduction assistance, he said, "does not mean that nuclear materials are stored poorly." See Svetlana Babaeva, "Responsible, Rational, With No Fear on His Face," *Izvestia,* trans. by *What the Papers Say*, April 9, 2004.

supporters of al Qaeda and of IS, and weakened by the deaths of senior leaders of the group, but still poses a significant potential threat.[73] Perhaps more significantly, Russian President Vladimir Putin has estimated that 5–7,000 people from Russia and other former Soviet states are fighting for IS; many of these fighters still have extensive networks of contacts in Russia.[74] Recent reports suggest that Islamic extremism is spreading from the North Caucasus to the Urals, where several major Russian nuclear facilities are located.[75]

Corruption and Organized Crime. Corruption continues to be a serious problem throughout Russia, including in the nuclear industry and the security services that guard it. This has included such remarkable cases as the arrest of the director and two of the deputy directors of the Siberian Chemical Combine, one of Russia's largest HEU and plutonium processing facilities, for millions of dollars in kickbacks, and a general commanding a nuclear weapon storage facility relieved of his duties for corruption.[76] From 2009 to 2012, Rosatom fired 276 manager or executive level employees because of corruption charges.[77] In 2015, Transparency International ranked Russia 119th out of 168 countries, placing it in the most corrupt third of countries in the world.[78] An environment of pervasive corruption and embezzlement increases the chance that insiders could be bribed to participate in or facilitate a nuclear theft. At the same time, Russia continues to suffer a serious problem of organized crime, with far-reaching networks—including deep heroin-trafficking connections to Afghanistan—that might be used by nuclear thieves or smugglers. Organized crime has also penetrated into Russia's closed nuclear cities, in some of which narcotics pose a serious problem.[79]

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73 See, for example, Gordon M. Hahn, "The Caucasus Emirate Jihadists: The Security and Strategic Implications," in Stephen J. Blank, ed., *Russia's Homegrown Insurgency: Jihad in the North Caucasus* (Carlisle, PA: U.S. Army Strategic Studies Institute, 2012), pp. 1–97; Bill Roggio and Thomas Joscelyn, "Russian Trooops Kill Leader of Islamic Caucasus Emirate," *Long War Journal,* (April 19, 2015), http://www.longwarjournal.org/archives/2015/04/russian-troops-kill-leader-of-islamic-caucasus-emirate.php (accessed June 20, 2015).

74 "Putin: 'Thousands' from former Soviet bloc fighting with IS," *BBC News*, October 16, 2015, http://www.bbc.com/news/world-middle-east-34552318 (accessed February 9, 2016). Joanna Paraszczuk, "Russia Unveils New Post To Wage 'War On IS,'" *Radio Free Europe Radio Library*, March 13, 2015, http://www.rferl.org/content/russia-isis-islamic-state/26899257.html (accessed March 13, 2015).

75 Malashenko and Starostin, *The Rise of Nontraditional Islam in the Urals.*

76 Russian press accounts of the case are summarized in "Russia: CEO of Enrichment Center Arrested for Massive Fraud," *Uranium Intelligence Weekly*, June 29, 2012.

77 "Rosatom Risks: Exposing the Troubling History of Russia's State Nuclear Corporation" (The Netherlands: Greenpeace, October 2014), http://www.greenpeace.org/hungary/PageFiles/636986/rosatom_risks.pdf (accessed February 5, 2016), p. 20.

78 Transparency International, *Corruption Perceptions Index 2015* (Berlin: Transparency International, 2015), https://www.transparency.org/cpi2015 - results-table (accessed February 4, 2016).

79 Robert Orttung and Louise Shelley, *Linkages Between Terrorist and Organized Crime Groups in Nuclear Smuggling: A Case Study of Chelyabinsk Oblast*, PONARS Policy Memo No. 392 (Washington, D.C.: December, 2005); http://www.csis.org/media/csis/pubs/pm_0392.pdf (accessed February 22, 2016).

Risk Summary and Trend: Overall, the risks of nuclear theft in Russia appear to be moderate. Nuclear security measures are drastically improved, but still have some weaknesses, and the threats these security systems must counter are substantial. While Russia continues to make some nuclear security improvements, the overall risk trend appears to be toward increasing risk, with the end of all but a modest portion of U.S.-Russian nuclear security cooperation, an increase in the threat of Islamic terrorism, and increasing economic uncertainty that could make it difficult for facilities to allocate resources for nuclear security.

Pakistan

In Pakistan, a modest but rapidly growing nuclear stockpile, with substantial security measures, must protect against some of the world's most capable terrorist groups, in an environment of widespread corruption and extremist sympathies.[80]

Pakistan has substantially strengthened its nuclear security in the past two decades. In a recent survey of nuclear security experts, the Pakistani participant reported dramatic recent changes in the organizations governing nuclear security; in the numbers, training, and equipment of guard forces; in approaches to screening personnel; in requirements for nuclear material accounting and control; and in approaches to strengthening security culture, along with substantial changes in every other aspect of nuclear security covered in the survey.[81] By some estimates, the Strategic Plans Division, which manages Pakistan's nuclear weapons, has 25,000 troops available to guard Pakistani nuclear stocks and facilities. [82] Pakistani officials report that sites are equipped with extensive barriers and detection systems, that the components of nuclear weapons are stored separately (though that may be changing as Pakistan moves toward tactical nuclear weapons intended to

80 For a previous assessment, see Bunn *et al., Advancing Nuclear Security,* pp. 17–20.

81 Bunn and Harrell, *Threat Perceptions and Drivers of Change*, p. 9.

82 Finance Minister Ishaq Dar asserted that a "special security force of 25,000 personnel, who have been specially trained and provided sophisticated weapons, has been deployed to protect (the nuclear assets)." See "Pakistan Says "25,000 Guards Watching Nukes," *Global Security Newswire*, June 25, 2013, http://www.nti.org/gsn/article/pakistan-says-25000-nuke-oversight-duty/ (accessed June 5, 2015). By another account, the total strength of the "security division" of the National Command Authority was 20,000 in 2013, but headed upward to 28,000. Not all of these personnel may be assigned to guard duties at any particular time. See Naeem Salik and Kenneth N. Luongo, "Challenges for Pakistan's Nuclear Security," *Arms Control Today,* March, 2013, https://www.armscontrol.org/act/2013_03/Challenges-for-Pakistans-Nuclear-Security (accessed February 9, 2016). Security force for nuclear sites at 20,000, heading up to 28,000. Used to be mainly retired military. Now they are being replaced by new recruits trained at the new training center, allegedly comparable to the one the U.S. has established in New Mexico. Security force capabilities tested through "field exercises and war games." Sites have inner and outer perimeters with electronic sensors "and counterintelligence teams." All personnel brought into "any components of the strategic program" are screened "in concert with other intelligence agencies" (presumably ISI).

be rapidly deployed to the field), and that Pakistani weapons are equipped with locks to prevent unauthorized use. [83] The United States has engaged in extensive cooperation with Pakistan to improve nuclear security, an effort reportedly expanded after President Obama took office.[84] Despite a variety of negative reports in the U.S. press on Pakistani nuclear security, U.S. officials from President Obama to the Chairman of the Joint Chiefs of Staff have repeatedly expressed confidence in Pakistani nuclear security arrangements. It is notable, however, that these statements of confidence have not been repeated at recent high-level U.S.-Pakistani meetings—suggesting that the United States has concerns about some elements of Pakistan's nuclear security approach.[85] The Director of the U.S. Defense Intelligence Agency, however, testified in February 2015 that improvements were continuing.[86]

There are also negative trends, which may be related to the absence of recent U.S. expressions of confidence. Pakistan has the world's fastest-growing nuclear arsenal, and is shifting toward tactical nuclear weapons intended to be dispersed to front-line forces early in a crisis, increasing the risks of nuclear theft should such a crisis occur. This increase in numbers of weapons is probably leading to an increase in numbers of locations as well. In particular, Pakistan brought a fourth plutonium production reactor online in 2014, and in 2015 reports suggested that a new plutonium reprocessing plant for handling the spent fuel from these reactors was either operational or nearly so.[87]

Pakistan's nuclear security systems must protect against almost overwhelming adversary threats. Terrorist groups continue to demonstrate that they are willing and able to launch

83 For separate component storage, see, for example, David Albright, "Securing Pakistan's Nuclear Infrastructure," in Lee Feinstein, ed., *A New Equation: U.S. Policy Toward India and Pakistan After September 11* (Washington, D.C.: Carnegie Endowment for International Peace, 2002), http://www.carnegieendowment.org/files/wp27.pdf (accessed July 9, 2015). For weapons incorporating locks, see, for example, Hamid Mir, "Interview With Former Pakistan Atomic Energy Commission Chairman Samar Mubarakmand" (Geo-TV, March 5, 2004), http://www.pakdef.org/forum/topic/8015-dr-samar-mubarakmands-interview-with-geo-tv/ (accessed May 27, 2015). It is not known how such locks would be incorporated in weapons that are stored in disassembled form, or how difficult the Pakistani lock designs would be to bypass.

84 For one unclassified account of this cooperation and the U.S. concerns that drove it, see David Sanger, *Confront and Conceal: Obama's Secret Wars and Surprising Use of American Power* (New York: Crown, 2012), pp. 58–67.

85 See, for example, "U.S.-Pakistan Strategic Dialogue Joint Statement" (Washington, D.C.: U.S. Department of State, March 1, 2016), http://www.state.gov/r/pa/prs/ps/2016/03/253857.htm (accessed March 13, 2016). That statement only notes activities such as Pakistan hosting IAEA events and committing to ratify the amendment to the CPPNM; there is no mention of nuclear security cooperation and no expression of confidence in Pakistan's nuclear security arrangements.

86 Quoted in Paul K. Kerr and Mary Beth Nikitin, "Pakistan's Nuclear Weapons" (Washington, D.C.: Congressional Research Service, January 14, 2016), https://www.fas.org/sgp/crs/nuke/RL34248.pdf (accessed January 26, 2016), p. 19.

87 David Albright and Serena Kelleher-Vergantini, "Pakistan's Fourth Reactor at Khushab Now Appears Operational," *Institute for Science and International Security,* January 16, 2015, http://isis-online.org/uploads/isis-reports/documents/Khushab_January_2015_reactor_four_operational_FINAL.pdf (accessed January 16, 2016). See also, Zia Mian, "Pakistan's Chashma reprocessing plant may be completed," *International Panel on Fissile Materials Blog,* February 23, 2015, http://fissilematerials.org/blog/2015/02/pakistans_chashma_reproce.html (accessed February 5, 2016).

complex, well-coordinated attacks on heavily defended military targets within Pakistan. For example, In September 2014, a group of naval officers who had been recruited by al Qaeda's newly formed South Asia branch attempted to seize a Pakistani frigate, with the idea of using its anti-ship missiles to attack U.S. naval vessels, provoking an extended firefight.[88] The Pakistani defense minister told Parliament "without assistance from inside, these people could not have breached security."[89] Sympathy for Islamic extremist causes remains widespread in Pakistan, including in the nuclear and security establishments—some of whom have long been key sources of support for the Taliban, Lashkar e Taiba, Jaish Mohammed, and other terrorist groups. At the same time, the militants' extreme violence has undermined any support they once had and provoked significant Pakistani military action against them; if successful, these actions may reduce the risk that militants could succeed in a nuclear theft attempt. Pakistan also suffers pervasive and deeply ingrained corruption, which can create additional opportunities for insider recruitment.[90]

Risk Summary and Trend: Overall, the risk of nuclear theft in Pakistan appears to be high. The trend seems to be toward increasing risk, as Pakistan's nuclear arsenal expands and shifts toward tactical nuclear weapons, while adversary capabilities remain extremely high. Over the longer term, the possibilities of state collapse or extremist takeover cannot be entirely ruled out, though the near-term probability of such events appears to be low.

88 For accounts of this incident, see, for example, Syed Shoaib Hasan, Saeed Shah, and Siobhan Gorman, "Al Qaeda Militants Tried to Seize Pakistan Navy Frigate: Al Qaeda Raid Foiled After Firefight Involving Rogue Naval Officers," *Wall Street Journal*, September 16, 2014, http://www.wsj.com/articles/al-qaeda-militants-tried-to-seize-pakistan-navy-frigate-1410884514 (accessed June 5, 2015); Syed Raza Hassan and Kattherine Houreld, "In Attack by Al Qaeda, Lines Blur Between Pakistan's Military, Militants," *Reuters*, October 1, 2014, http://www.reuters.com/article/2014/10/01/us-pakistan-militants-attacks-insight-idUSKCN0HP2MM20141001 (accessed June 5, 2015). In addition to the four plotters killed in the attack, the Pakistani Navy reportedly arrested eight other men, including four serving on the ship.

89 Hasan, Shah, and Gorman, "Al Qaeda Militants."

90 In 2014, Transparency International ranked Pakistan 126th out of 174 countries in its Corruption Perceptions Index. See Transparency International, *Corruption Perceptions Index 2014* (Berlin: Transparency International, 2014), http://www.transparency.org/cpi2014 (accessed February 4, 2016). For a discussion of the potential links between corruption and nuclear theft, see Matthew Bunn, "Corruption and Nuclear Proliferation," in Robert Rotberg, ed., *Corruption, Global Security, and World Order* (Washington, D.C.: Brookings, 2009).

India

India has a relatively small stockpile of nuclear weapons and weapons-usable nuclear material at a limited number of sites, which are believed to be heavily guarded.[91] Unlike Pakistan, India has a civilian plutonium reprocessing program.

India's approach to nuclear security is highly secretive, and little is publicly known about India's nuclear security arrangements. Like the United States and many other countries, India requires facilities to be protected against a set of threats specified in a DBT. In a 2014 survey, the Indian expert participating indicated that nuclear security requirements in India have become much more stringent in the last 15 years, primarily in reaction to incidents within India, and that in particular there have been dramatic changes in the DBT.[92] A special security agency, the Central Industrial Security Force (CISF), guards both nuclear installations and other especially dangerous or sensitive industrial facilities. Indian experts report that India performs systematic vulnerability assessments in designing physical protection systems for nuclear facilities and makes use of some modern security technologies, including access controls and various types of intrusion detectors.[93] CISF leaders, however, reportedly complained about 40 percent cuts from their request in weapons for CISF, 45 percent cuts in training equipment, and low morale.[94] U.S. officials have reportedly ranked Indian nuclear security measures as weaker than those of Pakistan and Russia, and U.S. experts visiting the sensitive Bhabha Atomic Research Centre in 2008 described the security arrangements there as "extraordinarily low key."[95]

In 2011, the Indian government proposed legislation to replace its existing nuclear safety regulator, the Atomic Energy Regulatory Board (AERB), with a new Nuclear Safety Regulatory Authority (NSRA) that would finally be fully independent of the Department of

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91 For a summary of the limited available information, see Rajeswari Pillai Rajagopalan, *Nuclear Security in India* (New Delhi, India: Observer Research Foundation, January 7, 2015), http://www.orfonline.org/wp-content/uploads/2015/02/NUCLEAR_SECURITY_IN_INDIA.pdf (accessed February 5, 2016). Some additional detail was provided in presentations at International Atomic Energy Agency, "IAEA Regional Training Course on Security for Nuclear Installations," (Mumbai, India, May 11–20, 2003).

92 Bunn and Harrell, *Threat Perceptions and Drivers of Change,* pp. 26–31. The reported changes in most other elements of nuclear security were much more modest.

93 Presentations to International Atomic Energy Agency and Bhabha Atomic Research Centre, "IAEA Regional Training Course on Security for Nuclear Installations," Mumbai, India, May 11–20, 2003. Since then, India has hosted IAEA regional training courses almost every year.

94 Draft CSIF report, cited in Adrian Levy and R. Jeffrey Smith, "India's nuclear explosive materials are vulnerable to theft, U.S. officials and experts say," *The Center for Public Integrity,* December 17, 2015, http://www.publicintegrity.org/2015/12/17/18922/india-s-nuclear-explosive-materials-are-vulnerable-theft-us-officials-and-experts (accessed February 5, 2016).

95 Levy and Smith, "India's Nuclear Explosive Materials."

Atomic Energy. Despite a scathing legislative report on the AERB in 2012, however, the NSRA legislation has still not been passed.[96] The AERB only has authority to regulate security at civilian facilities; the organizations managing India's military nuclear activities (where the bulk of India's HEU and separated plutonium reside) regulate themselves.

India has generally refused substantial nuclear security cooperation with the United States. In recent years, however, there have been workshops on the topic at India's Global Centre for Nuclear Energy Partnership (GCNEP) and trainings organized by the U.S. State Department's Partnership for Nuclear Security.[97]

Like Pakistan, India is expanding its nuclear stockpile, continuing to produce both plutonium and HEU. India is expanding uranium enrichment, reportedly plans two new plutonium production reactors, and is building a new reprocessing plant at Kalpakkam. India's prototype fast breeder reactor will be able to produce an estimated 140 kilograms of plutonium annually once it opens.[98] In the future, India has plans for large-scale breeding, reprocessing, and recycling of plutonium fuels, and eventually breeding of U-233 from thorium.[99]

The threats India's nuclear security systems have to confront appear to be significant—though not as great as the threats that exist in Pakistan.[100] India faces both domestic terrorist threats and threats from attacks by terrorist organizations based in Pakistan. For example, on January 2, 2016, heavily armed members of the Jaish-e-Mohammed terrorist group attacked the Pathankot Air Force base in northern India, killing seven security guards. The attackers were able to infiltrate the base by climbing over a tree that had grown along the side of a security fence in an area where floodlights were not operating.[101]

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96 World Nuclear Association, "Nuclear Power in India" (London: World Nuclear Association, February 2014), http://www.world-nuclear.org/info/Country-Profiles/Countries-G-N/India/ (accessed March 7, 2014).

97 U.S. Department of Energy, *FY 2016 Congressional Budget Request Volume 1*, DOE/CF-0107 (Washington, D.C.: Department of Energy), p. 531; "PNS Supports Efforts to Include Nuclear Security Curricula in Trainings for Future Technical Nuclear Experts," *Partnership for Nuclear Security News,* February 2015, https://www.pns-state.net/en-us/news/133-pns-supports-efforts-to-include-nuclear-security-curricula-in-trainings-for-future-technical-nuclear-experts.html (accessed February 5, 2016).

98 For a summary of India's stockpiles, see *Global Fissile Material Report 2015: Nuclear Weapon and Fissile Material Stockpiles and Production* (Princeton, N.J.: International Panel of Fissile Materials, 2015), http://fissilematerials.org/library/gfmr15.pdf (accessed February 9, 2016), pp. 9, 15–16, 26–27, 32–33.

99 World Nuclear Association, "Nuclear Power in India." For a critique of India's plans and practices to date, see M.V. Ramana, *The Power of Promise: Examining Nuclear Energy in India* (New York: Penguin, 2013).

100 For a useful summary of the threat in India, see Rajeswari Pillai Rajagopalan, Tobias Feakin, Jennifer Cole, Rahul Prakash, Wilson John, and Andrew Somerville, *Chemical, Biological, and Radiological Materials: An Analysis of Security Risks and Terrorist Threats to India* (New Delhi: Observer Research Foundation and Royal United Services Institute, 2012).

101 Kamaldeep Sing Brar and Navjeevan Gopal, "Probing Pathankot attack: Fence floodlights that didn't work, gaps in border control, patchy police response," *The Indian Express*, January 8, 2016, http://indianexpress.com/article/india/india-news-india/probing-pathankot-attack-fence-floodlights-that-didnt-work-gaps-in-border-patrol-patchy-police-response/?google_editors_picks=true#sthash.bZHnH3Rp.dpuf (accessed February 10, 2016).

Moreover, there are concerns about insider threats within Indian nuclear facilities. India faces significant insider corruption, though corruption in India is thought to be less severe than it is in Pakistan or Russia.[102] Additionally, in 2014, Vijay Singh, a head constable at the Madras Atomic Power Station at Kalpakkam, shot and killed three people with his service rifle soon after arriving at work.[103] Although the CISF had a personnel reliability program in place, it was not able to detect Mr. Singh's deteriorating mental health, despite multiple red flags, including his telling colleagues that he was about to explode like a firecracker.

Risk summary and trend: Given the limited information available about India's nuclear security measures, it is difficult to judge whether India's nuclear security is capable of protecting against the threats it faces. Although India has taken significant measures to protect its nuclear sites, recent reports suggest that its nuclear security measures may be weaker than those of Pakistan, though likely adversary threats in India are less extreme. Overall, the risk appears to be moderate, and there is no clear trend, either upward or downward.

Nuclear Security Changes in Other Countries

Beyond these three countries, nuclear security in the other countries with weapons-usable nuclear material varies widely. A recent U.S. Government Accountability Office (GAO) report, for example, indicates that in assessing security at 43 sites with U.S.-origin nuclear materials from 2009 to 2015, U.S. experts concluded that a quarter of the sites—including six with Category I nuclear materials, requiring the highest level of security—still did not have security in place consistent with IAEA physical protection recommendations (which themselves are somewhat basic, specifying, for example, that sites should have fences, vaults, and intrusion detectors, but not how effective any of these security elements should be).[104] Remarkably, the GAO also found that two-thirds of the unirradiated U.S.-origin HEU in foreign countries was at sites whose owners had not allowed U.S. experts to visit in more than 20 years.[105] Some countries—including the Netherlands, and Sweden among others—still have no armed guards at their nuclear facilities, relying on off-site

102 In 2014, Transparency International ranked India 85th out of 175 states included in its index for the severity of corruption, while Pakistan was ranked at 126th and Russia was ranked at 136th. See Transparency International, *Corruption Perceptions Index 2014* (Berlin: TI, 2014), www.transparency.org/cpi2014 (accessed January 25, 2016).

103 Levy and Smith, "India's Nuclear Explosive Materials."

104 GAO, *DOE Made Progress,* pp. 26–27.

105 GAO, *DOE Made Progress*, p. 25.

response forces a few minutes way (that is, unless the adversaries take action to slow their arrival—as they did in the Vastberga cash depot heist described in our last report, placing a package that appeared to be a bomb at the police heliport and scattering tire-puncturing "caltrops" on the road near the building they were robbing).[106]

Three categories of weapons-usable nuclear materials exist in these countries: civilian HEU (primarily at research reactors or in the research reactor fuel cycle); civilian separated plutonium (primarily at reprocessing plants and plutonium fuel fabrication facilities); and military stocks. In general, security is weakest for the civilian HEU; many research reactors are on university campuses or at other locations where it may be difficult to provide the kind of security appropriate for potential nuclear bomb material, and many of these facilities do not have enough revenue to pay for significant armed guard forces. Nevertheless, security at a number of research reactors has been significantly improved in recent years, and, as discussed later in this report, many are converting to low-enriched uranium (LEU) or shutting down, eliminating the HEU at their sites. In particular, as described in our previous report, all of the sites in non-nuclear-weapon states with enough high-quality HEU for the simplest gun-type terrorist nuclear bomb have either been eliminated or had substantial security upgrades in recent years.[107]

Overall, countries around the world have made substantial progress in improving nuclear security in recent years. In a recent survey of nuclear security experts from a majority of the countries where HEU or separated plutonium exist, all of the experts reported that their countries had adopted either much more stringent or somewhat more stringent nuclear security policies in the years since the 2001 terrorist attacks in the United States. Changes included increasing the adversary capabilities included in DBT, expanding guard force capabilities, putting in place more realistic and regular testing, and more.[108] The political pressure for action generated by the nuclear security summits has clearly resulted in countries taking additional steps to strengthen nuclear security.

There is not enough publicly available data to offer a comprehensive account of recent nuclear security improvements around the world. A sampling of these improvements includes:

106 For a description of the Vastberga heist and its implications, see Bunn et al., *Advancing Nuclear Security,* p. 8.

107 Bunn *et al*., *Advancing Nuclear Security.*

108 Bunn and Harrell, *Threat Perceptions and Drivers of Change.*

- At least seven countries had revised or were in the process of revising their DBTs by the time of the 2014 Nuclear Security Summit.[109]

- Belgium significantly strengthened its protections against insider threats in December 2014, requiring more security cameras and greater use of two-person and three-person rule, in response to an insider sabotage earlier that year.[110] Belgium also deployed armed personnel to protect nuclear facilities.[111] Overall, Belgium has made some of the most substantial nuclear security improvements in the world since the last nuclear security summit.

- South Africa finished major security upgrades at its Pelindaba site in January 2015. The upgrades included new intrusion detection and assessment, better delay, and improved access controls.

- South Korea revised its DBT based on a 2013 threat analysis that included cyber threats. There are plans for a force-on-force exercise at a Korean nuclear site sometime in 2016.[112]

- Canada updated its requirements for nuclear response forces, incorporating force-on-force exercises at high-security nuclear sites.[113]

- Countries are increasing their protection against cyber threats.[114] Australia incorporated facility-level insider threats and cybersecurity into its DBT. Belgium incorporated cyber security into its DBT. Canada is establishing national standards for protecting electronic data and data systems. In 2013, Finland created new requirements for nuclear information security and published a strategy for cybersecurity. In December 2013, France adopted a law on cybersecurity, as well as new regulations on the protection and control of nuclear materials. In 2013, Italy passed legislation that created a new system for protecting nuclear facilities, which included protection against cyber threats. In 2012, the Dutch government created

109 The seven countries included Australia, Belgium, Canada, Germany, Hungary, Indonesia, and The Netherlands. See "Highlights from National Progress Reports 2014 Nuclear Security Summit" (Washington, D.C.: Partnership for Global Security, March 24, 2015), https://pgstest.files.wordpress.com/2015/03/2014-progress-reports-highlights.pdf (accessed March 15, 2016).

110 Robin Sayles, "Belgian Regulator Sets New Security Steps After Suspected Sabotage," *Inside NRC,* December 29, 2014, from LexisNexis Academic database.

111 Robert-Jan Bartunek, "Belgian army to protect nuclear sites: interior ministry," *Reuters*, March 4, 2016, http://www.reuters.com/article/us-belgium-nuclear-security-idUSKCN0W61KR (accessed March 11, 2016).

112 Hosik Yoo, Na-Young Lee, and Jang-Hoon Seo, *Efforts for Further Strengthening the ROK's Nuclear Security* (South Korea: Korea Institute of Nuclear Nonproliferation and Control), pp. 305–348.

113 See "Highlights from National Progress Reports 2014 Nuclear Security Summit."

114 All National Progress Reports from the Nuclear Security Summit in March 2014 at The Hague are available at http://nuclearsecuritymatters.belfercenter.org/2014-hague-summit (accessed February 10, 2016).

the National Cyber Security Center, which provided advice on how to avoid and detect cyber incidents. Belgium was also supposed to implement a new DBT including cyber threats. China's nuclear security Center of Excellence is scheduled to open at the beginning of 2016.

- In 2014, Japan's Nuclear Regulatory Authority established a working group to consider how to determine trustworthiness of nuclear facility staff, in an effort to finally address the lack of background checks for nuclear personnel in Japan.[115]
- Additionally, security is being improved at Incirlik Air Base in Turkey and Aviano Air Base in Italy, both of which house U.S. nuclear weapons. Both bases are installing new security perimeters with double fences, new lights, cameras, and intrusion detection technology, and a vehicle patrol road is being constructed.[116]

The IAEA's Division of Nuclear Security plays an important role in helping countries around the world implement effective and sustainable nuclear security measures. It offers:

- Recommendations and guidance on issues ranging from physical protection of nuclear materials to finding lost radioactive sources. In 2014 and 2015, the IAEA published new guidelines on information security, the application of risk assessments to nuclear security, and material accounting and control.
- Information and analysis, including the Incident and Trafficking Database.
- Training programs and workshops on particular aspects of nuclear security. This includes working with the Centers of Excellence and with a network of universities to coordinate their training programs.
- Reviews of nuclear security arrangements, such as the IPPAS. From 1996 through 2015, the IAEA organized 69 IPPAS missions in 44 countries. Forty-four of those missions, roughly two-thirds of the total, involved countries that possessed separated plutonium or HEU. Some 16 of the 69 of the missions were to countries that had, at the time of visit, operational nuclear power reactors, but no weapons-usable

115 Tomoaki Inamura and Tomoyuki Tanabe, "Issues on Security Clearance for Nuclear Security in Japan," (paper presented at the 55th Annual Meeting of Nuclear Materials Management, Atlanta, GA, July 20–24, 2014), http://www.inmm.org/source/proceedings/files/2014/a302_1.pdf (accessed February 10, 2016).

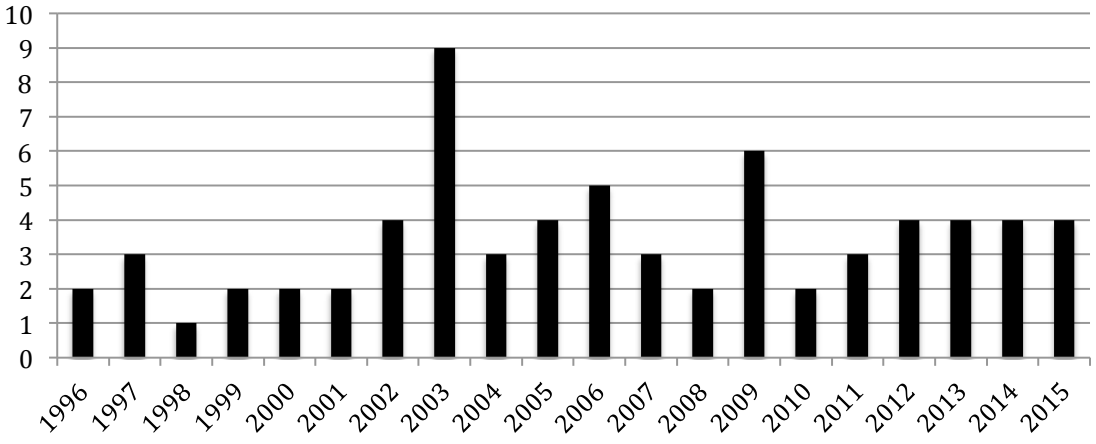
116 Hans M. Kristensen, "Upgrades at U.S. Nuclear Bases in Europe Acknowledge Security Risk," *Federation of American Scientists Blog,* September 10, 2015, http://fas.org/blogs/security/2015/09/nuclear-insecurity/ (accessed February 10, 2016).

nuclear material. Only nine countries received visits without having either weapons-usable nuclear material or an operating nuclear power plant.[117]

- Small-scale assistance in implementing nuclear security improvements, and coordination of assistance from donor states. In particular, the IAEA has worked with many member states—primarily developing countries—to lay out Integrated Nuclear Security Support Plans (INSSPs), covering everything from security for radiological sources to border controls on nuclear smuggling. As of mid-2015, 67 countries had approved INSSPs, and eight more were developing or reviewing them.[118]
- Assistance and coordination in removals of nuclear material (though these are generally paid for by the United States or, rarely, by other donors).

The IAEA's role in nuclear security continues to grow. In 2013, the Office of Nuclear Security was elevated to become the Division of Nuclear Security within the Department of Safety and Security, and the IAEA hosted its first ministerial level conference focused on nuclear security. Another such conference is planned in late 2016.

Figure 1: **IPPAS Missions, 1996–2015**



Source: IAEA, December 2015

WINS also plays an increasingly important role in helping to achieve effective and sustainable nuclear security implementation. While the IAEA largely works with member states, WINS, a non-governmental membership organization, primarily targets its efforts at the

117 Data provided by the IAEA. One of the nine countries without having either weapons-usable nuclear material or an operating nuclear power plant that was visited was Georgia in 2008. By all accounts, no one was aware HEU was still there at the time.

118 IAEA, *Nuclear Security Report 2015*, GOV/2015/42-GC(59)12, (Vienna, Austria: July 13, 2015), https://www.iaea.org/About/Policy/GC/GC59/GC59Documents/English/gc59-12_en.pdf (accessed February 10, 2016).

level of operating organizations and individuals. WINS offers workshops, best practice guides, and now the WINS Academy, which provides training and certification for nuclear security managers and staff.[119] WINS' membership continues to grow, and the importance of its work is increasingly recognized. The 35-nation nuclear security implementation initiative, for example, included a pledge to support or participate in the development of WINS' best practice guides.[120]

Risk summary and trend: The risks of nuclear theft in these different countries vary widely, given varying nuclear security measures and different threat environments. Some countries still have nuclear security measures that are not likely to provide protection against the full spectrum of plausible adversary threats. Civilian HEU likely poses the highest risks, but the risks posed by civilian plutonium and military materials cannot be ignored. Overall, the average trend in these countries appears to be toward decreasing risk, as nuclear security measures continue to improve. Whether security improvements will continue to keep pace with evolving threats in the future remains uncertain, however.

Consolidating Nuclear Weapons and Weapons-Usable Materials

Consolidating nuclear weapons and weapons-usable material to fewer sites is a critical element of the effort to reduce the risk of theft. The only way to completely eliminate the risk of nuclear theft at a site is to eliminate the weapons-usable nuclear material from the site. And states can achieve more effective nuclear security at less cost by protecting fewer sites. Moreover, eliminating HEU or plutonium from a location is inherently sustainable: once weapons-usable nuclear material has been eliminated from a site, it stays gone.

Here, the measure of progress is clear: what fraction of the sites with nuclear weapons or weapons-usable nuclear materials in the world, or in a particular category of concern, have been eliminated?

Reductions in the size of nuclear stockpiles are much less important to the risk of nuclear theft than reductions in the number of locations. A building with 100 tons of weapons-usable nuclear material represents essentially the same risk of nuclear theft as a building with 10 tons—already more than thieves would likely be able to carry away. By contrast,

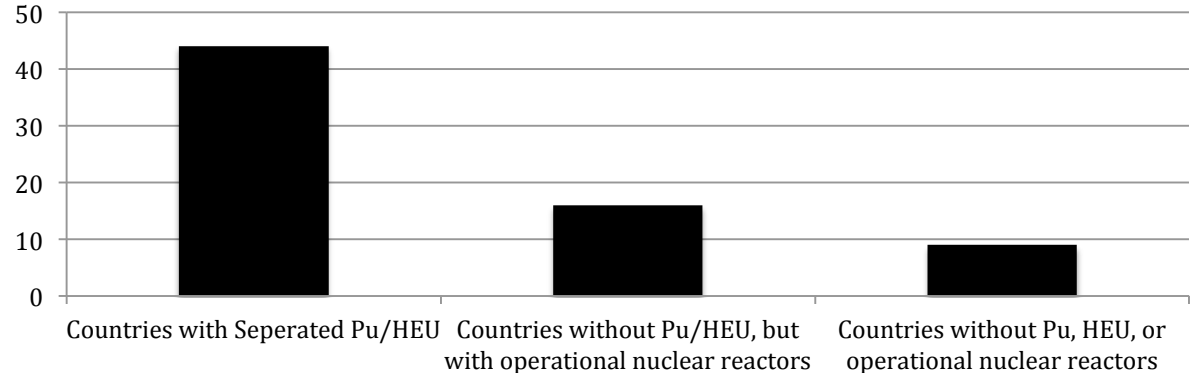
119 For information on WINS mission, goals, and services, visit https://www.wins.org/.

120 Dal, Herbach, and Luongo, "The Strengthening Nuclear Security Implementation Initiative."

eliminating a site means eliminating another chance for mistakes to create a vulnerability that might be exploited, and another group of insiders with access to potential nuclear bomb material. Hence, the number of sites with all weapons-usable nuclear material removed is a far better measure of progress than the quantity of HEU or plutonium removed.

Over the past 30 years, there has been considerable progress in reducing the number of places where nuclear weapons and the materials needed to make them can be found. At one time, U.S. and Soviet nuclear weapons were deployed in many countries around the world. Today, except for roughly 200 bombs at a few bases in Europe, all U.S. and Russian nuclear weapons are in the United States and Russia. In the United States, those weapons not on strategic delivery systems are stored at a very few storage facilities. In Russia, the number of storage facilities is far larger, but still significantly smaller than it was decades ago. Throughout the nuclear age, a total of 57 countries have possessed weapons-usable nuclear materials. That number has been cut by more than half. Even within countries that still have weapons-usable nuclear materials, the number of sites has been substantially reduced, particularly in the United States, where the costs of meeting post-9/11 security requirements have motivated many sites to eliminate these materials.

Figure 2: **IPPAS Missions in Countries with/without Relevant Materials or Technology**



Note: Based on data from the IAEA

Despite this significant progress, nuclear weapons are stored in more than a hundred sites in fourteen countries. The material needed to make nuclear weapons, HEU, and plutonium, is

located in hundreds of buildings spread across 27 countries.[121] More than four-fifths of these materials, however, are in Russia and the United States, along with the largest number of locations where these materials reside. The number of nuclear weapons sites has stabilized in the United States and Russia and may be increasing in Pakistan and elsewhere; reductions in the U.S. and Russian nuclear weapons stockpiles have slowed; reductions in the global HEU stockpile have slowed dramatically with the end of the HEU Purchase Agreement; stocks of civilian separated plutonium continue to increase, while a few countries continue to produce military plutonium; and efforts to convert research reactors to LEU fuel and to remove unneeded HEU and LEU around the world appear to be slowing.

Bulk Processing Facilities

Nearly all of the confirmed thefts of plutonium and HEU are material in bulk form such as powders, which appear to have been stolen from bulk-processing facilities. Given the uncertainties in measurement, in a bulk-processing facility handling tons of plutonium or HEU each year, it is very difficult for accounting systems to confirm that a few kilograms have not gone missing.

Hence, bulk processing facilities should be a top priority for efforts to reduce the number of locations with nuclear weapons or weapons-usable nuclear material. Unfortunately, no programs targeted on reducing the number of bulk-processing facilities exist, though the United States and other countries have long sought to limit the spread of plutonium reprocessing (one form of bulk processing) and uranium enrichment to additional countries.

Despite the lack of programs focused on them, a number of bulk-processing facilities have shut down or reduced operations in recent years. With the end of the Cold War, both the United States and Russia shut down military plutonium production, closing reprocessing facilities, while also consolidating and reducing the throughput of facilities for fabricating plutonium and HEU weapons components. In Japan, the Rokkasho Reprocessing Plant has still not opened, and the pilot-scale Tokai reprocessing plant has shut down. In the U.K., the Thermal Oxide Reprocessing Plant (THORP) at Sellafield has never performed

121 The *NTI Nuclear Security Index* lists 24 remaining countries with a kilogram or more of HEU or separated plutonium. Since then, all the plutonium has been removed from Switzerland. In addition, however, Ghana, Syria, and Nigeria have just under a kilogram of this material in the cores of Slowpoke or Miniature Neutron Source Reactors (MNSRs), and Indonesia has just three kilograms of irradiated HEU from past nuclear activities. See U.S. National Nuclear Security Administration, National Nuclear Security Administration, "United States Collaborates with Switzerland to Remove Last Remaining Separated Plutonium" (Washington, D.C.: NNSA, March 4, 2016), http://nnsa.energy.gov/mediaroom/pressreleases/united-states-collaborates-switzerland-remove-last-remaining-separated (accessed Mar 15, 2016); GAO, *DOE Made Progress*, 2015, pp. 17–18.

well, and is slated to shut down in a few years, when it finishes its existing contracts. The plutonium-uranium mixed oxide (MOX) fuel fabrication plant at Mol, in Belgium, closed years ago, as did the MOX plant at Caderache, in France, and the Sellafield MOX Plant in the United Kingdom. A new MOX plant under construction in the United States will likely never be completed, due to escalating costs, but a new MOX plant is still under construction in Japan. As noted earlier, however, new reprocessing plants have been completed or are under construction in both Pakistan and India; China is considering construction of commercial-scale reprocessing plants; Russia opened a new MOX plant in 2015 to implement its obligations under the U.S.-Russian Plutonium Management and Disposition Agreement (PMDA) and continues to plan to build a new reprocessing plant in the future.[122]

Civilian HEU

Since 1978, the United States has been working to convert research reactors so they no longer use HEU, and then eliminate the HEU they no longer need. Since 1991, 30 countries have eliminated all of their weapons-usable nuclear material.[123] More than half—17 countries—eliminated all of their weapons-usable nuclear material during the Obama administration, 13 during the four-year effort, three more during 2015, and one so far in 2016.[124] Today, 27 countries still have weapons-usable nuclear material on their soil. Nine of these countries are states with nuclear weapons. For many of the others, the only weapons-usable nuclear material on their soil is civilian HEU at one or a small number of research reactor facilities.

From 1996 through the end of 2015, the United States supported more than 200 removals from more than 40 countries, totaling over four tons of weapons-usable nuclear

122 For a discussion of the Chinese plans, see Hui Zhang, *Rethinking Chinese Policy on Commercial Reprocessing* (Cambridge, MA: Project on Managing the Atom, Harvard Kennedy School, March 2012), http://belfercenter.ksg.harvard.edu/files/ChinaReprocessing_hzhang.pdf (accessed February 19, 2016). See also *Global Fissile Material Report 2015: Nuclear Weapon and Fissile Material Stockpiles and Production* (Princeton, N.J.: International Panel of Fissile Materials, 2015), http://fissilematerials.org/library/gfmr15.pdf (accessed February 9, 2016), pp. 17–18, 33.

123 The 30 countries are Brazil, Bulgaria, Colombia, Denmark, Greece, Iraq, Latvia, Philippines, Portugal, Slovenia, South Korea, Spain, Thailand, Austria, Chile, Czech Republic, Hungary, Libya, Mexico, Romania, Serbia, Sweden, Switzerland, Taiwan, Turkey, Ukraine, Vietnam, Uzbekistan, Georgia, and Jamaica. See "NNSA Achievements: 2015 by the Numbers," http://nnsa.energy.gov/content/2015-year-review (accessed February 19, 2016); and National Nuclear Security Administration, "United States Collaborates with Switzerland to Remove Last Remaining Separated Plutonium." In some of these countries, a few grams or tens of grams of material remain for research purposes, but these amounts are far too small to be a significant part of the material needed for a nuclear bomb.

124 The 13 countries that eliminated their weapons-usable nuclear material during the four-year effort are Austria, Chile, Czech Republic, Hungary, Libya, Mexico, Romania, Serbia, Sweden, Taiwan, Turkey, Ukraine, and Vietnam. Twelve of those countries eliminated their HEU during that period. Sweden, which had eliminated its HEU in 2002, eliminated its plutonium stocks. The three countries that eliminated their nuclear material during 2015 are Uzbekistan, Georgia, and Jamaica. The combined amount of HEU in all three of these countries was less than 10 kg, and none of it was fresh fuel. See GAO, *DOE Made Progress*, 2015. Switzerland eliminated its plutonium in 2016.

material.[125] Early on, removals concentrated on U.S.-origin HEU, but in recent years, they have included Russian-origin HEU, small amounts of plutonium, and small amounts of material that originated in other countries as well. Since 2009, only 85 kilograms of repatriated nuclear material has been of U.S. origin (see Figure 3.)

Approximately 1.6 tons, or 40 percent, of this material was removed or disposed of during the four-year effort, from 2009 through the end of 2013, an average of more than 300 kilograms of material per year.[126] Removals have slowed since then. In 2014, the United States helped to remove 135 kilograms of weapons-usable nuclear material, which included material taken from Belgium and Italy in the run-up to the nuclear security summit in April of that year.[127] In 2015, the United States helped to remove or eliminate 141 kilograms of HEU. This included the removal of 36 kilograms of HEU from the Institute of Nuclear Physics (INP) in Almaty, Kazakhstan, and of two kg of HEU from a breeder reactor in Georgia.[128]

In FY 2016, the National Nuclear Security Administration (NNSA) expects the amount of nuclear material removed to increase again. The United States plans to assist in the removal of an additional 723 kilograms of nuclear material by the end of the year, including complete cleanout of four additional countries: Switzerland, Poland, Indonesia, and Argentina.[129] There are also plans to ship a small amount of Georgian HEU being stored in

125 This figure includes only removals of HEU or plutonium supported by U.S. programs. NNSA often includes in its totals 1,240 kilograms of HEU the U.K. blended down and 112 kilograms of HEU Japan blended down without U.S. support. See GAO, *DOE Made Progress*, p. 14. All but a small amount of this material was HEU.

126 GAO, *DOE Made Progress,* 2015. Additionally, in 2013, the United States verified that the United Kingdom had downblended 1,240 kg of HEU and Japan had downblended 112 kg of HEU, but it is unclear when that took place or what part the United States played in it. Our estimate in *Advancing Nuclear Security* took into account the downblending of the British material, but we were unaware of the Japanese material.

127 See "Belgium Highly Enriched Uranium and Plutonium Removals," *National Nuclear Security Administration Fact Sheet*, March 24, 2014, http://nnsa.energy.gov/mediaroom/factsheets/belgiumremovals and "Fact Sheet: Italy Highly Enriched Uranium and Plutonium Removals" March 24, 2014), https://www.whitehouse.gov/the-press-office/2014/03/24/fact-sheet-italy-highly-enriched-uranium-and-plutonium-removals (accessed February 19, 2016).

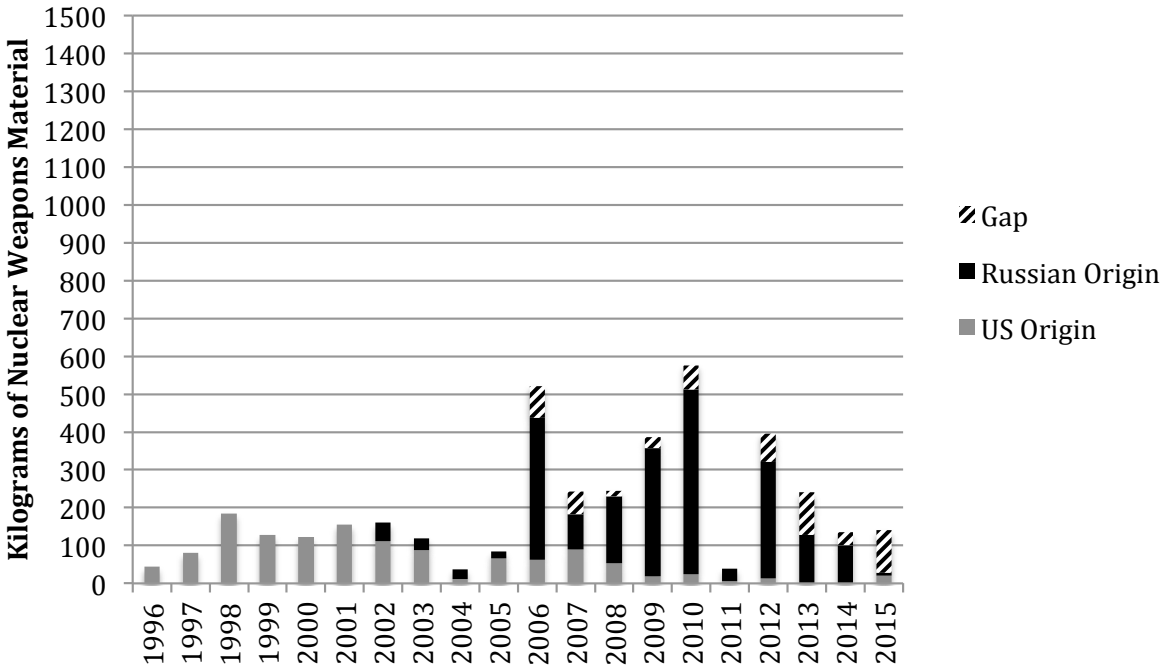
128 World Nuclear News, "Georgia ships Breeder-1 HEU to Russia," *WNN Regulation and Safety News*, December 23, 2015, http://www.world-nuclear-news.org/RS-Georgia-ships-Breeder-1-HEU-to-Russia-23121501.html (accessed February 10, 2016); and "U.S., Kazakhstan Cooperate to Eliminate Highly Enriched Uranium," *National Nuclear Security Administration Press Release,* January 7, 2015, http://nnsa.energy.gov/mediaroom/pressreleases/kazakhstan (accessed February 10, 2016). Until the announcement by the IAEA that this material had been removed most of the world had been under the impression that all HEU had been removed from Georgia in 1998 as part of Operation Auburn Endeavor. See the White House, Office of the Press Secretary, "Operation Auburn Endeavor," (Washington, D.C.: The White House, April 24, 1998), http://fas.org/nuke/control/ctr/news/980424-wh.htm (accessed February 19, 2016).

129 U.S. Department of Energy, *FY 2017 Congressional Budget Request: National Nuclear Security Administration*, Vol. 1, DOE/CF-0119 (Washington, D.C.: DOE, February 2016), http://energy.gov/sites/prod/files/2015/02/f19/FY2016BudgetVolume1_1.pdf (accessed May 2, 2014), p. 479. Supplemented with data supplied by NNSA, March 2015 and March 2016.

the United Kingdom to the United States.[130] Between FY 2017 and FY 2021, NNSA plans to remove or confirm the disposition of 745 kilograms of additional HEU or plutonium, an average of nearly 150 kilograms of material a year.[131] This is a significantly reduced rate compared to what was planned in 2015.

Most of the 2016 material is expected to be the 215 kilograms of HEU and 331 kilograms of plutonium from Japan's Fast Critical Assembly (FCA), which Japan pledged to eliminate at the 2014 nuclear security summit.[132] This will eliminate one of the few places in non-nuclear weapon states with enough weapon-grade HEU metal for a simple gun-type nuclear bomb, representing a major step forward for consolidation efforts.[133]

Figure 3: **Removals of U.S. Origin, Russian Origin, and Gap Nuclear Weapons Materials**



Note: This chart is based on data provided by the National Nuclear Security Administration. It does not include 1352.3 kilograms of Japanese and British HEU that were confirmed in 2013 to have been downblended. This downblending likely took place much earlier, without the support of the United States.

130 This is the small amount of irradiated material included in the HEU removed in Operation Auburn Endeavor, which is being removed from Dounreay as part of the decommissioning of that facility.

131 DOE, *FY 2017 Congressional Budget Request: NNSA,* p. 479.

132 Matthew Bunn, "Eliminating Potential Bomb Material from Japan's Fast Critical Assembly," *Nuclear Security Matters Blog,* March 24, 2014, http://nuclearsecuritymatters.belfercenter.org/blog/eliminating-potential-bomb-material-japan%E2%80%99s-fast-critical-assembly (accessed February 10, 2016).

133 Bunn, "Eliminating Potential Bomb Material from Japan."

Unfortunately, although the goal should be to eliminate all civil HEU, the planned removals would leave large quantities of civil HEU still in the world. For example, over 13 tons of U.S.-origin civil HEU existed in foreign countries as of 2013, and more than 10 tons of that material would not be covered in NNSA's current removal plans.[134] If U.S.-Russian cooperation on consolidation and HEU reactor conversion remains suspended, and Russia continues not to prioritize such efforts, large quantities of civil HEU are likely to remain in Russia, as well.

In the case of research reactors using HEU fuel, the reactors must convert to other fuel or shut down before all the HEU can be removed from the site. Hence, reactor conversion and shutdown are also major parts of the effort to consolidate nuclear material to fewer locations.

From 1978, when U.S.-sponsored reactor conversion programs began, through 2015, 65 reactors converted from HEU fuel to LEU fuel, and well over 100 HEU-fueled reactors have closed; together, the conversions and shutdowns represent something in the range of 60 percent of what was once the world's total of HEU-fueled research reactors. Still, more than 125 reactors around the world (not counting an additional several dozen naval propulsion reactors) continue to use HEU for their fuel or for targets for isotope production.[135] Of these, roughly 90 are civilian reactors of various types, which would have to be addressed if the goal of eliminating the civil use of HEU were to be achieved.[136]

Table 2 shows the number of reactors that converted to LEU fuel or shut down in the years before the 2004 founding of GTRI; from 2004-2008, before the four-year nuclear security effort began; and from 2009-2015. From 2004 to 2008, 17 HEU reactors or medical isotope production facilities were converted and six shut down. From 2009-2015, only 13 facilities that use HEU were converted and 20 shut down. From FY 2016 through FY 2020, NNSA plans to convert or confirm the shutdown of 18 research reactors, representing some 14

134 The United States only plans to remove a cumulative total of 6,800 kilograms of nuclear material by 2021. By 2013, the United States had already helped remove approximately 2,965 kilograms of nuclear material. This means only an additional three tons of nuclear material will be removed from 2014 through 2021. See DOE, *FY 2017 Congressional Budget Request: NNSA,* p. 473.

135 This includes the 118 land-based reactors identified by the International Panel on Fissile Materials (except for two that are actually plutonium-fueled rather than HEU-fueled), and nine reactors for nuclear-powered icebreakers in Russia. See International Panel on Fissile Materials, "Facilities: Reasearch and Isotope Production Reactors" (Princeton, N.J.: IPFM, 2015), http://fissilematerials.org/facilities/research_and_isotope_production_reactors.html (accessed May 3, 2015).

136 This includes 74 civilian research reactors using or planning to use HEU fuel; six reactors using HEU for targets for isotope production; two civilian power reactors (the BN-600 and BN-800 reactors in Russia); and the nine icebreaker reactors. For a list of the 74 civilian HEU-fueled research reactors, along with lists of military-purpose and icebreaker reactors, see U.S. National Academies of Sciences, Engineering, and Medicine, *Reducing the Use of Highly Enriched Uranium in Civilian Research Reactors* (Washington, D.C.: National Academies Press, January, 2016), pp. 31–33, 186–187.

percent of the remaining HEU-fueled reactors.[137] If that pace remained constant after FY2020, it would take a quarter-century to convert the remaining civilian HEU-fueled reactors.

In recent years, there have been significant setbacks in the effort to convert HEU-fueled research reactors. First, there are technical barriers: developing high-density fuels to convert high-performance research reactors is taking far longer than expected because of early test failures and problems ramping up fabrication of the new fuel. As a result of these hurdles, NNSA has pushed back its deadline of converting 200 reactors from 2020—the goal it set for itself in 2010—to 2035, although there is significant uncertainty even in that estimate.[138] This long timeline for conversion has caused some to begin debating the question of whether to convert existing reactors or build new ones. (Different LEU fuels being developed in Europe, Russia, and South Korea will probably be available sooner, but do not offer a high enough density to convert the highest-performance reactors.)

The conversion effort is also facing political problems. Roughly half of the remaining operational HEU reactors in the world are in Russia, and Russia has suspended cooperative work on reactor conversions there. In 2010, the United States and Russia agreed to study conversion of six Russian HEU-fueled reactors to LEU, but only one—the Argus reactor at the Kurchatov Institute in Moscow—actually converted before cooperation was suspended.[139] Russian experts have made clear that neither converting reactors to LEU within Russia nor shutting down HEU-fueled reactors are priorities, though Russia continues to develop high-density fuels that could be used for future conversions.[140] Russian reactors, in short, are not likely to convert in substantial numbers unless Russia changes its approach. In addition, Russia appears to be prepared to export HEU fuel (as it did for the China Experimental Fast Reactor), which could undermine the influence the United States has wielded from being the only available source of HEU fuel for most countries.

At the same time, the United States is planning to restart the HEU-fueled Transient Reactor Test Facility at the Idaho National Laboratory for studies of severe accidents at nuclear reactors. This will be the first time the United States has added an HEU-fueled reactor to its fleet in many years, though DOE hopes to convert the facility to LEU after the initial startup with HEU.[141]

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137 U.S. Department of Energy, *FY 2016 Congressional Budget Request: NNSA.*

138 U.S. Department of Energy, *FY 2016 Congressional Budget Request: NNSA*, p. 565.

139 International Panel on Fissile Materials, "Russia completed conversion of Argus research reactor," *IPFM Blog,* November 30, 2014, http://fissilematerials.org/blog/2014/11/russia_completed_conversi.html (accessed February 10, 2016).

140 Interview with Rosatom expert, October 2015. See also Khlopkov, "Russia's Nuclear Security Policy."

141 Pavel Podvig, "United States Prepares to Restart TREAT Reactor," *International Panel on Fissile Materials*, October 7, 2014, http://fissilematerials.org/blog/2014/10/united_states_prepares_to.html (accessed February 10, 2016). For the plan to start with HEU and then convert to LEU, see Alfred Sattleberger and John W. Herczeg, "Status of NEAC Fuel Cycle Subcommittee Recommendations," *U.S. Department of Energy,* December 11, 2015, http://www.energy.gov/sites/prod/files/2016/01/f28/NEACRecommendationsStatus-NE-5(FINAL).pdf (accessed February 10, 2016).

One area where there has been steady progress throughout the Obama administration is in reducing the use of HEU for producing medical isotopes, principally molybdenum-99 (Mo-99, sometimes referred to as "moly-99"). Until recently, all of the largest producers made their Mo-99 from HEU, using over 40 kg of weapons-grade HEU every year (as the production process involves only brief irradiation, nearly all of the HEU used ends up in "waste" that is still very highly enriched and not very radioactive). South Africa, with extensive U.S. support, became the first of the large producers to produce Mo-99 from LEU; Belgium and the Netherlands have both committed to converting and are both in the process of doing so, though with some delays; Canada, the last of the large producers, plans to shut down its production in 2018; and NNSA has supported companies that are expected to begin producing Mo-99 within the United States without HEU in the next few years. Within a few years, it should be possible to meet all of global demand for medical isotopes without HEU.[142] At the same time, Rosatom intends to expand its isotope production, still using HEU fuel and targets; while Russia is considering converting to LEU, there are concerns that expanded Russian production using HEU could undercut producers that have converted away from HEU.[143]

Table 2: **Total Worldwide GTRI Conversion and Shutdown Reactors**

Years	1978–2003	2004–2008	2009–2015
Converted	35	17	13
Shutdown	90	6	20

Note: Data from Ole Reistad and Styrkaar Hustveit, "Appendix II: Operational, Shut Down, and Converted HEU-Fueled Research Reactors," *Nonproliferation Review,* Vol. 15, No. 2 (July 2008), http://cns.miis.edu/npr/pdfs/152_reistad_appendix2.pdf (accessed May 21, 2015) and information provided by NNSA officials, January 2016. The number of reactors converted from 1978–2003 are adapted from NNSA data. NNSA counts a reactor as converted when conversion begins, and this table attempts to count reactors as converted when they are no longer using HEU fuel; at a minimum, this affects one research reactor in Mexico and one in Austria whose first use of LEU fuel was before 2003 but whose conversions were completed in 2012, and one in Vietnam whose conversion began in 2007 but was completed in 2011. Additionally, the chart counts a research reactor in Switzerland and one at Georgia Tech as shut down rather than converted because both were reportedly shut down before operating without HEU.

142 Anton Khlopkov and Miles Pomper, with Valeriya Chekina, "Ending HEU Use in Medical Isotope Production: Options for U.S.-Russian Cooperation," *Nuclear Threat Initiative Media,* February 14, 2014, http://www.nti.org/media/pdfs/Ending_HEU_Use_in_Medical_Isotope_Production.pdf?_=1393952246 (accessed February 10, 2016); and *World Nuclear News*, "U.S. firms target revival in domestic Mo-99 production," *WNN Corporate News,* May 1, 2015, http://www.world-nuclear-news.org/C-US-firms-target-revival-in-domestic-Mo-99-production-01051501.html (accessed February 10, 2016).

143 Khlopkov, Pomper, Chekina, "Ending HEU Use: U.S.-Russian Options."

Civilian Plutonium

Global stocks of civilian separated plutonium are immense, amounting to over 270 tons, more than all the plutonium in all the world's military stockpiles combined, and continue to grow every year as reprocessing of plutonium continues to outpace its use as fuel. Few current efforts are targeted either on minimizing these huge stocks or reducing the number of locations where they are stored and handled.

Unlike HEU, most civilian plutonium is at reprocessing plants or fuel fabrication facilities, not at small research facilities. Current minimization efforts are focused on addressing the few small stocks of plutonium at research facilities and other locations where its owners have concluded it is no longer needed. These efforts are small: only one percent of the nuclear material the United States has helped to remove or confirm disposition of since 1996 has been plutonium.

Nevertheless, the United States has helped eliminate plutonium from several locations around the world. In March 2016, the United States helped remove 20 kg of plutonium from Switzerland.[144] As noted above, if all goes as planned, 2016 will also see the biggest plutonium removal yet, of some 331 kg of plutonium from the FCA in Japan. Nevertheless, these plutonium removals are addressing only a very small part of the overall problem of civilian separated plutonium around the world.

Military Stockpiles

Some 85 percent of the world's weapons-usable nuclear material is in military programs, rather than in civilian use. Some of the world's largest military stockpiles exist in countries with track records of corruption, theft, and political instability.

Russia and the United States have by far the largest military nuclear complexes, making consolidation a particular issue for those two countries. Both have consolidated their nuclear weapons complexes in the last two decades. In the United States in particular, a variety of factors, including a push to consolidate nuclear material at fewer locations, led to the closure and decommissioning of the Rocky Flats plutonium facility; an end to plutonium reprocessing, except for some modest processing for cleanup purposes that continues at Savannah River; the elimination of Category I and II weapons-usable nuclear

144 U.S. National Nuclear Security Administration, "United States Collaborates with Switzerland to Remove Last Remaining Separated Plutonium."

material from the Sandia and Livermore national laboratories, and from Technical Area 55 at Los Alamos National Laboratory; and the clean-out of dozens of buildings that once held weapons-usable nuclear material at other sites. The number of buildings with weapons-usable nuclear material has been reduced to a fraction of what it was at the peak of the Cold War.

In Russia, as noted above, four nuclear weapons assembly and disassembly plants have been reduced to two, the last plutonium production reactors and their associated reprocessing plants have closed, and fabrication of plutonium and HEU weapons components has been consolidated at a single site. But overall, Russia still has much farther to go, with much larger number of nuclear weapon storage facilities than any other country; some 200 buildings with weapons-usable nuclear material; and something in the range of two-thirds of all the world's HEU-fueled pulse reactors and critical assemblies. For its own interests, Russia could get the military support and research operations it needs for less cost and risk with a smaller number of facilities.

Few initiatives are under way to consolidate nuclear weapons or military stocks of weapons-usable nuclear material. There have been, however, major initiatives to reduce the size of these stockpiles. In 2013, the United States and Russia completed the 20-year-long HEU Purchase Agreement, which eliminated 500 tons of Russian HEU. The HEU Purchase Agreement was a seminal achievement for nuclear security, eliminating thousands of bombs' worth of nuclear material, providing revenue and employment to stabilize key Russian nuclear facilities at a critical time, and introducing innovative transparency measures.[145] Unfortunately, Russia declined U.S. suggestions for a follow-on effort to blend more HEU.[146]

By contrast, U.S.-Russian plutonium disposition programs have made only modest progress. As noted earlier, the U.S. MOX plant appears likely to be abandoned, among skyrocketing costs.[147] It appears that the favored alternative is to store plutonium at the Waste Isolation Pilot Plant (WIPP) in New Mexico.[148] There are, however, significant tech-

145 "The 1993 United States-Russian Federation Highly Enriched Uranium Purchase Agreement: Overview, Implementation and Results," *NNSA Office of Nonproliferation and Arms Control*, http://www.state.gov/documents/organization/242396.pdf (accessed January 16, 2016).

146 For suggestions on approaches Russia could take to use its remaining excess to make billions of dollars while supporting its nuclear energy growth and export objectives, see Matthew Bunn, "Expanded and Accelerated HEU Downblending: Designing Options to Serve the Interests of All Parties," (presented at the 49th Annual Meeting of the Institute for Nuclear Materials Management, Nashville, TN, July 17, 2008), http://belfercenter.hks.harvard.edu/files/inmm-expanded-blend-down-incentives.pdf (accessed March 6, 2016).

147 Kingston Reif, "Cost Estimate for MOX Plant Jumps," *Arms Control Today*, June 2015, https://www.armscontrol.org/ACT/2015_06/News-Briefs/Cost-Estimate-for-MOX-Plant-Jumps (accessed January 15, 2016).

148 Derrek Asberry, "White House hopefuls tackle MOX, eminent domain," *Aiken Standard*, February 17, 2016, http://www.aikenstandard.com/article/20160217/AIK0101/160219533 (accessed February 19, 2016).

nical, safety, and legal issues that need to be addressed before the WIPP alternative could be implemented.[149] Russia has completed its MOX plant and brought the BN-800 online, but the fate of the U.S.-Russian plutonium disposition agreement and whether the BN-800 will run on former weapons plutonium or reactor plutonium remain uncertain.[150]

Strengthening Security Culture and Combating Complacency

As discussed below, strong security cultures, in which all security-relevant staff take the issue seriously and are always looking for vulnerabilities to be fixed and ways to make improvements—are essential to nuclear security excellence. The foundation of a strong security culture is belief in the threat—never "forgetting to be afraid."[151]

Initiatives such as the nuclear security summits and GICNT have done a great deal to build international consensus that the threat of nuclear terrorism is real, and that nuclear security is a critical element of efforts to address the threat. Nevertheless, in many quarters, complacency remains.

Progress in combating complacency and strengthening security culture is extraordinarily hard to assess. But that is no excuse for not focusing on the issue, given its crucial importance to nuclear security success. Indicators that could be used to assess progress in these areas include:

- The fraction of the world's locations with nuclear weapons, separated plutonium, or HEU that are managed by organizations with targeted programs in place to strengthen their security culture, and assess their progress in doing so.
- The degree of improvement such programs are achieving in attitudes and behavior of staff, as measured in surveys and self-assessments.
- The degree to which national policymakers involved in nuclear security decisions express belief in the threat and the need for action to improve nuclear security—and the degree to which they back that up by allocating resources and approving stringent nuclear security requirements.

149 Oak Ridge National Laboratory, *Final Report of the Plutonium Disposition Red Team* (Oak Ridge, TN: Oak Ridge National Laboratory, August 13, 2015), http://www.ucsusa.org/sites/default/files/attach/2015/08/final-pu-disposition-red-team-report.pdf (accessed March 6, 2016).

150 "Russia Launches Commercial MOX Fuel Fabrication Facility," *International Panel on Fissile Materials,* September 28, 2015, http://fissilematerials.org/blog/2015/09/russia_launches_commercia.html (accessed January 16, 2016).

151 James Reason, *Managing the Risks of Organizational Accidents* (Aldershot, U.K.: Ashgate, 1997), p. 195.

International nuclear terrorism exercises can provide officials with a visceral sense of the dangers of nuclear terrorism and magnitude of the stakes involved. Many such exercises have already been conducted. Most prominently, perhaps, the 2014 nuclear security summit included the leaders participating in a "scenario-based discussion"—in essence, a simulation of a nuclear terrorism event—and a similar activity is planned for the 2016 summit.[152] In January 2016, the DOE and the government of the Netherlands co-hosted a minister-level nuclear terrorism exercise known as Apex Gold, working through how each of the participating countries and organizations might be able to contribute in an unfolding nuclear terrorism emergency.[153] The Nuclear Threat Initiative has sponsored an exercise in Russia featuring former senior U.S. and Russian officials, and a similar event in China (both of which led the participants to recommend that currently serving officials take part in similar joint exercises), and Harvard has sponsored smaller-scale exercises in its executive program for U.S. and Russian generals.[154] In addition, a series of exercises focused on particular pieces of the problem have been conducted as part of the GICNT, and others have occurred in U.S. cooperation with particular countries.

Officials and nuclear managers in many countries, however, still tend to dismiss the threat of nuclear terrorism. Many have little awareness of the specifics of past terrorist nuclear ambitions and activities or of real incidents of nuclear theft and sabotage. That tendency is likely to grow as time goes by since the last nuclear security summit and the most recent major revelations about terrorist nuclear activity expand. Focused efforts are needed to address complacency and build international understanding of the threat.

A number of programs around the world have been targeted on strengthening nuclear security culture in recent years. The nuclear security summit process strongly endorsed the concept, with the 2014 summit communiqué calling on all operators to take steps to establish effective nuclear security culture.[155] The U.S. government sponsored an extensive nuclear security culture program in Russia, which, as noted earlier, contributed to Rosatom requiring each of its major facilities to have a security culture improvement program

152 Laura S. Holgate, "Preparing the Leaders' Path to the 2016 Nuclear Security Summit," *White House Blog,* August 5, 2015, https://www.whitehouse.gov/blog/2015/08/05/preparing-leaders-path-2016-nuclear-security-summit (accessed February 11, 2016).

153 "Apex Gold Discussion Fosters International Cooperation in Run-Up to 2016 Nuclear Security Summit" (Washington, D.C.: National Nuclear Security Administration, February 1, 2016), http://nnsa.energy.gov/blog/apex-gold-discussion-fosters-international-cooperation-run-2016-nuclear-security-summit (accessed March 6, 2016).

154 See *Black Dawn: A Scenario Based Exercise* (Washington, D.C.: Nuclear Threat Initiative and Center for Strategic and International Studies, May 3, 2004), http://csis.org/files/media/csis/pubs/040503_blackdawn.pdf (accessed February 19, 2016).

155 "The Hague Nuclear Security Summit Communiqué," U.S. Department of State, March 25, 2014, http://www.state.gov/documents/organization/237002.pdf (accessed February 10, 2016).

(which is more than can be said for comparable U.S. facilities). NNSA has also sponsored in-depth workshops on steps to strengthen nuclear security culture in China, Pakistan, and elsewhere; the U.S. State Department's Partnership for Nuclear Security has made security culture a major part of its programs. The IAEA has established a major nuclear security culture program, with guidance, workshops, and other activities. WINS has been a major promoter of nuclear security culture, also publishing guides for organizations and holding workshops to exchange experience and good practices. Many of the nuclear security Centers of Excellence have made security culture a major part of their programs.

It is difficult to assess, however, how much progress organizations are making toward strong security cultures. Most organizations handling nuclear weapons, HEU, or separated plutonium do not have specific programs focused on strengthening security culture. There is clearly a great deal still to be done to foster such a culture around the world, including better understanding how national and institutional cultures affect security practices in different organizations.

Building Confidence in Effective Nuclear Security

A nuclear weapon or nuclear material stolen in one country could be used on the other side of the world. And nuclear security is only as strong as its weakest link. Hence, every nation on earth has a national interest in making sure that all the countries with nuclear weapons and weapons-usable nuclear material fulfill their responsibility to provide effective protection. Today, however, there are few mechanisms that allow a country to confirm that nuclear security in other countries really is effective.

Here, too, measuring progress is very difficult. Indicators of progress could include:

- The fraction of locations with nuclear weapons, HEU, or separated plutonium covered by initiatives to build confidence that effective security is in place; and

- The degree to which these initiatives actually make it possible to understand and have confidence in a country's approaches to nuclear security. (For example, permitting experts from another country to visit and examine security procedures provides much more confidence than simply asserting that effective security is in place.)

Countries legitimately regard the specifics of how they guard their nuclear stocks as secret, and neither the IAEA nor any other international group has the legal right to inspect what

they do (though some countries voluntarily request an IAEA-led review of their physical protection arrangements.) Hence, no one—not the IAEA, not the U.S. government, and not any other government—has a complete assessment of nuclear security around the world, which really identifies where the strongest and weakest points lie.[156]

There is, however, increasing acceptance that states should provide *some* information about their approaches to nuclear security, since nuclear material stolen in one state could be used to threaten other states. Countries are required to report to a United Nations committee on the steps they have taken to implement the UNSCR 1540 obligation to provide "appropriate effective" security and accounting for nuclear weapons and weapons-usable materials (along with other controls to prevent nuclear, chemical, and biological proliferation); many countries publish progress reports at the nuclear security summits highlighting particular steps they have taken; published regulations, regulators' reports, and conference papers can also provide very useful information. But publications that simply assert all is well with a state's nuclear security, or highlight steps forward without mentioning challenges, do little to build confidence.[157]

The protesters' 2012 intrusion at the Y-12 HEU facility in the United States raises an even more fundamental issue for such international confidence-building: governments themselves may not know about nuclear security weaknesses in their own nuclear complexes. As noted earlier, a week before the intrusion, if you had asked officials managing security in the U.S. nuclear complex where the more secure sites were, Y-12 would have been close to the top of the list.

A variety of existing and proposed approaches offer greater confidence than simple assertions that effective nuclear security is in place. Technical cooperation programs, for example, often include in-depth discussions of existing nuclear security arrangements, and sometimes also include visits to key nuclear facilities to observe implementation on the ground. Some nuclear suppliers (especially the United States) visit locations handling nuclear material they exported to ensure that it has adequate physical protection. The IAEA organizes a number of nuclear security review services, particularly IPPAS,

156 The U.S. government has attempted such an assessment, known as the Nuclear Materials Information Program (NMIP). NMIP has a great deal of useful information (much of it classified), but substantial gaps remain.

157 As one example of public assertions that did not build much confidence, in Pakistan's first report on actions taken under UNSCR 1540, with respect to the requirement for "appropriate effective" security and accounting measures for nuclear weapons and weapons-usable materials, Pakistan simply said: "The Government has put in place effective physical protection measures for the safety and security of its installations, equipment, material, and personnel," without even a general description of what these effective measures might be. See Government of Pakistan, "Pakistan's National Report on National Measures on the Implementation of Security Council Resolution 1540 (2004)," S/AC.44/2004/ (02)/22, November 5, 2004, http://www.nti.org/media/pdfs/pakistan-1540-initial-report.pdf?_=1316804762 (accessed March 15, 2016).

Security Culture Case Study: Clinton Prison, United States, 2015

In early June 2015, David Sweat and Richard Matt—both convicted murderers—escaped from the maximum-security Clinton Correctional Facility in Dannemora, New York. They cut holes in the back of their cells, climbed down several stories, and crawled through a series of tunnels, eventually emerging from a manhole outside the prison. Until this incident, nobody had ever escaped from the maximum-security area, and nobody had escaped from the prison at all in more than 100 years.

In the weeks following the incident, investigations revealed that Sweat and Matt were able to escape because they were assisted by prison employees and because of staggering lapses in facility security, reflecting a very weak security culture. According to current and retired officers, "a sense of complacency had taken hold" among the 1,400 correction officers at the facility, leading to numerous lapses in security.[i]

Security Lapses

During hourly bed checks at night, prison regulations stipulated that officers needed to be able to see skin and detect breathing. Yet, at the time of the breakout, prisoners were frequently allowed to sleep entirely covered, wear hooded sweatshirts, and cover their faces with pillows. Trying to avoid waking up prisoners, guards rarely shined flashlights on prisoners' faces. Corrections officers also allowed inmates to hang sheets across cell bars, frequently for lengthy periods, despite rules prohibiting such actions except when an inmate was using the toilet. Unlike in many other prisons, there were no video cameras in the cellblocks to detect suspicious activities.[ii] These lapses allegedly allowed Sweat and Matt to stuff "dummies" under their blankets and work undetected throughout the night.

Additionally, according to current officers, tunnels beneath the cellblocks and catwalks behind the cells (used by Matt and Sweat to escape) had not been inspected regularly in years. Guards were no longer stationed in two 35-foot guard towers during the night (despite rules requiring the towers to be manned and the catwalks to be inspected). Some have alleged that the inmates may have had access to power tools left on the catwalks by contractors. In addition, one former corrections officer at the facility noted that inmates frequently use power tools to perform maintenance.[iii]

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i Michael Winerip, Michael Schwirtz, and Vivian Yeehune, "Lapses at Prison May Have Aided Killers' Escape," *New York Times*, June 21, 2015, http://www.nytimes.com/2015/06/22/nyregion/new-york-prison-escape-an-array-of-oversights-set-the-stage.html (accessed February 18, 2016).

ii Allie Healy, "FBI launches investigation into Clinton Correctional Facility for possible drug trafficking, more," *Syracuse.com*, June 29, 2015, http://www.syracuse.com/crime/index.ssf/2015/06/fbi_launches_investigation_into_clinton_correctional_facility_for_possible_drug.html (accessed February 18, 2016).

iii Brian Mann, "Inside Clinton Correctional: Power Tools And Barbecue Grills," *National Public Radio*, June 13, 2015, http://www.npr.org/2015/06/13/413914664/inside-clinton-correctional-power-tools-and-tailgate-parties (accessed February 18, 2016).

The prison's location in a small town meant that corrections officers and staff are often related and especially close-knit. Jeff Hall, the prison historian, alleged that this tight web of relationships has often stymied investigations in the past.[iv]

Insider Assistance

Two prison employees aided Sweat and Matt. Joyce Mitchell, a tailor and industrial training supervisor since 2008, reportedly provided the two inmates with a variety of tools that aided their escape, including hacksaw blades, chisels, a punch, and a screwdriver bit.[v] Mitchell had developed a romantic relationship with one of the prisoners and told investigators that she was supposed to pick up the prisoners and, after they killed her husband (Lyle Mitchell, also an employee at the prison), drive them to a destination approximately seven hours away from the prison. At the last minute, however, she claims she had a change of heart. Instead of picking them up, she checked into a hospital seeking treatment for a panic attack.[vi]

The other employee, Gene Palmer, admitted that—in exchange for paintings and drawings from Matt—he provided the inmates with contraband, including a screwdriver and pliers, passed frozen meat to them from Mitchell (which Palmer asserts he did not know contained a hacksaw), and granted Sweat access to the catwalk behind his cell—which he and Matt later used to escape.[vii] Palmer claims, however, that he was trading these favors for useful information on prisoner activities, with no knowledge that he was contributing to an escape plot.

The implications of this incident are important for any organization that is trying to foster an effective security culture, but particularly for those that protect against the theft of nuclear material.[viii] The central mission of a prison is to keep prisoners locked up. Moreover, prison employees face the very likely possibility that, if they are not vigilant, prisoners might try to escape. Yet, the incident at the Clinton Correctional Facility shows that even when the threat is ever-present, complacency can dramatically undermine security, with devastating results.

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iv Brian Mann, "A Dozen Officials Suspended As Probe Into N.Y. Prison Break Widens," *National Public Radio*, June 30, 2015, http://www.npr.org/2015/06/30/418915785/a-dozen-officials-suspended-as-probe-into-n-y-prison-break-widens (February 18, 2016).

v Faith Karimi, "New York prison worker Joyce Mitchell charged with helping inmates escape," *CNN*, June 13, 2015, http://www.cnn.com/2015/06/13/us/new-york-prison-break/ (accessed February 18, 2016).

vi Susanne Craig, William K. Rashbaum, and Benhamin Mueller, "New York Prison Escapee Traded Art for Favors From a Guard," *New York Times*, June 25, 2015, http://www.nytimes.com/2015/06/26/nyregion/corrections-officer-new-york-prison-escape.html?_r=0 (accessed February 18, 2016).

vii "Gene Palmer's Sworn Statement to New York State Police," *New York Times*, June 25, 2015, http://www.nytimes.com/interactive/2015/06/25/nyregion/document-gene-palmer-statement-to-new-york-state-police.html (accessed February 18, 2016).

viii For an excellent analysis of nuclear security lessons learned from the prison break, see Kate Miller, "The Dannemora Prison Break: Lessons for Nuclear Facilities," *Nuclear Security Matters,* September 9, 2015, http://nuclearsecuritymatters.belfercenter.org/blog/dannemora-prison-break-lessons-nuclear-facilities (accessed March 15, 2016).

which contribute to confidence and to spreading good practices at the same time. The information from both IPPAS missions and technical cooperation visits remains confidential, however, so the degree of confidence others can have in the results depends on their confidence in the IAEA or the countries participating in the technical cooperation. Some countries publish sufficiently detailed information about their approaches to contribute significantly to confidence building. The U.K. regulator of civilian nuclear security, for example, used to publish detailed annual reports outlining the issues facing nuclear security in the United Kingdom and the steps being taken to address them (unfortunately, these reports did not continue after the regulator was folded into the broader U.K. nuclear regulatory agency.) The United States publishes a great deal of information on its nuclear security arrangements, and has several times, for example, allowed experts from other countries to observe force-on-force exercises testing the effectiveness of U.S. nuclear security systems. Overall, however, for most countries, the information available either to other states or to the public is insufficient to offer much confidence in the effectiveness and sustainability of nuclear security implementation.

Continuing an Effective Nuclear Security Dialogue After the Summits

Forums where states can discuss nuclear security and decide on next steps are also an essential element of an effective and sustainable nuclear security system. The nuclear security summit process has provided a very important forum for such discussions that had not existed before. The summits have helped to raise the issue to a high political level, increase awareness of the terrorism threat, provide a regular forum for high-level dialogue on next steps, create moments for action, and provoke new interagency discussions within governments.[158] The end of the nuclear security summit process with the 2016 meeting will leave a substantial gap that will be difficult to fill.

Nuclear Security Summits

The nuclear security summit process has transformed the international nuclear security discussion. The issue is now far more broadly recognized as an important element of the international security agenda; the threat of nuclear terrorism is far more broadly understood and accepted as a concern; the IAEA's role in nuclear security has been strengthened

158 See Bunn *et al., Advancing Nuclear Security,* p. 58.

and is now overwhelmingly endorsed by its member states; and many actions by individual states or groups of states, from eliminating particular stocks of HEU to putting in place new protections against cyberattack on nuclear facilities, have been driven or at least accelerated by the summit process.

The summits have included several key institutional elements. First, the summits themselves focused the attention of dozens of presidents and prime ministers from around the world on nuclear security, often leading to action on issues that had been delayed or blocked before. Second, the summit dates served as deadlines that accelerated action, as leaders often wanted something to be done so they could announce it at the summit. Third, the summits focused narrowly on nuclear security and not on nonproliferation, disarmament, or broader political issues. Remarkably, this made it possible for Israeli and Arab leaders, Pakistani and Indian leaders, and leaders from nuclear weapon states, non-nuclear-weapon states, and states outside the NPT to sit down together and discuss initiatives that could serve all their interests.[159] The Sherpa process to prepare for each summit allowed regular private discussions of nuclear security among a group of senior officials from dozens of countries, making it possible to float new ideas, hash out disagreements, and build consensus. Fourth, the summits established a tradition of participants making pledges to strengthen their nuclear security, known as "house gifts." Unlike the communiqués, which required all the participating states to agree, a single country's decision was enough in the case of a house gift—so many of these were more meaningful and far-reaching than the actions pledged in the communiqués. Fifth, the second summit established the new tradition of "gift baskets"—groups of states making pledges together. This made it possible to build group commitments even if some of the states participating in the summit did not want to join them.

There were noteworthy house gifts and "gift baskets" announced at each of the nuclear security summits. For example, at the 2010 Nuclear Security Summit Ukraine pledged to have all of its HEU removed by the end of the year. At the 2012 Summit, more than two-dozen nations supported an initiative to strengthen national legislation related to nuclear security. At the 2014 summit, 35 nations launched the nuclear security implementation initiative, discussed above. Each of the summits resulted in a communiqué generated by consensus, reaffirming the participants' support for strengthening nuclear security.

159 A number of countries, however, resented the exclusion of disarmament issues, seeing it as yet another attempt by the nuclear weapon states to evade their disarmament responsibilities. See, for example, the joint statement from Algeria, Argentina, Brazil, Chile, Egypt, Indonesia, Kazakhstan, Malaysia, Mexico, New Zealand, the Philippines, Singapore, South Africa, Ukraine, and Vietnam: "In Larger Security: A Comprehensive Approach to Nuclear Security" Statement at the Hague Nuclear Security Summit, March 25, 2014, http://www.state.gov/documents/organization/235496.pdf (accessed March 13, 2016).

One of the key questions that will be addressed at the 2016 Nuclear Security Summit will be how to sustain momentum and continue an effective dialogue in the absence of continuing meetings. At the summit, suggested plans will be presented to strengthen the nuclear security role of five organizations—the International Atomic Energy Agency, the United Nations, the GICNT, the GP, and Interpol. The potential role of each of these organizations—and particularly their role in continuing the dialogue—will be discussed below, along with other potential venues for a continuing dialogue.

The International Atomic Energy Agency

There is no doubt that the IAEA will continue to play a central role in nuclear security in the future, providing all the services described above. Moreover, with its series of international nuclear security meetings, the IAEA will clearly be one of the key elements of maintaining a high-level nuclear security dialogue. Discussions at the IAEA, open to all member states, carry a political legitimacy and acceptance that the invitation-only nuclear security summit process does not. At the same time, however, the consensus processes typically found at IAEA meetings tend toward least-common-denominator outcomes, making it difficult to reach agreement on substantial new nuclear security steps.

In 2013, the IAEA held the first of its international meetings on nuclear security that included both presentations by technical experts and a gathering at the level of government ministers. The statement from the ministerial part of the meeting, however, said little: it called on states to provide effective nuclear security, endorsed the role of the IAEA in nuclear security (something that was not broadly supported among member states a few years before), and called on states to join relevant treaties, but did little more. Because of the politics of the IAEA, it did not even explicitly mention initiatives ranging from the nuclear security summits to the GICNT to the World Institute for Nuclear Security (WINS), saying only that "initiatives" and "summits" could play a role if they were "inclusive."[160] The question for the future is whether IAEA meetings can become a more effective forum for high-level dialogue without sacrificing their advantages of political legitimacy and inclusiveness.[161]

160 "Ministerial Declaration" (International Conference on Nuclear Security: Enhancing Global Efforts, July 1–5 2013), http://www-pub.iaea.org/MTCD/Meetings/PDFplus/2013/cn203/cn203MinisterialDeclaration.pdf (accessed March 8, 2014).

161 See, for example, Trevor Findlay, "Beyond Nuclear Summitry: The Role of the IAEA in Nuclear Security Diplomacy after 2016" (Cambridge, MA: Project on Managing the Atom, Belfer Center for Science and International Affairs Harvard University, March, 2014), http://belfercenter.hks.harvard.edu/files/beyondnuclearsummitryfullpaper.pdf (accessed February 10, 2016).

The United Nations

To date, the United Nations has played only a modest role in nuclear security. As noted earlier, UNSCR 1540 legally obligates all UN member states to provide "appropriate effective" security for any stocks of nuclear weapons and weapons-usable material they have. The committee established to monitor implementation of UNSCR 1540 now has a mandate to identify "effective practices" in the various areas covered by the resolution, and is undertaking a comprehensive review of approaches to implementation. But the committee's small staff and modest expertise in nuclear security, coupled with the limited role it has played so far, suggest that significant changes in approach would be needed for the UN to be a major focus of effective dialogue on next steps in nuclear security in the future.

The Global Initiative to Combat Nuclear Terrorism

The United States and Russia, both of whom remain the co-chairs, established the GICNT in 2006. As of early 2016, GICNT had 86 participating states, including eight of the nine states that possess nuclear weapons (all but North Korea) and all but a few of the other states with weapons-usable nuclear material on their soil. GICNT is open to any state willing to commit to its principles. It also includes five observer organizations. GICNT's flexible approaches have made it possible to reach agreement in various areas, from strengthening emergency preparedness to developing guidance on nuclear forensics. (The forensics guidance developed in GICNT was later largely adopted by the IAEA, giving it increased political legitimacy—an interesting example of a strategy that could combine the advantages of flexibility in developing new ideas with political legitimacy in approving them.)

GICNT's statement of principles includes improving "accounting, control, and protection of nuclear material" and enhancing "security of civilian nuclear facilities." To date, however, GICNT has focused primarily on responses to the threat of nuclear terrorism other than security for nuclear weapons and materials—radiation detection, emergency response, nuclear forensics, law enforcement, and more. GICNT's work takes place primarily in working groups on particular topics, and there is no working group on improving security for nuclear materials. In essence, those who established the initiative concluded that there was already a range of international cooperative efforts targeted on improving security for nuclear weapons and weapons-usable nuclear material, and focused the new initiative in other areas. "Multilateral conferences, workshops, and

exercises" are GICNT's primary activities, rather than contributing directly to upgrading security at particular nuclear sites; only a handful of these activities have focused on discussing approaches to security for weapons-usable nuclear materials, and there is no working group on that topic.[162] Clearly, significant changes—such as establishing a nuclear security working group—would be needed for GICNT to play a major part in sustaining effective dialogue on nuclear security after the summit process comes to an end.

Nevertheless, by pulling together a large number of states for regular meetings examining the threat of nuclear terrorism and specific steps that can be taken to address the problem, it seems very likely that GICNT has increased many countries' perception of the threat of nuclear terrorism. That increased threat perception may well have contributed to improvements in their rules and procedures for securing their weapons-usable nuclear material.

The Global Partnership Against the Spread of Weapons and Materials of Mass Destruction and G7 Summits

In 2002, partly in reaction to the 9/11 attacks, the Group of Eight (G8) industrialized democracies established the GP, pledging a total of $20 billion over ten years to efforts to dismantle and control nuclear, chemical, and biological weapons and materials.[163] Half of the total was to come from the United States, and half from the other participating countries.

In 2008, the G8 agreed to extend the focus from projects in Russia and Ukraine to countries around the world that may need help in implementing the effective nonproliferation controls mandated by UNSCR 1540. In 2011, the G8 agreed to extend the effort beyond its original 2012 end date, and to focus it on improving nuclear security and other nonproliferation controls around the world.[164] While the effort began with the G8, more than a dozen other donor states are now participating, and a number of important developing

162 See "Global Initiative to Combat Nuclear Terrorism" (U.S. Department of State, 2013), http://www.state.gov/t/isn/c18406.htm (accessed July 7, 2015). For a list of GICNT activities, see "Global Initiative to Combat Nuclear Terrorism: Key Multilateral Workshops and Exercises" U.S. Department of State, 2012, http://www.gicnt.org/download/iag/Running_List_of_All_GICNT_Events_-_December_2013.pdf (accessed July 7, 2015).

163 See "Global Partnership Against the Spread of Weapons and Materials of Mass Destruction," Nuclear Threat Initiative, online, http://www.nti.org/treaties-and-regimes/global-partnership-against-spread-weapons-and-materials-mass-destruction-10-plus-10-over-10-program/ (accessed March 8, 2014).

164 See, for example, "Global Partnership Against the Spread of Weapons and Materials of Mass Destruction ('10 Plus 10 Over 10 Program')," James Martin Center for Nonproliferation Studies, (Washington, D.C.: Nuclear Threat Initiative, 2013), http://www.nti.org/treaties-and-regimes/global-partnership-against-spread-weapons-and-materials-mass-destruction-10-plus-10-over-10-program/ (accessed July 7, 2015). See also Bonnie Jenkins, "The Future Role of the G8 Global Partnership: Combating Weapons of Mass Destruction" (Muscatine, IA: Stanley Foundation, June 2010), http://www.state.gov/documents/organization/184789.pdf (accessed July 7, 2015).

countries are often invited to relevant discussions.[165] To date, however, only a small amount of non-U.S. funds have gone to improving security for nuclear weapons and weapons-usable nuclear materials, as opposed to other projects.

In 2014, the G8 became the G7 when Russia was kicked out of the group because of actions in Ukraine. Traditionally, G7 summits include an extensive statement on nonproliferation, including, in recent years, nuclear security issues; these statements are drafted by a group of senior nonproliferation officials from the G7 countries, which meets between the summits. The idea of the GP originally came out of that process, and it is conceivable that discussions in that context could contribute in a modest way to ongoing nuclear security dialogue. With Russia excluded, however, with the world's largest nuclear stockpile, the G7 will have even less coverage and less legitimacy for its nuclear security initiatives than it had as the G8.[166]

Interpol

Interpol, the international police agency, has a sub-directorate focused on nuclear, chemical, biological, and radioactive crime and terrorism. Its efforts primarily focus on stopping nuclear smuggling and responding to incidents, not on preventing theft of nuclear material in the first place. Interpol provides:[167]

- Information on incidents related to nuclear and radiological materials. This includes Project Geiger, which combines data from the IAEA, law enforcement agencies, and open sources; Operation Fail Safe, which collects information on people known or suspected of being involved in nuclear or radioactive smuggling; and the *CBRNE Monthly Digest*, which summarizes open-source reporting on incidents around the world involving these materials.

- Training, workshops, and exercises focused on stopping nuclear smuggling and responding to or investigating nuclear and radiological incidents.

165 See Nuclear Threat Initiative, "Global Partnership Against the Spread of Weapons and Materials of Mass Destruction."

166 In 2015, for example, the G7 affirmed "the need for a robust and comprehensive international security architecture"; supported the outcomes of the Nuclear Security Summits; and pledged to "draw" on the "momentum" from the summits to "achieve sustainability of results and ideas created, developed, and implemented" in the summit process. See "G7 Statement on Nonproliferation and Disarmament," G7 Summit, Germany, April 15, 2015, http://www.auswaertiges-amt.de/sid_18514F1CEBD77EB51BCA26992A2DCFF7/DE/Infoservice/Presse/Meldungen/2015/150415_G7_NPDG.html?nn=546272 (accessed February 10, 2016).

167 See Interpol, "CBRNE," http://www.interpol.int/fr/Crime-areas/Terrorism/CBRNE/Radiological-and-nuclear-terrorism, (accessed February 8, 2015).

In January 2016, Interpol hosted a global meeting on countering nuclear smuggling, as part of the lead-up to the 2016 Nuclear Security Summit.[168] There is a good deal Interpol can do to support law enforcement aspects of preventing nuclear smuggling and nuclear terrorism. So far, though, its effort in this area has been small, and virtually none of it is focused on security for nuclear weapons and materials. Given its law enforcement emphasis, it seems unlikely that Interpol will be a major part of the dialogue on security for such stocks after the summit process ends.

Bilateral Dialogues

Some of the most effective international discussions of nuclear security take place between two states. As already discussed, in the past the United States and Russia had extensive nuclear security cooperation, overseen by a joint steering committee. The United States has ongoing cooperation, including in-depth discussions of nuclear security issues, with states such as Pakistan and China, as well as with U.S. allies such as the United Kingdom and France. In recent years, the United States has also had ongoing nuclear security dialogues with Japan and South Korea.[169]

Other Proposals

As discussed in more detail below, other institutions could also play a role in sustaining an effective international nuclear security dialogue. These mechanisms have not yet been put in place, so assessment of what they have accomplished so far is not possible, but those that are defined in treaties or the subject of major public proposals are worth mentioning:

- *CPPNM review conferences.* The amendment to the CPPNM calls for a review conference to be held after the amendment enters into force; if a majority of parties want further review conferences, they can be held at five-year intervals thereafter.[170]

168 "INTERPOL nuclear trafficking conference looks ahead to 2016 Nuclear Summit," *Interpol Media Center*, January 29, 2016, http://www.interpol.int/fr/News-and-media/News/2016/N2016-015 (accessed February 10, 2016).

169 See "United States-Japan Nuclear Security Working Group" (The White House, Office of the Press Secretary, March 24, 2014), https://www.whitehouse.gov/the-press-office/2014/03/24/fact-sheet-united-states-japan-nuclear-security-working-group (accessed March 6, 2016) and "The United States-Republic of Korea Alliance: Shared Values, New Frontiers" (The White House, Office of the Press Secretary, October 16, 2015), https://www.whitehouse.gov/the-press-office/2015/10/16/joint-fact-sheet-united-states-republic-korea-alliance-shared-values-new (accessed March 6, 2016).

170 Jonathan Herbach and Samantha Pitts-Kiefer, "More Work to Do: A Pathway for Future Progress on Strengthening Nuclear Security," *Arms Control Today,* October 2015, https://www.armscontrol.org/ACT/2015_10/Features/More-Work-to-Do-A-Pathway-for-Future-Progress-on-Strengthening-Nuclear-Security (accessed February 11, 2016).

- *A proposed nuclear security convention.* In March 2015, the Nuclear Security Governance Experts Group, an international non-government organization, proposed a framework convention on nuclear security. Regular meetings to discuss implementation of the convention and steps to strengthen the international nuclear security regime would be a key element of the convention. Each party would be required to make a national report on implementation that could be discussed, as in the case of the Convention on Nuclear Safety.[171]

- *A continuing group of interested states.* There have been proposals for a group of states interested in promoting nuclear security to continue meeting after the summit process ends—perhaps at a level similar to the current nuclear security summit Sherpas—to discuss implementation of commitments from the summit process and any new initiatives that seem desirable.[172] This would be the most informal of the options being discussed, probably making it easiest to reach agreement—but by the same token might have less political legitimacy than other options, unless the group's suggestions were endorsed by more inclusive groups, such as the IAEA.

It seems clear that no one forum will be able to fill all the roles that the nuclear security summits have played. The record of the past suggests that all of the forums discussed above have a role to play, but each has its own limitations.

Nuclear Security Funding

Fundamentally, states must take responsibility for their own nuclear security—and hence must provide the needed funding for effective and continuously improving nuclear security systems. But over the years, additional support from the United States has been critical in helping many countries improve nuclear security or eliminate nuclear materials. Other states have contributed as well, but the United States has been by far the largest of the donor states, investing billions of dollars in international nuclear security programs in the quarter-century since the collapse of the Soviet Union. Adequate funding is needed for all of the areas of progress just described.

171 Ambassador John Bernhard, Ambassador Kenneth C. Brill, Dr. Anita Nilsson, and Dr. Shin Chang-Hoon of the Nuclear Security Governance Experts Group, "International Convention on Nuclear Security" (Washington, D.C.: Asan Institute for Policy Studies, Partnership for Global Security, and the Stanley Foundation, March 2015), http://www.nsgeg.org/ICNSReport315.pdf (accessed February 18, 2016).

172 Interview with Obama Administration officials, March 1, 2016.

Nuclear security spending is a cost-effective investment in U.S. security, reducing the danger of a nuclear terrorist attack on the United States—which successive U.S. presidents have called the greatest threat to U.S. national security—for amounts that never amounted to as much as one-half of one percent of U.S. national security spending, and today constitute less than one part in a thousand of that spending.[173] Even a doubling of U.S. international nuclear security spending would be little more than a rounding error in the U.S. defense budget: hence, no program that offers the promise of significantly reducing the risk of nuclear terrorism should ever be allowed to be slowed, postponed, or stopped for lack of funds.

Unfortunately, the Obama administration has been cutting nuclear security spending for years, and weeks before the nuclear security summit, proposed a budget with substantial further spending cuts—in parallel with large proposed increases in nuclear weapons spending. These proposed spending reductions, if approved by Congress, would further slow nuclear security progress, undermining President Obama's otherwise impressive nuclear security legacy.

Some of the nuclear security budget reductions that have taken place during the Obama administration have been justified by the completion of major projects and the refusal of Russia and other countries to allow other work to continue. In other cases, it may be possible to mitigate the effects of the spending cuts by using unspent money from previous years. Nevertheless, there is little doubt that some work has been slowed by tight budgets. While lack of funds is by no means the largest barrier to progress, it has been one important barrier.[174]

Most U.S. nuclear security work is conducted through the NNSA. For more than a decade, the two major DOE nuclear security programs were International Materials Protection and Cooperation and the Global Threat Reduction Initiative. Those programs have now been rearranged into two new programs: Global Material Security and Material Management and Minimization (sometimes referred to as M^3). The Global Material Security program works with foreign countries to help improve security for nuclear weapons, weapons-usable nuclear materials, and radiological materials. It also includes the program once known as Second Line of Defense (now called Nuclear Smuggling Detection and Deterrence). The Material Management and Minimization program is responsible for removing HEU and separated plutonium from vulnerable sites; converting research

173 For a graphic representation of the insignificance even of threat reduction spending more broadly, see Bunn, *Securing the Bomb 2010*, pp. 68–69.

174 See Matthew Bunn, Nickolas Roth, and William H. Tobey, *Cutting Too Deep: The Obama Administration's Proposals for Nuclear Security Spending Reductions* (Cambridge, MA: The Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, July 2014).

reactors and medical isotope production facilities so they no longer use HEU; and disposition of HEU and plutonium.

From FY 2009 to FY 2013, the U.S. DOE allocated approximately $3.65 billion for programs to help other countries improve nuclear security or consolidate nuclear materials, an average of roughly $730 million per year.[175] The NNSA anticipates it will spend only $2.72 billion on these programs from FY 2017 through FY 2021, a yearly average of $544 million, more than a 25 percent cut from the previous level.[176]

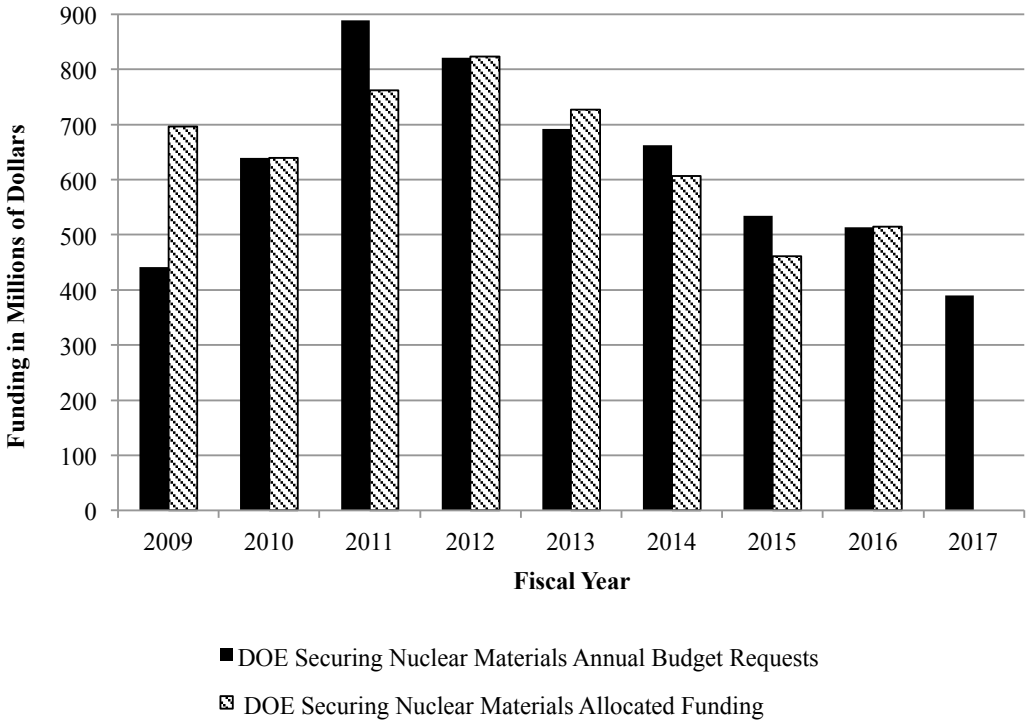
For FY 2011, to ramp up the nuclear security effort, the Obama Administration requested approximately $889 million for DOE nuclear security programs. Over each of the next six years, the amount of money requested for these programs declined, to $822 million for 2012; $692 million for 2013; $663 million for 2014; $534 million for 2015; $513 million for 2016, and $389 million for 2017—more than a 50 percent drop in requests for nuclear security programs over this period (see Figure 4.) The actual funding for DOE nuclear security programs has declined by 38 percent, from a high of $824 million in FY 2012 to $514 million in FY 2016.

For FY 2017, the Obama Administration has proposed substantial further reductions. The proposal would cut NNSA's International Nuclear Security program—the program once known as Material Protection, Control, and Accounting (MPC&A), which is most directly responsible for security upgrades around the world—by roughly two-thirds, to a level not seen since these programs were first beginning in the mid-1990s. This dramatic cut is from an FY 2016 budget from which Russian work had already been eliminated. The administration argues that the cut is merely a matter of using unspent money from prior years. But in fact the administration is now projecting lower spending year after year for years to come, postponing or canceling a wide range of nuclear security activities that had been included in earlier plans.

175 For a description of the programs included in our calculations of "nuclear security" funding, see the notes to Figure 4. We include DOE programs specifically focused on security for nuclear and radiological materials, excluding programs focused on detecting nuclear smuggling or on broader nonproliferation issues. Hence, in the old structure, our estimates included funding for the Global Threat Reduction Initiative; for the International Material Protection and Cooperation program except for the portion devoted to Second Line of Defense; and for the program known as International Nuclear Security, charged with conducting visits to check on the security of U.S.-origin material. Though the names have changed in some cases, we include the same programs in the new structure, making for an apples-to-apples comparison

176 U.S. Department of Energy, *FY 2017 Congressional Budget Request: National Nuclear Security Administration*, pp. 466–467, 485–486.

Figure 4: **Requested and Allocated Funding for U.S. Department of Energy Nuclear Security Programs**



Note: From 2009 to 2015, the programs we count as "International Nuclear Security Programs" included the Global Threat Reduction Initiative, International Material Protection and Cooperation (excluding Second Line of Defense, which focused on stopping nuclear smuggling rather than improving security for nuclear materials and facilities), and International Nuclear Security. As a result of the recent reorganization of NNSA non-proliferation programs, several of these programs have been renamed, but the underlying programs remain largely the same, making it possible to come very close to apples-to-apples comparisons. After fiscal year 2015, the programs we include in our accounting of nuclear security programs include Material Management and Minimization (excluding plutonium and HEU disposition) and Global Material Security (excluding Nuclear Smuggling Detection and Deterrence, the successor to Second Line of Defense). This chart uses the term "allocated" because small amounts of funding shift around between programs after funds are appropriated. Figure 4 is based on official data from DOE's FY 2017 budget request and those from prior years.

These were not anticipated funding reductions that occurred because of planned changes such as the completion of major programs, but major cuts from what NNSA had previously expected to be spending. For example, in 2013, NNSA predicted it would be spending $759 million on nuclear security programs in FY 2017. But the administration only requested $389 million for FY 2017, nearly 50 percent less than the anticipated amount set in 2013. The budget proposed for FY 2017 is more than $200 million less than NNSA anticipated it would spend as recently as last year (see Figure 5.)

Of course, the suspension of nearly all nuclear security cooperation with Russia—and the completion of many Russian projects before the suspension—explains a major part of the

reductions in nuclear security spending in recent years. There have also been setbacks in convincing countries like Belarus and South Africa to eliminate their stocks of HEU.

Table 3: **FY 2017 Request for Department of Energy Nuclear Security Programs**

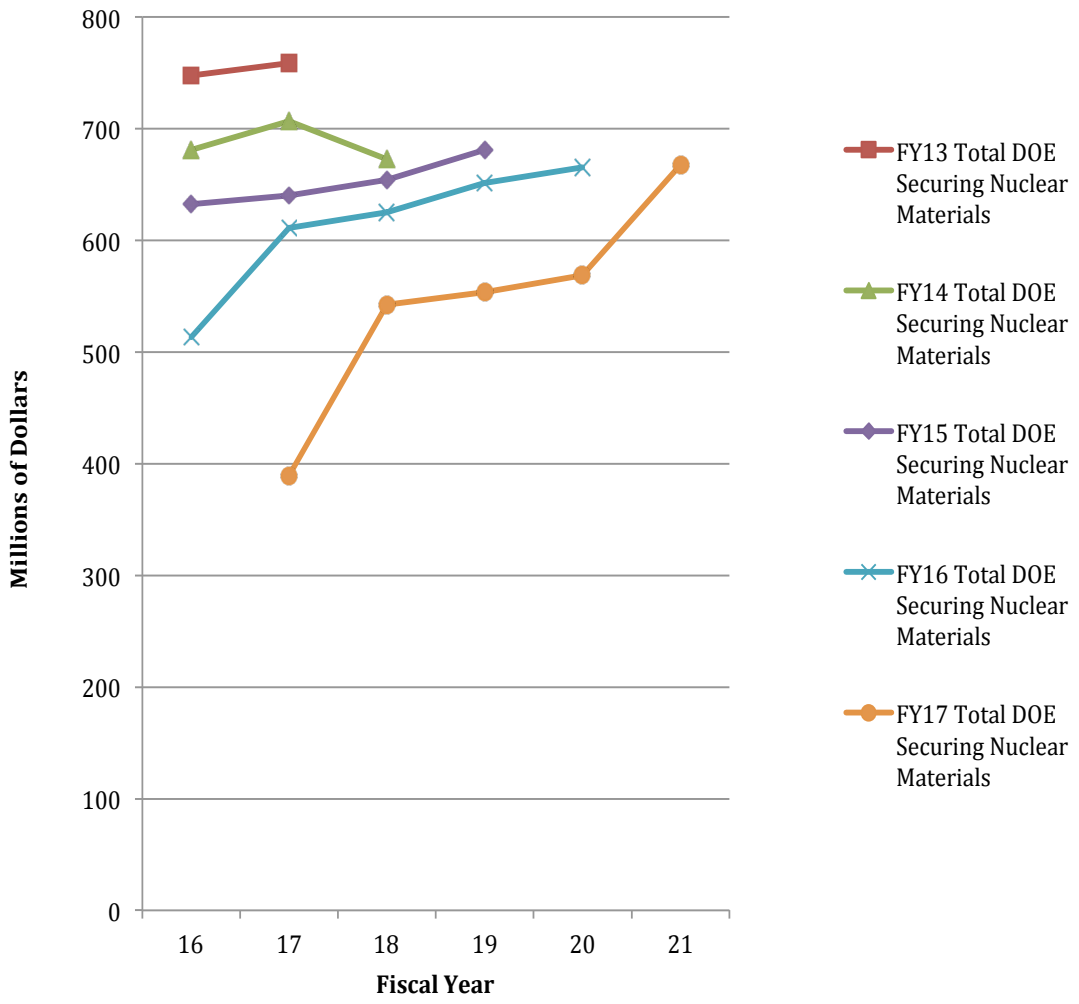
(all figures in thousands of dollars)	Fiscal Year 2015 Appropriation	Fiscal Year 2016 Appropriation	FY17 Request	% change from FY16 to FY17 request
Global Material Security*	272,708	284,276	192,133	-32%
International Nuclear Security	134,875	130,527	46,027	-65%
Radiological Security	137,833	153,749	146,106	-5%
Material Management and Minimization**	187,919	230,000	197,261	-14%
HEU Reactor Conversion	119,383	115,000	128,359	12%
Nuclear Material removal	68,536	115,000	68,902	-40%
Total	**460,627**	**514,276**	**389,394**	**-24%**

Note: This table is for comparison purposes only. The programs listed here had different names before FY 2016, and the match of the old programs to the new structure is not quite exact. In particular, in FY 2015, as a result of small program shifts during the reorganization, DOE reported receiving $4 million less for GTRI and IMPC (not including Second Line of Defense) than it reported for the reorganized Global Material Security and Material Management and Minimization programs received. See the Fiscal Year 2016 Department of Energy Budget Request, Vol. 1.

* Does not include Nuclear Smuggling Detection and Deterrence.
** Does not include Material Disposition.

But other factors were at work as well. With budget caps limiting how much DOE could spend on national security programs, pressure for additional funding for nuclear weapons modernization inevitably put pressure on NNSA's non-proliferation accounts, including nuclear security. But given what a bargain nuclear security programs are for U.S. national security, the U.S. government should have the wisdom to adequately fund both needed nuclear weapons programs and equally important nuclear security efforts.

Figure 5: **DOE Outyear Nuclear Security Spending Estimates**



Note: Data from NNSA budget justifications, FY 2013–FY 2017.

Over the years, Congress has offered strong support for nuclear security programs. To sustain that backing, NNSA will have to work closely with Congress, and offer a clear vision for nuclear security cooperation in a new era, less focused on U.S.-funded upgrades and more centered on convincing and helping other countries to do more themselves.[177]

177 For a recommendation of strengthened approaches to DOE's nuclear nonproliferation programs more generally, see Secretary of Energy Advisory Board, *Report of the Task Force on Nuclear Nonproliferation* (Washington, D.C.: U.S. Department of Energy, March 31, 2015), http://energy.gov/sites/prod/files/2015/04/f21/2015-03-31_FINAL_Report_SEABNuclearNonproliferationTaskForce_0.pdf (accessed February 22, 2016), pp. 14–25.

5. Formidable Obstacles to Nuclear Security Progress

In 2009, when President Obama declared the goal of securing all vulnerable weapons-usable nuclear material worldwide in four years, the objective appeared achievable. The essential ingredients of nuclear weapons existed in only a few dozen countries, at only a few hundred sites. The cost of providing effective security or eliminating material from sites where it was no longer needed was very small by comparison to what countries routinely pay to strengthen their military security. Yet, although the world has made major progress since the 1990s in reducing the danger of nuclear theft, it remains a long way from the goal of having effective, continuously improving security for all nuclear weapons and weapons-usable nuclear material. What makes continued progress on strengthening security for nuclear weapons, materials, and facilities so difficult?

A large part of the reason for the recent slowing of progress described in this report is that the low-hanging fruit is already plucked: the readily achievable actions have already been taken. Making further gains in nuclear security will require overcoming cognitive biases that help to foster a sense of complacency, formidable political disputes, organizational weaknesses, and technical problems and costs. Secrecy poses an additional barrier, and bolsters each of the other obstacles. To make further progress, governments will need to fashion policies that help to break down each of these barriers.

Complacency and Other Psychological Barriers

Complacency is the enemy of action. Unless policymakers believe that nuclear terrorism is a real and serious threat to their own countries' security, and that improvements in the aspects of nuclear security they control can significantly reduce the risk, they are unlikely to take the actions needed to address the threat. Although the era of nuclear security summits has helped to elevate concern about nuclear terrorism to the highest level of attention in capitals around the world, complacency about the threat of nuclear terrorism continues to impede progress. The attitude that current measures are sufficient and no action is needed to sustain or strengthen nuclear security is common at every level of decision-making on nuclear security in countries around the world, including, to some extent, in the United States. This complacency takes many forms and is often expressed in the following beliefs.

- *Terrorists could never pull off building a nuclear bomb.* Many policymakers continue to believe, as Anatoliy Kotelnikov, then in charge of security for Russia's nuclear complex, put it in 2002, that it would be "absolutely impossible" for terrorists to make a nuclear bomb even if they got the needed nuclear material.[178]

- *Terrorists could never get their hands on our stuff.* Others believe that existing nuclear security measures are adequate and that there is little chance of terrorists getting enough weapons-usable nuclear material to construct a bomb. Or they believe that while there may be vulnerabilities elsewhere, the security measures in their country or facility are more than sufficient. For example, at the first nuclear security summit, Russia emphasized that none of its material fell into the category of "vulnerable" weapons-usable nuclear material, so the issue was really about other countries.[179] Security managers at many nuclear facilities will argue that their existing security measures are sufficient by pointing out that there have been no thefts or attacks in decades of operation—ignoring the reality that the threats are evolving, and that a single theft could lead to disaster.

- *Nuclear terrorism is not our problem.* In many countries, policymakers and nuclear managers believe that even if terrorists could manage to steal weapons-usable material and construct an improvised nuclear device, its use would take place half a world away—in the United States, or perhaps Russia—and would have little effect on life in their country. The reality, by contrast (as described in the threat section of this report), is that an act of nuclear terrorism anywhere would have reverberating economic and political effects around the world, posing substantial risks to countries far from the city attacked.

Cognitive and organizational biases inevitably contribute to these complacent attitudes. Like everyone else, nuclear guards, security managers, regulators, and policymakers are subject to such biases.[180] Because the probability of nuclear theft or successful sabotage in most nuclear facilities is small—indeed, most people who work to secure nuclear materials and facilities will go through an entire career without witnessing a single serious security incident—it is easy for both guards and managers to convince themselves that

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

179 Office of the Russian President, "Statement of the Russian Federation on Nuclear Security," April 13, 2010, http://news.kremlin.ru/ref_notes/520 (accessed July 6, 2015).

180 For a discussion of some of the biases of government decision-making, see Bryan D. Jones and Frank R. Baumgartner, *The Politics of Attention: How Government Prioritizes Problems* (Chicago: University of Chicago Press, 2005). For a summary of some of the findings of behavioral economics concerning broader biases in human judgment, see Daniel Kahneman, *Thinking, Fast and Slow* (New York: Farrar, Straus, and Giroux, 2011). For a discussion of how these biases affect nuclear security, see Matthew Bunn, *Guardians at the Gates of Hell* (forthcoming, MIT Press).

the risk is completely negligible. Several well-known cognitive limitations are hard-wired into human decision making, which makes sustaining and strengthening nuclear security an uphill and counterintuitive battle. Key biases include status quo bias (the tendency of people and organizations to continue with past decisions and arrangements until evidence that change is needed becomes overwhelming); the availability heuristic (the tendency to discount the chance of something happening that has not happened in recent memory or cannot be called readily to mind); optimism bias (the tendency to believe that your risk of suffering a negative event is much less than it actually is); affect bias (the tendency to think that a person or institution liked for one reason has other positive characteristics as well, such as assuming that a facility providing one's job is also safe and secure); confirmation bias (the tendency to seek out and give weight to evidence confirming preexisting beliefs, while ignoring or discounting evidence that would challenge them); and conformity desire (the tendency to believe what others around you believe).

Because of these factors, security anomalies at nuclear facilities are easily discounted when they happen. If a guard expects that all alarms will be false alarms, his or her first instinct when confronted with one is to confirm the expectation. This appears to be what guards did at the Y-12 facility in July 2012, when an 82 year-old nun and two other protesters breached four fences (three of which were equipped with intrusion detectors) and made straight for the building where thousands of bombs' worth of HEU was stored, ultimately spending a substantial period pounding on the wall of the building with sledgehammers, pouring blood on it, and singing protest songs, before finally being accosted by a single guard.

The government's analysis of the incident pointed out a series of problems across the organization.[181] But some of the problems appear to have involved cognitive errors. In part because the new intrusion detection system was causing frequent false alarms, the guards appear to have assumed that the alarms the protesters set off were also false. When heavily armed guards inside the building heard the sounds of the protesters hammering, they assumed it must be a work crew, even though it was before dawn and they had not been told of any scheduled construction—and they did not bother to check. These responses appear to have been driven by complacency and confirmation bias—the guards interpreted what they saw and heard as consistent with what they expected to see and hear.

In addition to these cognitive failures, workers in a security organization may in fact be motivated to "look the other way" rather than report security vulnerabilities or violations.

181 For a detailed account of the incident, see Office of the Inspector General U.S. Department of Energy, "Inquiry Into the Security Breach at the National Nuclear Security Administration's Y-12 National Security Complex," DOE/IG-0868 (Washington, D.C., DOE, August 2012), http://energy.gov/sites/prod/files/IG-0868_0.pdf (accessed January 29, 2016).

Workers are rewarded for advancing the mission of their organization, be it producing medical isotopes, electricity, or plutonium. They focus on tasks that bring immediate benefit and are less likely to focus on, or be rewarded for, reducing already low risks to even lower levels. Indeed, in many organizations, every hour an employee spends on following security procedures is an hour not spent on activities more likely to lead to a raise or a promotion. Moreover, no one likes creating problems for their co-workers. People who insist on pointing out vulnerabilities that their co-workers have tolerated for decades tend to be seen as troublemakers. In one recent case at a major U.S. nuclear facility, an employee reported concerning behavior by another employee who was especially skilled at an uncommon specialty. The worker who had reported his concerns was heavily criticized for doing so by his boss, because the skilled technician was taken away from sensitive work until the concerns had been resolved.[182]

Training and exercises, testing and peer review, regulation and other forms of scrutiny, if done creatively, can help to counteract complacency (and not simply induce fatigue). But doing so costs money and requires effort, which can be difficult to mobilize on behalf of the objective of preventing improbable events.

Political Obstacles

Governments sometimes fail to take necessary steps to strengthen and sustain nuclear security because they have other interests that take priority. Political differences or disputes with others—principally with the United States, since it has been the main champion of strengthening nuclear security worldwide—can impede important nuclear security cooperation and block progress. As discussed in more detail elsewhere in this report, the widening rift in U.S.-Russian relations resulted in the cessation of all but a small portion of more than two decades of bilateral cooperation between the two countries on nuclear security.

Political disputes have slowed cooperation in other contexts as well. U.S. accusations that Chinese scientists had spied on U.S. nuclear weapons program brought lab-to-lab cooperation between the U.S. and Chinese weapons labs to a grinding halt, and China has been unwilling to restart them without a formal U.S. statement that past cooperation was both legal and beneficial to both sides, which the United States has been unwilling to provide. Hence, while China and the United States have cooperated extensively on nuclear security in recent years, there have not been formal links between the U.S. and Chinese labs.

182 Discussion with the worker who reported his concerns, U.S. nuclear facility, March 2015.

India has refused most cooperation with the United States on nuclear security for many years, in part because of lingering resentment over the U.S. sanctions on India's nuclear establishment that were in place for decades after India's 1974 nuclear test. Even the 2008 U.S.-India civilian nuclear cooperation agreement was not enough to overcome that barrier, though in recent years India has participated in the nuclear security summits and undertaken a modest number of nuclear security workshops with the United States. Of course, not all security improvements depend on cooperation with the United States. But cooperation often accelerates such improvements and offers increased assurance that they are really taking place.

Political obstacles have also slowed consolidation of weapons-usable nuclear material in recent years. From the perspective of many nonaligned countries, the nuclear-armed states pose the greatest nuclear dangers, and hence their compliance with their disarmament obligations should be the top international nuclear priority. Indeed, some nonaligned states have expressed the view that the focus on nuclear security in recent years is a misplaced priority that hampers access to technology and development.[183] Such attitudes are an important part of the reason for South Africa's refusal to ship out or blend down hundreds of kilograms of HEU left over from its nuclear weapons program (though South Africa has worked closely with the United States on extensive security upgrades at the Pelindaba site where these materials reside).[184] Political obstacles have also delayed the elimination of Belarus's stocks of HEU. In 2010, Belarus agreed to ship out its HEU, but suspended the arrangement in 2011 in retaliation for EU and U.S. sanctions imposed after an election was judged to be rigged.[185]

Particularly as nuclear security cooperation moves from a focus on U.S.-funded equipment installations to convincing (and helping) countries to do more themselves, assessments of the political factors constraining cooperation in each country, and how they might be addressed, will be essential. In a number of cases, high-level diplomacy and offers of compromises in other areas are likely to be needed to make nuclear security progress.

183 See, for example, William Potter and Gaukhar Mukhatzhanova, *Nuclear Politics and the Non-Aligned Movement* (London: International Institute for Strategic Studies, 2012), pp. 122–133.

184 South Africa's perspective emphasizing the connection between minimizing the use of HEU and progress on disarmament was articulated in "South African Perspectives on Highly Enriched Uranium (HEU)," Speech by Abdul Minty at the IAEA Board of Governors at the IAEA Symposium on HEU, Oslo, June 19–20, 2006. The US security upgrades at Pelindaba are noted in GAO, *DOE Made Progress,* p. 14.

185 Michael Schwirtz, "Belarus Suspends Pact to Give Up Enriched Uranium," *New York Times*¸ August 19, 2011, http://www.nytimes.com/2011/08/20/world/europe/20belarus.html?_r=0 (accessed January 26, 2016).

Organizational Obstacles

Bureaucratic interests, standard operating procedures, and entrenched organizational cultures can pose formidable obstacles to progress on nuclear security. Leaders of organizations seek to protect their budgets and organizational prerogatives. The manager of a research reactor or a nuclear weapon storage site is very likely to oppose shutting the site down. The staff at the site is going to be concerned about jobs and pay. In some countries, the handling of HEU or plutonium may entail additional pay that would be threatened by consolidation or minimization programs. Some sites may be concerned that without HEU or plutonium, they will no longer be as competitive with other sites or as essential as they were before. At one site in Russia, for example, even though the site employs some 10,000 people and only a small number work at its main research reactor, staff expressed concern that if that facility closed, "it will be the end" for the site.[186]

Even if such fears are not present, security may simply be low on the list of an organization's priorities, and may conflict with other organizational imperatives. A recent report from the U.S. National Academies found that in Russia, which has 40 percent of the world's remaining civilian HEU-fueled research reactors, conversion to the use of LEU fuel "is largely a matter of priorities." Progress is stymied by "resistance on the part of reactor operators and users (a problem not confined to Russia). The confidence of Russian authorities in the effectiveness of physical security measures to secure HEU fuel at civilian sites serves to further decrease the level of priority given to reactor conversions."[187] In discussions, a responsible Russian official confirmed that Russia had no plans to prioritize providing the funds needed to convert Russian reactors to LEU.[188]

Organizational procedures and bureaucratic processes can also make security upgrades a challenge. In U.S.-Russian cooperation, for example, issues ranging from complex contracting and competition procedures to arrangements for tax exemptions slowed progress; in some cases, review of proposed contracts by either the U.S. or the Russian governments delayed work for months. Making any substantial change in security arrangements often requires many layers of review and approval, from certifying equipment to assessing the potential impacts on operations and safety.

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186 Interview with site employee, July 2011. The employee specifically reported that this was also the view of the site director. For more on organizational and other obstacles to consolidation efforts in particular, see Matthew Bunn and Eben Harrell, *Consolidation: Thwarting Nuclear Theft* (Cambridge, MA: Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, 2012), pp. 12–13.

187 *Reducing the Use of Highly Enriched Uranium in Civilian Research Reactors*, p. 100.

188 Interview, October 2015.

Organizational structures frequently impede progress as well: in some cases, the organization providing security is separate from the organization managing the facility, creating an "us versus them" dynamic between operations and security—and often leaving security largely ignored as "another organization's issue" by the top leadership of the operating organization. The policy in many countries of setting security rules and expecting organizations to find the money to comply with them from their general funds encourages doing the minimum needed to pass inspection. Combined with complacency, security can become a matter of regulatory box checking, with little real effort to look for vulnerabilities to be fixed. Organizations that are complacent about their existing security measures and facing such financial constraints may ignore and even punish employees who try to highlight security problems. Information flow can often be a fundamental problem, with work groups avoiding letting others know about incidents in their team, facilities wanting to fix problems without telling regulators about them, and so on.

Technical and Cost Issues

Some nuclear security tasks—particularly HEU minimization through the conversion of HEU-fueled reactors—face technical challenges that are costly and time-consuming to overcome.[189] Today's highest-performance research reactors cannot convert to LEU fuel without significant losses in performance until new, higher-density fuels are available – and the development of those fuels has been suffering dramatic delays. Creating means to produce medical isotopes without HEU and without substantial increases in cost and waste has taken time. Some reactors may be technically difficult or expensive to convert to LEU fuel.

There are also genuine costs involved in strengthening nuclear security. Well-trained, well-armed, professional guard forces that must be on duty 24 hours a day, 365 days a year, are expensive. Effective intrusion detection and assessment systems are costly, especially for large sites. In general, more precise and accurate material control and accounting systems are likely to be more expensive than less effective systems. Beyond the purely economic costs are the inconveniences of operating in a highly secure environment: security procedures take time away from whatever the facility's main mission may be. Nuclear managers may also worry that security measures make their facility seem like a jail, making it more difficult to recruit high-quality people. For those reasons, among others, it is crucial to develop efficient security approaches that minimize cost and inconvenience, and are well integrated with safety and successful operation of the facility.

189 For an up-to-date review of technical obstacles, see *Reducing the Use of Highly Enriched Uranium*.

Transporting nuclear weapons and materials to a smaller number of sites advances consolidation efforts, but also costs money (though it often reduces total cost over the long run, by eliminating the expense of providing security at the sites that no longer have weapons-usable nuclear materials). In some cases, the high-density LEU fuels to which reactors might be converted will cost more than the HEU fuels they have used in the past; indeed, for reactors with lifetime cores (such as critical assemblies and pulse reactors), conversion means buying new fuel when they would not otherwise have to buy any fuel at all.

These costs may seem substantial from the point of view of a facility manager, especially at a research reactor with modest revenue. But they are very small by comparison to what countries routinely spend to assure their security. If countries overcome complacency and make nuclear security a priority, the price tag, judged at a national level, will be minor. Moreover, in many cases, the United States and other interested countries are willing to cover part of the expense of increased security, in the interest of reducing the risk of nuclear theft and terrorism. These concerns should not be allowed to stand in the way of lowering the risk of nuclear terrorism the world faces.

Secrecy

Finally, many countries keep most of the specifics of what they do to protect their nuclear stockpiles as closely guarded secrets—in part to keep potential nuclear thieves or saboteurs from knowing what security measures they would be up against. This tendency is particularly powerful in states with nuclear weapons, where there is another layer of military secrecy involved. Secrecy often makes in-depth nuclear security cooperation difficult: it makes it difficult to know where the most urgent work needs to be done, what particular elements of nuclear security most need to be addressed, and even how much material exists at how many sites, making it hard to understand the overall scale of the job to be done. And it makes the mechanics of cooperation more difficult—limiting, for example, the ability to check that money or equipment was used for the purposes agreed upon. In particular, while there is much that can be done without actually going to nuclear facilities, such visits have great value, making it possible for experts to see the situation on the ground, have discussions with experts and staff at the site, work directly on aspects of the cooperation program, and more.

Even before tensions with Russia led to the rupture of most nuclear security cooperation, disputes over access to sensitive sites had been a recurring impediment to progress for years—despite the remarkable scope of cooperation that at times involved U.S. experts visiting nearly all of the sites where Russia's nuclear weapons and weapons-usable nuclear materials are located.[190] Pakistan, while engaging in extensive nuclear security cooperation with the United States, has not allowed U.S. experts to visit its key nuclear facilities or even to know where they are, out of fear that the United States would use information it could gather on the location of Pakistan's weapons to seize or destroy its arsenal.[191] China engages in substantial nuclear security discussions with the United States, and the two countries are cooperating to build a world-class nuclear security testing and training center on the outskirts of Beijing. But like Pakistan, China does not permit U.S. experts to visit its military nuclear sites, where most of its weapons-usable nuclear material resides.[192] The limited cooperation the United States has established with India has not involved visits to the nuclear material areas of any of their major nuclear facilities.

The obstacles to continuing improvement in nuclear security are real and formidable. Future progress will depend on designing approaches that anticipate problems of complacent beliefs, political disputes, organizational barriers, technical problems, high costs, and secrecy.

190 See National Research Council, *Future of the Nuclear Security Environment in 2015: Proceedings of a Russian-U.S. Workshop* (Washington, D.C.: The National Academies Press, 2009), http://www.nap.edu/catalog/12590/future-of-the-nuclear-security-environment-in-2015-proceedings-of (accessed March 1, 2016).

191 These fears are discussed in Kerr and Nikitin, "Pakistan's Nuclear Weapons."

192 See Hui Zhang and Tuosheng Zhang, *Securing China's Nuclear Future* (Cambridge, MA: Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, March 14, 2014).

6. Recommendations: Getting to Continuous Improvement in Nuclear Security

Nuclear security efforts should have a clear goal: ensuring that all nuclear weapons and all the materials that could be used to make them, wherever they are in the world, are effectively and sustainably secured against the full spectrum of threats that terrorists and thieves might plausibly pose. All the various nuclear security policy tools should be assessed for their contribution to that goal.[193]

Many actions by many different parties will be needed to achieve this goal. Action will be needed from:

- Nuclear facility operators and transporters handling nuclear weapons, HEU, and separated plutonium;
- Governments of the countries where these stocks reside;
- The broader international community, and international organizations such as the IAEA; and
- Civil society, including industry associations, nonprofit organizations, academia, and the media.

Given the central role the United States has played in nuclear security initiatives, actions to be taken by the next U.S. president will be particularly critical. Hence, in this section, each category of recommendations includes steps the next U.S. president should take.

Indeed, the work has no fixed end date: nuclear security must continually evolve and adapt in the face of evolving threats, changing technology, and improved understanding of vulnerabilities. Yesterday's security may not be adequate to meet tomorrow's threat. Hence, past U.S. approaches that focused on finishing a fixed set of activities by a specific date will need to be modified for the nuclear security efforts of the future. For nuclear security, even more than for nuclear safety, the focus must be on continual improvement,

[193] Similar goals could and should be established for preventing nuclear reactor sabotage and controlling dangerous radiological sources (see Box: "Protecting Against Nuclear Sabotage," p.114). The recommendations in this section draw in part on previous work by the authors, including Bunn et al., *Advancing Nuclear Security*, pp. 61–78.

in the never-ending search for excellence. Effective security measures that are regularly assessed, probed, and tested will continue to be needed as long as terrorists seeking mass destruction and the materials needed to make nuclear weapons both exist in the world.

While there are many steps that should be taken to improve security for nuclear weapons and weapons-usable nuclear materials around the world, we believe that actions in six categories would be most important in filling existing gaps:

1. Committing to stringent nuclear security principles;
2. Revitalizing programs to implement such principles;
3. Expanding efforts to strengthen security culture and combat complacency;
4. Broadening efforts to consolidate nuclear weapons and materials to the minimum number of sites;
5. Developing approaches to confirm that effective nuclear security is in place; and
6. Continuing an effective nuclear security dialogue after the summits end.

We will discuss recommendations in each of these areas in turn. We also provide brief recommendations on strengthening other lines of defense against nuclear terrorism (see Box: "Preventing Nuclear Terrorism: Tools Beyond Nuclear Security," p. 130) and on protecting against and responding to sabotage of nuclear facilities and attacks with radiological "dirty bombs" (see Box: "Protecting Against Nuclear Sabotage" p. 114, "Reducing the Risk of Radiological Dirty Bombs," p. 98).

Reducing the Risks of Radiological Dirty Bombs

Tens of thousands of radiological sources are used all around the world for a variety of commercial purposes, from food sterilization to cancer treatment. By one estimate, radiological sources big enough to pose a serious danger exist in over 13,000 buildings in more than 100 countries.[i] A "dirty bomb" used to disperse such radioactive material could cause widespread fear and disruption, and necessitate costly evacuation and cleanup. The consequences of this type of attack, while substantial, would be utterly unlike those of a nuclear explosive: rather than incinerating the heart of a major city and killing tens or hundreds of thousands of people, a dirty bomb would create an expensive and disruptive mess, probably not killing anyone beyond those killed by the explosives that might be used to disperse the material.[ii]

Given the huge numbers of radioactive sources in use, it is hopeless to try to provide highly effective security for all of them. Instead, global radiological security efforts have focused primarily on the largest radioactive sources that could contaminate substantial areas if used as a dirty bomb—mainly those designated by the IAEA as "Category I" or "Category 2" sources.[iii]

Every country using such sources should:[iv]

- Require operators to provide appropriate security measures—including alarms that would notify police or other response forces if the source were removed or tampered with; appropriate locks and equipment designs to increase the time and effort required to remove a source (such as making it impossible to remove without explosives or special tools); and armed personnel where appropriate.[v]
- Provide training programs to inform operators of the best ways to secure sources—and to highlight the ongoing danger these sources pose.

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i Estimate provided by NNSA, July 2013.

ii See, for example, Ji Young Park, "The Economic Impacts of Dirty Bomb Attacks on the Los Angeles and Long Beach Ports: Applying the Supply-Driven NIEMO (National Interstate Economic Model)," *Journal of Homeland Security and Emergency Management,* Vol. 5, No. 1, 2008, http://www.degruyter.com/view/j/jhsem (accessed March 8, 2014), pp.1-20. See also Peter D. Zimmerman with Cheryl Loeb, "Dirty Bombs: The Threat Revisited," *Defense Horizons,* No. 38 (January 2004), pp. 1–11.

iii For a description of which sources fall in which category, see International Atomic Energy Agency, "Code of Conduct on the Safety and Security of Radioactive Sources" (Vienna: IAEA, 2004).

iv See Matthew Bunn and Tom Bielefeld, "Reducing Nuclear and Radiological Terrorism Threats," in *Proceedings of the Institute for Nuclear Materials Management 48th Annual Meeting,* Tucson, Arizona, July 8–12, 2007 (Northbrook, IL: INMM, 2007).

v For example, NNSA's Global Threat Reduction Initiative has worked with manufacturers to create new designs that make it far more difficult for adversaries to remove radioactive sources from machines that use them, and kits to modify machines already in use. Such "in-device delay" technology had been installed on more than 200 cesium chloride irradiators (some of the most dangerous sources in use) in the United States by April 2013. See "NNSA: Securing Domestic Radioactive Material" (*NNSA Media Room Fact Sheet,* April 12, 2013), http://nnsa.energy.gov/mediaroom/factsheets/gtri-protect (accessed March 9, 2014).

- Require transporters to provide appropriate security measures, including continuous tracking of vehicles carrying such sources, use of genuinely safe "safe havens" when drivers are sleeping or stopping, armed escorts where appropriate, a "panic button" allowing drivers to signal if trouble comes up, and engineered vehicle features that would make the vehicle and its contents more difficult to steal (as armored cars for transporting valuables routinely have—such as a button that effectively stops the vehicle from being driven). This should include improved security training for all drivers of dangerous radioactive sources.
- Maintain a cradle-to-grave register tracking the location and use of each source.
- Provide safe and secure options for disposing of such sources when they are no longer needed, with requirements for users to send them there.
- Establish a program for finding and securing lost and orphan sources, potentially including through effective use of radiation detection equipment.
- Shift quickly to non-radioactive alternatives wherever practicable—such as the linear accelerators now used in the United States and other developed countries instead of the type of teletherapy source stolen in the incident in Mexico.[vi]

In addition, because a great deal of the impact of a radiological dirty bomb would come from the public fear of radiation, it is crucial to begin preparing public communication strategies and broader emergency response and cleanup approaches to mitigate the disruption and fear that might result as much as practicable.

The United States, the IAEA, and other donors have been helping countries take such steps, and have made significant progress, removing thousands of unneeded sources around the world and installing security upgrades for sources in more than 2,000 buildings, within the United States and elsewhere. To date, however, neither the United States nor any other country has been willing to provide the funding needed to upgrade security for or replace all of the world's most dangerous sources. It may be that most of the job should be accomplished by convincing countries to require operators to provide adequate security themselves, rather than most of the job being paid for by U.S. taxpayers. But there are clearly some circumstances where international funds will be needed if security is to be provided at a reasonable pace. The United States has reduced its budget for radiological security assistance, even though the task was far from complete: at the U.S. program's current pace, it would take another 17 years to meet its much-reduced target of helping to secure just under 4,400 buildings with dangerous radioactive material—down from a target of 16,000 a few years ago.[vii]

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vi Rafael Romo. Nick Parker, and Mariano Cas, "Mexico: Stolen Radioactive Material Found," *CNN*, December 4, 2013, http://www.cnn.com/2013/12/04/world/americas/mexico-radioactive-theft/ (accessed March 11, 2016).

vii U.S. Department of Energy, *FY 2017 Congressional Budget Request: National Nuclear Security Administration*.

1. Commit to Stringent Nuclear Security Principles

The time has come to seek to build a common understanding that wherever nuclear weapons, HEU, or plutonium exist, certain key security and accounting elements are needed.[194] There should not be a "one size fits all" approach, as countries legitimately have somewhat different approaches to implementing and regulating nuclear security, and face different adversary threats to their nuclear stocks. A nuclear security system capable of reducing the risk of nuclear theft to a very low level in Canada might not be remotely adequate in Pakistan, where both outsider and insider threats are far more substantial. Hence, what is needed is a set of principles specific enough to be meaningful, but broad and flexible enough to permit each country to implement nuclear security in its own way.

Governments will not negotiate a treaty establishing stringent nuclear security principles in the near term. But it is quite possible that a group of like-minded states with substantial stocks of nuclear materials could work together to draft a political commitment to a set of principles that they were each willing to implement. They could invite all other states with plutonium and HEU on their soil to join them in the commitment, and offer help to those countries wishing to implement the principles but needing technical or financial help to do so. Such a commitment could potentially be worked out in experts' meetings of the permanent five members of the UN Security Council, within a new working group of GICNT, or in a grouping established for this purpose.

The initial participants in such a commitment will have to work out what the specific principles would be.[195] One approach would be to look to the goals in areas such as physical protection, material control, and material accounting that Russian and U.S. experts agreed to work toward in their technical cooperation.[196] We suggest that such an arrangement include commitments to:

194 We use the terms "key elements" and "principles" here, rather than "standards," as many countries interpret the word "standard" to mean that the implementation should be identical, as in a technical standard for high-definition television or something of that kind.

195 Such an initiative would be a substantial complement to the nuclear security implementation initiative announced at the 2014 Nuclear Security Summit, offering substantially stronger nuclear security commitments, and clearly extending to both military and civilian stocks.

196 William Tobey, Building a Better International Nuclear Security Standard (Cambridge, MA.: Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, March 2012), http://uskoreainstitute.org/wp-content/uploads/2012/03/USKI_NSS2012_Tobey.pdf (accessed March 17, 2016). For other ideas on approaches to building stronger commitments on military stockpiles in particular, see Des Browne, Richard Lugar, and Sam Nunn, co-chairs, *Bridging the Military Nuclear Materials Gap* (Washington, D.C.: Nuclear Threat Initiative, November 2015), http://www.nti.org/media/pdfs/NTI_report_2015_e_version.pdf (accessed March 17, 2016); and Fissile Materials Working Group, *The Results We Need in 2016: Policy Recommendations for the Nuclear Security Summit* (Washington, D.C.: FMWG, June 2105), http://www.fmwg.org/FMWG_Results_We_Need_in_2016.pdf (accessed March 17, 2016).

- Require facility operators and transporters to protect nuclear weapons, HEU, and separated plutonium against the full range of plausible adversary capabilities and tactics—including, at a minimum, a modest group of well-armed and well-trained outsiders; a well-placed insider; and both outsiders and an insider working together.[197] Given the global reach that terrorists have demonstrated, it seems clear that such a baseline level of security is essential wherever nuclear weapons and their essential ingredients exist, even in the safest countries.
- Accept that national leaders have a responsibility they cannot delegate to others to ensure effective and continually improving security for all nuclear weapons or weapons-usable nuclear materials under their country's control.
- Provide on-site armed guard forces that are well equipped, well trained, professional, and have sufficient capabilities to defeat adversary threats.
- Put in place a comprehensive suite of measures to protect against insider threats.
- Implement material control and accounting systems adequate to detect and localize any theft of weapons-usable nuclear material.
- Ensure that protection against cyber threats is strong and fully integrated with other nuclear security measures.
- Require facility operators and transporters to institute programs to assess and improve security culture, and to exchange and learn from security best practices.
- Put in place effective nuclear security and accounting rules, and give regulators the authority, independence, expertise, and resources to ensure that operators implement them effectively.
- Carry out regular, realistic tests of the performance of nuclear security systems, including force-on-force exercises.
- Ensure that all facility operators and transporters have the resources and plans to sustain effective nuclear security and accounting for as long as they are handling these items and materials.
- Review each site where stocks of nuclear weapons or weapons-usable materials exist and remove these items from any site where the costs and risks of their presence outweigh the continuing benefits.

197 For a more detailed rationale for this suggestion, see Matthew Bunn and Evgeniy P. Maslin, "All Stocks of Weapons-Usable Nuclear Materials Worldwide Must be Protected Against Global Terrorist Threats," *Journal of Nuclear Materials Management*, Vol. 39, No. 2 (Winter 2011), pp. 21–27.

- Regularly host international nuclear security peer reviews, such as the IPPAS reviews led by the IAEA.
- Regularly review and update nuclear security requirements and approaches in the face of changing technology, accumulating experience, and the evolving threat.

Such a commitment would be, in effect, the strongest nuclear security "gift basket" yet—a joint commitment entered into by a substantial group of countries. Assuming that no such commitment emerges from the upcoming summit, it could be developed later, in forums for ongoing nuclear security discussion, discussed below.

Beyond these commitments focused on protecting nuclear weapons, HEU, and separated plutonium, the initiative (or parallel initiatives) could also include pledges to develop similar measures to protect nuclear power reactors and other major nuclear facilities from sabotage, and to provide effective security for radiological sources that might be used in a "dirty bomb." It could also include agreements to work together to stop nuclear smuggling and bring such smugglers to justice, along with expanded cooperation among law enforcement and intelligence agencies.

The participating states should agree to have experts and senior officials meet regularly, with the participation of the IAEA, to review progress in implementing these principles, and to discuss ways in which the initial principles should be modified or expanded, based on evolving threats, experiences with implementation, changing technology, and more. They should also agree to have experts work together to develop means to build confidence between states that these commitments are being fulfilled, without compromising secret information.

Finally, the participants should commit to work together to strengthen the nuclear security role of the IAEA and ensure that it has sufficient, predictable funds to implement its nuclear security activities.

Steps Along the Path

There are other sets of existing commitments that are quite important, though they do not include the stringent nuclear security principles just discussed. States interested in promoting stronger nuclear security around the world should use their diplomatic efforts to encourage more countries to:

- Ratify the 2005 amendment to the Convention on Physical Protection of Nuclear Materials (CPPNM) and the International Convention on the Suppression of Acts of Nuclear Terrorism (ICSANT).
- Participate in the nuclear security "implementation initiative" announced at the 2014 Nuclear Security Summit, in which states commit to meet the objectives of IAEA nuclear security recommendations and accept regular peer review of their nuclear security arrangements. Participation by key holders of substantial stocks who are not yet participating, such as Russia, China, Pakistan, and India, would be particularly important.
- Participate in other important nuclear security "gift baskets" developed in the nuclear security summit process.
- Provide funding, experts, and political support to strengthen the IAEA's nuclear security role.
- Participate in and support the best practice exchanges and other activities of WINS.

Some nuclear security experts have advocated expressing such commitments in a new treaty on nuclear security, arguing that such an agreement could provide an overarching framework for the many elements of global nuclear security governance and plug the holes in the existing nuclear security framework.[198] Unfortunately, it appears very unlikely that states would be able to reach agreement on a convention that really imposed stringent security requirements in the near term. The experience of the amendment to the CPPNM is instructive. The amendment was first proposed by the United States in 1998, and it took seven years to negotiate an agreed text. Even though most of those negotiations occurred after the 9/11 attacks, the negotiators firmly rejected including any requirements that states implement specific nuclear security measures, any verification provisions, or even requirements for national reporting on implementation. Even so, as of early 2016, 18 years after it was first proposed, the amendment had still not entered into force.

198 See, for example, Kenneth C. Brill and John H. Bernhard, "A Convention on Nuclear Security: A Needed Step Against Nuclear Terrorism," *Arms Control Today,* June 2015. For a proposed text of such a convention, with explanatory material, see John H. Bernhard, Kenneth C. Brill, Anita Nilsson, and Shin Chang-Hoon, *International Convention on Nuclear Security* (Washington, D.C.: Nuclear Security Governance Experts Group, March 2015), http://www.nsgeg.org/ICNSReport315.pdf (accessed March 15, 2016).

Recommendations for the Next U.S. President

The next U.S. president should:

- Clearly establish as national policy the goal of effective and sustained protection against the full range of plausible outsider and insider threats for all stocks of nuclear weapons and weapons-usable nuclear materials worldwide.

- Order the implementation of the principles at home, shoring up vulnerabilities at U.S. sites, including through programs for improving and assessing security culture in relevant organizations.

- Work with other countries to launch an initiative on nuclear security principles such as that described above.

- In parallel, work to convince countries with stocks of weapons-usable nuclear materials who have not yet done so to join in the 2014 nuclear security implementation initiative.

- Declare as administration policy that nuclear security is an undelegatable executive responsibility and hold other heads of state and government colleagues to that standard.

2. Revitalize Programs to Implement Effective and Sustainable Nuclear Security

Achieving and sustaining excellent nuclear security will require both actions within individual countries and revitalized international cooperation. Particular attention should be focused on protecting against insider threats and cyberattacks, and on strengthening security at bulk-handling facilities, which appear to have been the source of most nuclear thefts to date.

Much of the job of achieving excellence in nuclear security, and sustaining and improving it over time, rests with operators—the organizations that actually run nuclear facilities and transport nuclear weapons and materials. These organizations should establish excellence in nuclear security as their goal, with approaches based on continuous improvement, just as in nuclear safety. They should be focused on safety, security, and successful operations

as co-equal goals, each necessary for the organization to be successful.[199] This should be communicated clearly throughout the organization, by word and deed.

In particular, these organizations will need to:

- Implement the nuclear security commitments described above.
- Develop and implement plans to provide the funding and the trained and certified personnel needed to achieve and sustain effective nuclear security.
- Motivate their employees to achieve strong nuclear security performance.
- Implement effective security practices, including those outlined in guidance from the IAEA and WINS. Operators should also participate in and support good practice exchanges.
- Ensure that all personnel responsible for nuclear security, at all levels of relevant organizations, are well trained and demonstrate competence through professional certification.
- Continuously assess their security programs and look for vulnerabilities, in order to improve security over time in the face of evolving threats.

Governments, of course, must help with the implementation of these goals, providing policy direction, funding where appropriate, threat information, additional response forces where needed, regulation and oversight, and other forms of support.

Three areas in particular will need to be the focus of attention, both for these organizations and for their governments: insider threats, bulk processing facilities, and cyber protection.

199 For those operations subject to international safeguards, effective safeguards must also be integrated with safety, security, and successful operations – making a "4S" concept. For a discussion of the "3S" approach—safety, security, and safeguards—see, for example, Kenneth E. Sanders, R.B. Pope, Y.Y. Liu, and J.M. Shuler, "Interfaces among Safety, Security, and Safeguards (3S)—Conflicts and Synergies," *Proceedings of the 56th Annual Meeting of the Institute for Nuclear Materials Management, Indian Wells, CA, July 12–16* (Northbrook, IL: INMM, 2015), https://rampac.energy.gov/docs/default-source/transportation/INMM56_3S.pdf (accessed January 18, 2016).

Protecting Against Insider Threats. Insiders appear to have carried out or assisted in all or nearly all of the known thefts of HEU or separated plutonium.[200] Protecting against insiders who have authorized access to the material, are trusted by the other staff, and may be well informed about the weaknesses of the security measures in place is particularly challenging. Operators handling nuclear weapons, plutonium, or HEU—working closely with the governments of the states in which they operate—should put in place comprehensive insider protection programs, combining effective screening and monitoring of personnel; storage of all material in secure vaults whenever it is not in use; strong material controls that ensure that material is monitored at all times and any removal would be rapidly detected; a two-person or three-person rule whenever relevant materials are handled, to ensure that no one is ever alone with a nuclear weapon or weapons-usable nuclear material; accounting of nuclear material that is accurate and timely enough to notice either a rapid or a protracted theft and help identify where the loss is occurring and who might have had access; portal monitors at all potential entrances and exits to set off an alarm if any material is being removed; and regular tests, assessments, and inspections to ensure the effectiveness of the insider protection program in place.[201]

Improved Security for Bulk-Processing Facilities. When nuclear material is being processed in bulk, it is far easier for insiders to steal small amounts at a time without anyone noticing. Nearly all of the seizures of stolen HEU and separated plutonium that have occurred have been of bulk material such as powders, apparently stolen from bulkprocessing facilities. All countries operating such facilities should: ensure that advanced material control and accounting systems are in place that are capable of detecting and localizing both abrupt and protracted thefts; minimize direct human access to bulk material; ensure that all pathways in and out of such facilities are carefully monitored for nuclear material; and take other measures to make it very difficult to remove weapons-usable nuclear material from these facilities.

Protecting Against Cyber Threats. As noted earlier, every aspect of nuclear operations and of nuclear security systems is increasingly digital. This is an area where the threat evolves and changes particularly rapidly and unpredictably. Operators must ensure that effective cyber protections are in place; establish programs to test and probe their systems

200 In many cases, how exactly the theft occurred is not known—but since the material has been bulk material stolen without anyone noticing, it seems very likely that the thefts were perpetrated by insiders.

201 World Institute for Nuclear Security, *Managing Internal Threats: A WINS International Best Practice Guide for Your Organization*, Rev. 1.0 (Vienna: WINS, 2010); International Atomic Energy Agency, *Preventive and Protective Measures Against Insider Threats*, IAEA Nuclear Security Series No. 8 (Vienna: IAEA, 2008). See also Matthew Bunn and Kathryn M. Glynn, "Preventing Insider Theft: Lessons from the Casino and Pharmaceutical Industries," *Journal of Nuclear Materials Management* 41.3 (Spring 2013): 4–16; and Matthew Bunn and Scott Sagan, "A Worst Practices Guide to Insider Threats: Lessons From Past Mistakes" (Cambridge, MA: American Academy of Arts and Sciences, March 2014).

for vulnerabilities; and integrate cyber protection with their traditional security measures, to protect against coordinated cyber and physical intrusions.

Strengthen International Nuclear Security Cooperation

The chances for achieving and sustaining nuclear security excellence worldwide will be far higher if countries work together, exchanging ideas and experiences and pooling the best experts to address difficult problems. But nuclear security cooperation is moving into a new era, focused less on donor states providing equipment and training and more on convincing (and helping) states to do more themselves. The approach will focus much more on genuine partnerships, with ideas and resources from all participants, rather than donor-recipient relationships. As one U.S. official put it, the role for the United States and other countries working to strengthen nuclear security will be as "an evangelist and a consultant," working through multiple channels to convince other countries to take additional nuclear security actions, and exchanging ideas about how best to do so—along with some continuing effort at providing help where needed.

This new era will still require experts in the disciplines of nuclear security, from physical protection system design to material control and accounting to security leadership and management. Such experts bring a better understanding of what needs to be done and what the difficulties are in doing it, and more credibility with their international counterparts; indeed, personal relationships among international experts can be a key intangible factor driving progress in nuclear security. But the new era will require fewer skills in managing construction programs and negotiating contracts, and more skills at energetic but sensitive diplomacy to push for additional action—the "evangelist" part of the equation.

It will also require in-depth analysis and assessment of what new steps are most needed. Countries cooperating to strengthen nuclear security should find ways to exchange more information – protected as appropriate to its sensitivity – about what their nuclear security arrangements actually are. For example, to assess progress toward the goal of protecting nuclear weapons and weapons-usable materials against the full spectrum of adversary threats would require an understanding of what kinds of threats countries are seeking to protect their stocks against. But U.S. officials report that in general they have little idea what DBTs other countries have established (and do little sharing of comparable U.S. information)– and in the case of U.S.-Japan cooperation, the participants have found that there is not an obvious legal basis for exchanging such sensitive information.[202]

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202 Interviews with U.S. National Security Council and National Nuclear Security Administration officials, April 2013, and February 2016.

Establish Funds to Finance Unexpected Nuclear Security Needs

Occasionally, nations attempting to provide effective nuclear security confront a funding shortfall relative to need. This can occur because of a financial or budgetary emergency, an urgent and unexpected security requirement, or the need for a capital investment too large to be accommodated in an annual budget.

The classic example of the first problem would be the nuclear security crisis caused by the dissolution of the Soviet Union, when guards went unpaid and fences were left unmended for a lack of funds. Today, Russia again faces severe budgetary constraints—with two successive across-the-board 10 percent federal budget cuts, and a federal budget depending on hydrocarbon revenues for half its income when oil and gas prices remain a fraction of what they were a few years ago.

The extraordinary funds that were required to guard the plutonium left over in the former Soviet nuclear test tunnels in Kazakhstan provide an example of the second type of problem. After weapons-usable fissile material was discovered in the tunnels, Astana (with U.S. assistance) provided guards and fencing at considerable cost on a temporary basis, until the tunnels could be permanently closed and the material immobilized. With respect to the third type of problem, capital expenditures for improved fencing and sensors or armored guard posts can easily match or exceed the annual security budgets for many facilities. Two policy options might address these needs.

First, the IAEA could administer a Nuclear Security Revolving Fund, initially capitalized by member states through voluntary contributions. Any member state could apply to the fund for a loan to improve the security of civil fissile or radiological material under extraordinary circumstances—financial or budgetary crisis, urgent and unexpected security exigencies, or requirements for large capital expenditures. The IAEA and the borrower would negotiate a term for repayment of the loan, perhaps 5-10 years, and the IAEA would verify both the security need and the implementation of the security improvements, with appropriate protection of sensitive information, including use of alternative measures such as trusted agents if needed. This service could be offered in connection with IPPAS missions. An initial fund of $20-$30 million would probably suffice. Such a fund could help overcome

political sensitivities that can impair cooperation between states on nuclear security, such as the currently fraught U.S.-Russian relationship. It could also provide a flexible and agile means to deal with extraordinary circumstances. Consistent with the IAEA's overall mission, it would be limited to civil material.

Second, to cover both civil and military material and facilities, the United States and Russia, despite changed political and economic circumstances, could establish a similar revolving fund that they would jointly administer. A board with equal numbers of U.S. and Russian experts could review and decide on applications to the fund and oversee implementation of funded projects. The United States and Russia have considerable experience they could draw on to work out arrangements to confirm that projects were implemented as agreed without compromising sensitive information. Facilities in either the United States or Russia, or in other countries, could apply for funding, or experts on the board could suggest projects for discussion.

This type of fund would advance several purposes. It would provide funding for urgent nuclear security requirements in a partnership-based approach rather than one based on a donor-recipient relationship. It could relieve some of the pressure that leadership at certain facilities may feel to cut corners on security in hard times. It would maintain valuable relationships between technical experts built over decades at great cost in time and money. It would also maintain a focus on the need for continual improvement in nuclear security in both countries. Moreover, it would serve as the basis for sharing insight and best practices, to improve both countries' security techniques. Finally, it would demonstrate that the United States and Russia could still work together on important security issues of mutual interest, even as their policies and interests in other realms diverge.

The effort to build continuously improving nuclear security systems will involve cooperation with many partners. The United States should seek renewed cooperation with Russia (see below); continued and deepened cooperation with Pakistan; a much broader set of cooperative activities with India; a broader agenda of cooperation with China; and ongoing cooperation to ensure that security is sustained and continues to improve where needed for research facilities with HEU around the world, from South Africa to Belarus. The United States should also expand its discussions with developed countries, to make the case for needed nuclear security actions, develop agreed-upon principles such as those discussed above, exchange good practices, discuss approaches to addressing remaining challenges, and more. For example, the United States should pursue joint workshops on topics such as strengthening security culture, protecting against insider threats, and cybersecurity with all of the countries where nuclear weapons or weapons-usable exist, regardless of whether they are developing or developed countries.[203]

Rebuild Nuclear Security Cooperation with Russia, Based on a New Approach

Rebuilding broad U.S.-Russian nuclear security cooperation is especially important. As the Russian government itself put it in early 2015, "Russia and the United States of America bear a special responsibility for ensuring safety and security of nuclear materials and their reliable physical protection, preventing them from falling into the hands of terrorist organizations."[204]

Despite current tensions at the political level, U.S. and Russian nuclear experts still respect each other and many would be eager to return to working together. Russia and the United States should each take actions to unravel this knot and revitalize their cooperation. It should be possible to cooperate in areas of mutual interest even while confronting each other where interests conflict—as the two countries did in Soviet times. For the United States, work on nuclear security is of particular interest; Russia is especially interested in nuclear energy cooperation.[205] Ultimately, the two countries should agree to a package of cooperation that includes both nuclear energy initiatives and a broader agenda of nuclear

203 Participation in such cooperation will never be universal. It is unlikely, for example, that North Korea will be willing to participate in nuclear security cooperation in the near term, or that Israel would be willing to have detailed discussions of security for whatever nuclear stocks it may have (since it does not acknowledge possessing such stocks).

204 Rosatom, "In 2015 Russia and the USA Will Continue Cooperation in Ensuring Global Nuclear Safety," *Rosatom Press Centre,* January 22, 2015, http://www.rosatom.ru/en/presscentre/news/1268ed0047075a019f90bff60e8e8c2a (accessed February 11, 2016). For discussion, see Matthew Bunn, "Russia Puts a Positive Spin on Nuclear Security Cooperation—Which is Good," *Nuclear Security Matters Blog*, Project on Managing the Atom, January 23, 2015, http://nuclearsecuritymatters.belfercenter.org/blog/russia-puts-positive-spin-nuclear-security-cooperation-—-which-good (accessed January 18, 2016).

205 Bunn, "Russia Puts a Positive Spin on Nuclear Security Cooperation—Which is Good."

security cooperation than is currently under way. Track II dialogues in which non-government experts explore ideas may help to lay the groundwork for such renewed cooperation.[206]

It is unlikely that U.S.-Russian cooperation will ever again resemble the Nunn-Lugar approach of old, in which the United States financed large-scale equipment installation and training programs in Russia and U.S. experts were permitted to visit a wide range of Russian nuclear facilities, many of them highly sensitive.[207] Cooperation in the future, if it can be rebuilt, will be based on a partnership approach, including ideas and resources from both sides, designed to serve both sides' interests.

Joint efforts could include:

- Establishing working groups in key technical areas, from vulnerability assessment to material accounting. These groups could carry out activities ranging from good practice exchanges and discussions of remaining challenges to jointly developing guides and training courses.
- Developing joint nuclear security principles, such as those suggested above.
- Conducting joint R&D to develop the next generation of more effective, lower cost, security and accounting technologies.
- Minimizing the number of sites with nuclear weapons, HEU, or separated plutonium. Each country, for example, should draw up a strategic plan to accomplish its remaining military and civilian missions with the minimum number of locations where these stocks exist.
- Strengthening nuclear security regulation, inspection, and testing.
- Exchanging technical visits to particular sites, to review implementation and exchange ideas.
- Working together to strengthen nuclear security in other countries.
- Working together to strengthen efforts to interdict nuclear smuggling, including development of improved detection technologies and strategies, sharing of intelligence, and more.

206 Several of the authors recently participated in a Track II dialogue on these topics sponsored by the Nuclear Threat Initiative and the Center for Energy and Security Studies in Moscow.

207 It is worth noting that while U.S. visits to Russian facilities were more extensive, the United States also invited Russian experts to visit U.S. facilities. These visits included all three of the U.S. nuclear weapons labs, the main U.S. plutonium-handling and HEU-handling facilities, and the U.S. nuclear weapons assembly and disassembly facility (a type of facility U.S. experts did not visit in Russia), so these visits were not as one-sided as they are sometimes made to seem in Russia.

- Conducting joint exercises to strengthen coordinated response in the event of a nuclear terrorism or nuclear smuggling event.
- Expanding cooperation against the IS and other terrorists who may combine the capabilities and intent to pose a nuclear threat in the future.[208]

Recommendations for the Next U.S. President

The next U.S. president should:

- Seek to revitalize nuclear security cooperation programs and adapt them to focus on convincing countries to take the actions needed to achieve nuclear security excellence, and helping them to do so.
- Work with Russia to rebuild and reform U.S.-Russian nuclear security cooperation, including being willing to restart U.S.-Russian nuclear energy cooperation as part of a larger nuclear cooperation package that includes nuclear security.

3. Expand Efforts to Strengthen Security Culture and Combat Complacency

To combat the complacency that undermines effective nuclear security, two interrelated sets of actions are needed: steps to strengthen nuclear security culture, and steps to broaden international understanding of the evolving threat and the remaining vulnerabilities that need to be addressed.

A New Nuclear Security Culture Initiative

Most nuclear organizations do not have any focused program to strengthen their nuclear security culture. They should. Countries interested in strengthening nuclear security should join together and commit to working with their operating organizations to take a series of steps to strengthen security culture.

208 For an existing set of recommendations for unilateral, bilateral, and multilateral work from a set of U.S. and Russian experts, see Matthew Bunn Matthew Bunn, Valentin Kuznetsov, Martin B. Malin, Yuri Morozov, Simon Saradzhyan, William H. Tobey, Viktor I. Yesin, and Pavel S. Zolotarev, *Steps to Prevent Nuclear Terrorism: Recommendations Based on the U.S.-Russia Joint Threat Assessment* (Cambridge, MA: Belfer Center for Science and International Affairs, Harvard Kennedy School, and Institute for U.S. and Canadian Studies, September, 2013), http://belfercenter.hks.harvard.edu/files/JTA eng web2.pdf (accessed January 18, 2016), pp. 19–22.

This would begin with the participating countries agreeing on the goal of excellence in nuclear security, with approaches based on the principle of continuous improvement, and on the importance of strong security culture to achieving that objective. Specific steps in such an initiative might include committing to:

- Ensure that all organizations managing high-consequence nuclear materials or facilities have programs in place to (a) assess their security culture, and (b) continuously strengthen it;
- Ensure that these organizations implement security culture recommendations of the IAEA and WINS;
- Ensure that all security-relevant managers and staff at such organizations receive regularly updated information on nuclear security threats, at levels of detail appropriate to their particular roles;
- Ensure that all such organizations establish programs of incentives for strong nuclear security performance (for individuals, teams, and organizations, as appropriate);
- Develop mechanisms for sharing good practices in strengthening security culture among nuclear organizations, and ensure that as many organizations as practical participate in these (including, as appropriate, through the IAEA and WINS); and
- Establish a joint working group charged with discussing progress and lessons learned, and developing additional suggestions for action.

Such an initiative could be one part of the broader nuclear security principles initiative suggested above, or it could be developed independently.[209]

209 For another account of the importance of security culture initiatives and potential actions leaders might take, see Igor Khripunov, "A Culture of Nuclear Security: Focus for the Next Nuclear Security Summit?" *Bulletin of the Atomic Scientists*, June 26, 2015, http://thebulletin.org/culture-security-focus-next-nuclear-security-summit8428 (accessed March 17, 2016).

Protecting Against Nuclear Sabotage

The disaster at the Fukushima Daiichi nuclear power plant in 2011 vividly demonstrated the terror, disruption, and costs that could be caused by a major nuclear accident—which could be caused by purely accidental events or by sabotage.[i] The sabotage of the Doel-4 reactor described in this report is only one of a number of sabotage events over the years, ranging from an insider bringing explosives into a plant and detonating them directly on the reactor's steel pressure vessel to terrorists overwhelming a plant's guards and seizing control of the facility before off-site response forces arrived.[ii] While none of these events released radiation, the danger of a major nuclear sabotage—a "security Fukushima"—is very real.

Preventing and responding to sabotage requires both deterring and delaying adversaries and providing effective safety and emergency response measures for coping with any emergency, whether caused by accident or terrorism. Steps such as ensuring that electric power to nuclear plants can quickly be restored and water can be provided to keep reactor cores and spent fuel stores adequately cooled can help reduce the chance of radioactive releases in any emergency, and steps such as filtered events can reduce the scale of radioactive releases if an emergency nevertheless occurs.[iii] For similar reasons, it would be more difficult for terrorists to cause a major radioactive release by sabotaging a new-generation reactor that relies more on passive systems to achieve safety, such as the AP-1000, than an older-design system more dependent on quick action of pumps and electrical systems; it would be still more difficult to cause a major radioactive release from an even more passive small modular reactor design, with less energy contained in its core to cause overheating.

To date, U.S. nuclear security programs have focused almost exclusively on security for materials that might be picked up and moved to the United States for an attack, rather than on helping countries protect against nuclear sabotage, which was seen as more their problem than a U.S. issue. Similarly, CPPNM did not include sabotage until its 2005 amendment, and the 2011 revision to the IAEA's nuclear security recommendations was the first that included specific recommendations for preventing and coping with sabotage. While the nuclear security summits have not focused in detail on sabotage, the 2012 communiqué noted the importance of the

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i For a discussion of both safety and security lessons from Fukushima, see Matthew Bunn and Olli Heinonen, "Preventing the Next Fukushima," *Science*, Vol. 333 (September 16, 2011), pp. 1580–1581.

ii The first of these incidents occurred at the Koeberg plant in 1982. For a useful summary, see Noah Gale Pope and Christopher Hobbs, *Insider Threat Case Studies at Radiological and Nuclear Facilities* (London: King's College and Los Alamos National Laboratory, April 13, 2015), http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-15-22642 (accessed February 29, 2016).The second incident mentioned occurred at the Atucha Atomic Power Station in Argentina in 1973. For a brief account of that incident (and many others) see Konrad Kellen, "Appendix: Nuclear-Related Terrorist Activities by Political Terrorists," in Paul Leventhal and Yonah Alexander, *Preventing Nuclear Terrorism* (Lexington, MA: Lexington Books, 1987), pp. x–xv. In both of these cases, the reactors were under construction and not yet loaded with fuel, so radioactive releases were not possibilities.

iii International Atomic Energy Agency, *Engineering Safety Aspects of the Protection of Nuclear Power Plants against Sabotage* (Vienna: IAEA, 2007), http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1271_web.pdf (accessed March 6, 2016).

safety-security link, and the 2014 communiqué included preventing sabotage as one of the fundamental nuclear security responsibilities of all states. A strong argument can be made that U.S. nuclear security programs should also begin including an expanded focus on sabotage: while it would not be in any way comparable to a nuclear detonation in a U.S. city, a foreign nuclear reactor sabotage could devastate the countries concerned and the global nuclear industry, seriously undermining any hope of expanding nuclear energy enough to play an important role in mitigating climate change.

There is clearly more to be done in many countries to provide adequate protection against sabotage.[iv] The protections that were in place in Belgium in 2014 were clearly inadequate to prevent a major sabotage—and Belgium (which has since upgraded security to prevent a recurrence) was not alone. Some countries have no armed guards at all at nuclear facilities, relying on offsite response forces some distance away; others have no background checks before allowing employees access to reactor vital areas or nuclear security systems. Experts in many countries unduly downplay the risk: in a recent survey of experts from 18 countries with HEU or plutonium on their soil, most respondents did not consider insider sabotage as a really credible threat, and some similarly downplayed the credibility of outsider sabotage.[v] Most individual country statements at the nuclear security summits do not mention the threat of sabotage or measures taken to address it.[vi]

States should take action to address these vulnerabilities. At a minimum, all nuclear power plants and other nuclear facilities whose sabotage could cause a major catastrophe should be protected against sabotage by a well-placed insider; a modest group of well-armed and well-trained outsiders, capable of operating as more than one team; and both an insider and outsiders working together. Plants in countries facing especially capable terrorist or criminal threats should be defended against even more capable adversaries. And all nuclear power plants should have fully operable and survivable equipment to provide emergency power and water in the event of a major accident or sabotage.

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iv Major international nuclear security instruments reflect this concern. The 2005 amendment to the physical protection convention, for example, broadens its coverage to include sabotage, and the 2011 revision to the IAEA's physical protection recommendations greatly expands their coverage of protection against sabotage. For a discussion of both safety and security lessons from Fukushima, see Matthew Bunn and Olli Heinonen, "Preventing the Next Fukushima."

v Bunn and Harrell, *Threat Perceptions and Drivers of Change,* p. 23.

vi "The Hague Nuclear Security Summit Communiqué," U.S. Department of State.

Increasing Understanding of the Nuclear Terrorism Threat

In addition to the security culture initiative, it is important to take steps particularly focused on increasing international understanding both of the nuclear terrorism threat and the potential vulnerabilities of existing nuclear security systems that require additional action. Important steps could include:

Agreement to Establish a Shared Database of Analyses of Incidents and Lessons Learned. Sharing of incidents, with root cause analyses and lessons learned, is routine, and extremely important, in strengthening nuclear safety. It is time to undertake a similar approach in nuclear security—within the inevitable constraints of necessary secrecy. The United States should work with other states to establish a shared database of security-related incidents. Each incident should be explored in depth, with analyses of the vulnerabilities that adversaries exploited to defeat security systems, and lessons learned (including security measures that could prevent such incidents from occurring at other sites). This would go well beyond the information available in the IAEA's databases, such as the Incident and Trafficking Database (ITDB); with a focus on how the incidents occurred and lessons learned from each one, it is more useful in understanding both the scope of the threat and the measures needed to address it.[210] Non-nuclear incidents that offer important lessons about the types of tactics against which nuclear materials and facilities must be protected should also be included.[211] Information about incidents and how to protect against them could be a major driver of nuclear security improvement, as it has been in safety; in a recent survey of nuclear security experts in 18 countries with weapons-usable nuclear material, incidents were cited far more often than any other factor as a dominant or very important driver of countries' recent changes in nuclear security policies.[212] The United States should kick things off with a detailed description of both the weaknesses that allowed the 2012 intrusion at the Y-12 nuclear complex to occur and the lessons learned and steps that have been taken to prevent similar occurrences in the

210 Even the ITDB information available to participating states offers little assessment of the causes of incidents or lessons learned. The information available to the public is little more than total numbers of incidents of particular kinds. See "IAEA Incident and Trafficking Database: Incidents of nuclear and other radioactive material out of regulatory control 2015 Fact Sheet," *International Atomic Energy Agency*, 2015, http://www-ns.iaea.org/downloads/security/itdb-fact-sheet.pdf (accessed February 19, 2016).

211 For three recent examples of such international incident assessments, seeking to draw lessons learned, see Jarret M. Lafleur, Liston K. Purvis, and Alex W. Roesler, *The Perfect Heist: Recipes From Around the World*, Vol. SAND-2014-1790 (Albuquerque, N.M.: Sandia National Laboratories, April 2014); Bunn and Sagan, *A Worst Practices Guide to Insider Threats: Lessons from Past Mistakes* and Pope and Hobbs, *Insider Threat Case Studies*. In the past, the U.S. government sponsored a nuclear security incidents database maintained by the RAND Corporation, but that effort is no longer being pursued. For examples of the kind of information that was included in the RAND database, see Kellen, "Appendix: Nuclear-Related Terrorist Activities by Political Terrorists."

212 Bunn and Harrell, *Threat Perceptions and Drivers of Change,* pp. 27–28.

future.[213] Participating states could begin with internal assessments of events within their territory, and then provide as much information as can reasonably be exchanged to an international collection of information.

Providing Briefings and Reports on the Threat. States that believe they have information on the nuclear terrorist threat should prepare reports and briefings and distribute them to other states. The United States, in particular, should prepare a detailed report on how easy or difficult it would be for a sophisticated terrorist group to make a crude nuclear bomb; past efforts by al Qaeda and other terrorist groups to get nuclear bombs and assessments of plausible future efforts by the IS and others; the potential for terrorists to be able to get plutonium or HEU from nuclear thieves and smugglers; and other elements of the nuclear terrorist threat. Different versions should be prepared for public distribution and for confidential exchange among states, including information that can be shared with non-nuclear-weapon states and more detailed information that could be shared with nuclear weapon states.[214]

Undertaking Discussions Among Intelligence Agencies. National governments get much of their information about the threats they face from their intelligence agencies. It would make sense, therefore, to work to ensure that relevant intelligence agencies are fully informed about nuclear terrorism threats. During the Bush administration, for example, Rolf Mowatt-Larssen, then head of the DOE Office of Intelligence and Counterintelligence, traveled to several capitals for in-depth discussions of the nuclear terrorism threat with intelligence counterparts. In some cases, these discussions appeared to provoke internal discussions between intelligence agencies and nuclear weapons design labs about the ease or difficulty of making a crude nuclear bomb, leading to intelligence agencies having a fuller appreciation of the topic.[215] In addition, in the years right after the 9/11 attacks, when U.S. intelligence encountered particularly alarming information about what were thought to be ongoing terrorist nuclear plots, it shared complete information with every government it thought likely to be able to help—even Iran.[216] The United States and other interested countries should launch a series of discussions among intelligence agencies to

213 While the United States has published several separate documents related to this incident, it has not make public any comprehensive account either of the root causes that led to the incident or the lessons the United States has learned about avoiding such incidents in the future.

214 For the briefing provided to the Sherpas for the 2014 Nuclear Security Summit, see William H. Tobey and Pavel S. Zolotarev, "The Nuclear Terrorism Threat," (paper presented at Meeting of the 2014 Nuclear Security Summit Sherpas, hosted by the Thai Ministry of Foreign Affairs Pattaya, Thailand 2014), http://belfercenter.ksg.harvard.edu/publication/23879 (accessed January 12, 2016).

215 Personal communication with Rolf Mowatt-Larssen, January 2016.

216 Mowatt-Larssen, *Al Qaeda WMD Threat*, p. 26.

explore assessments of the nuclear terrorist threat, remaining uncertainties, and priorities for reducing the uncertainties. Such discussions could also lead to expanded intelligence cooperation to deal with nuclear smuggling and nuclear terrorist activities.

Expanding the Use of Realistic Nuclear Security Tests, Including Force-on-Force Exercises. In the U.S. case, embarrassing failures in nuclear security inspections or tests—often followed by Congressional investigations—have driven action to strengthen nuclear security. Nothing is quite so convincing in countering the complacent view that a site's security measures are impregnable as a test in which mock adversaries manage to defeat them. The United States and other interested countries should work to convince as many of the countries with HEU or separated plutonium as possible to carry out regular, realistic tests of both their protection against insider thieves and their protection against outsiders trying to break in. Such exercises should be included in the commitment to stringent nuclear security principles suggested above, and should be a focus of nuclear security technical cooperation programs (which should include allowing experts from other countries to observe such exercises where appropriate). The fifth revision of the IAEA's nuclear security recommendations include a recommendation for force-on-force exercises; the IAEA should develop guidance and advisory services for states on how to conduct such tests, as well as realistic tests of protections against insider threats.

Nuclear Theft and Terrorism Exercises. Participating in a realistic simulation can give officials a "gut" feel for a problem in a way that no amount of reports, memos, and briefings can do. Building on past efforts, the United States and other interested countries should organize a series of exercises with senior policymakers from key states, exploring scenarios of nuclear theft and terrorist detonation of a nuclear bomb. Some exercises might focus on scenarios in which a nuclear theft has occurred and states need to cooperate to find and retrieve the nuclear material. Other scenarios might focus on intelligence that terrorists had nuclear material and were working to build a bomb at an unknown location; responding to a credible terrorist threat to detonate a nuclear bomb; dealing with a situation in which nuclear material or a nuclear bomb is on the road or on the sea and has to be found and intercepted; or coping with the aftermath of a terrorist nuclear detonation. Sabotage and "dirty bomb" scenarios should be the subject of such international exercises as well. These could be organized as part of the GICNT, through bilateral or "minilateral" cooperation among small groups of states, through the IAEA, or through non-government channels such as WINS.

The "Armageddon Test." There is much that is still unknown about the shadowy networks that attempt to smuggle nuclear and radiological materials. Many officials around the world believe terrorists would have little chance of getting nuclear material. An intelligence initiative could shed light on this question. The next U.S. President should direct U.S. intelligence—working in cooperation with agencies in other countries—to establish a small operational team dedicated to understanding and penetrating the world of nuclear theft and smuggling. They would seek to answer the outstanding questions from past cases—where previously confiscated material came from, who stole it and how, what smugglers were involved, whether there were real buyers, how buyers and smugglers connected with one another, and more. They would probe to see who is in the market today. In some cases they might pose as either potential buyers or sellers of nuclear material, although they should do nothing to simulate a demand for material that might make its theft more likely. In other cases, they might offer substantial sums for information leading to the capture of smugglers and the nuclear material in their possession. If they succeeded in making contact with smugglers who had access to weapons-usable material, this would dramatically highlight the continuing threat, and potentially identify particular weak points and smuggling organizations requiring urgent action. If they failed, that would suggest that terrorist operatives would likely fail as well, building confidence that measures to prevent nuclear terrorism are working.[217]

Recommendations for the Next U.S. President

The next U.S. president should:

- Work with other countries to launch an international initiative to strengthen nuclear security culture.
- Work with other countries to establish a shared database of security-related incidents and lessons learned, and to take other steps to build understanding of the threat and key vulnerabilities.

217 William Tobey and Rolf Mowatt-Larssen, "The Armageddon Test: To Prevent Nuclear Terrorism, Follow the Uranium," *Belfer Center for Science and International Affairs,* Harvard University, July 26, 2010, http://live.belfercenter.org/publication/20279/ (accessed January 21, 2016).

4. Broaden Nuclear Consolidation Efforts

The United States and other interested countries should make it a priority to reduce the number of locations where nuclear weapons and their essential ingredients exist around the world as much as possible. As detailed earlier in this report, existing consolidation programs have made considerable progress; half of all the countries that once had weapons-usable nuclear materials on their soil have eliminated it. These programs deserve strong support. But the consolidation effort should be broadened and expanded.[218] They should include not only civil HEU but civil plutonium and military stocks as well. Key steps are listed below.

A Comprehensive Approach

Each state with nuclear weapons, HEU, or separated plutonium should undertake a review of every site where these materials exist, eliminating any site whose continued benefits are outweighed by its costs and risks. This review should include the costs of ensuring effective security against a broad range of potential adversary threats if the material remains in place. The material at sites to be closed should then be consolidated at other locations.

Countries should ensure that operators have strong incentives to eliminate HEU or separated plutonium stocks where feasible, to help overcome facility operators' natural resistance to change.[219] Regulators should ensure that regulations appropriately require substantially more stringent security measures when HEU or separated plutonium is present (as IAEA recommendations suggest), so that operators can save money on security costs by eliminating this material.[220] States should eliminate any institutional incentives that may exist for operators to maintain HEU or separated plutonium (such as increased research funding for facilities using these materials, for example). The U.S. government and other interested governments should continue and expand their use of substantial

218 For more detailed analysis and recommendations, see Bunn and Harrell, *Consolidation: Thwarting Nuclear Theft.*

219 For more on eliminating the use of HEU, see Frank von Hippel, *Banning the Production of Highly Enriched Uranium* (Princeton, N.J.: International Panel of Fissile Materials, 2016), http://fissilematerials.org/library/rr15.pdf (accessed March 18, 2016).

220 In the United States, the high costs of meeting post-9/11 security requirements for plutonium and HEU have driven a major consolidation of nuclear materials in the DOE complex, with all Category I and Category II material eliminated from Livermore and Sandia National Laboratories, HEU removed from TA-55 at Los Alamos to the highly secure Device Assembly Facility in Nevada, and substantial reduction in the number of buildings with weapons-usable material elsewhere. But in a recent survey of nuclear security experts in 18 countries with plutonium or HEU, experts from nine countries reported that the nuclear security rules and procedures in their countries either created no significant incentive to consolidate these stocks or gave sites incentives to maintain the stocks they had. See Bunn and Harrell, *Threat Perceptions and Drivers of Change*, p. 31.

packages of incentives, shaped for the needs in each case, to convince countries to eliminate civilian sites with dangerous stocks of high-quality HEU or separated plutonium. Donors, for example, could offer financial support for work at other research reactors and help with decommissioning if an HEU-fueled research reactor shut down, or, if a high-flux research reactor agreed to convert to LEU fuel, donors could offer improved neutron guides that would allow the reactor to achieve a better flux of neutrons for their experiments than ever before.[221]

The U.S. government should have a blanket policy that wherever plutonium or HEU exists in the world, it will either take it back to be secured in the United States, help arrange its disposition elsewhere, or work to ensure that it has sustainable security that will protect it from the full range of plausible threats while it stays in place.

Bulk Processing Facilities

As large facilities that process weapons-usable nuclear material in bulk pose the greatest dangers of insider nuclear theft, the United States and other interested countries should work to ensure that:

- The number of such bulk-processing facilities does not increase;
- New states have incentives not to build such facilities;
- The overall scale of bulk processing worldwide decreases rather than increases;
- These facilities process material in forms as difficult to make into nuclear weapons as practicable; and
- Each of these facilities implements the highest standards of security, accounting, and control for the nuclear material it handles.

221 See Alexander Glaser and Uwe Filges, "Neutron-Use Optimization with Virtual Experiments to Facilitate Research Reactor Conversion to Low-Enriched Fuel," *Science & Global Security,* Vol. 20, No. 2–3 (2012), pp. 141–54.

Civil HEU

Countries using HEU for nonmilitary purposes should join together in agreeing on the goal of eliminating the civil use of HEU, and a target date for doing so.[222] While continuing to push to convert research reactors fueled with HEU to LEU, the United States and other interested governments should also offer incentives to shut down unneeded HEU-fueled reactors and to eliminate their dangerous nuclear material. (Most of the world's research reactors are underutilized, and many of the facilities with high-quality HEU would be quite difficult to convert to LEU.)[223] Shutting down reactors will frequently be cheaper than converting them, and unlike conversion, there are no technical barriers to shutdown. The United States, working with other countries (perhaps through the IAEA) should establish a program to offer incentives for unneeded HEU-fueled facilities to shut down, including assistance with decommissioning costs, funding for scientists to share time at other research reactors in their region, and more.[224]

The United States and other interested governments, working in collaboration with the IAEA, should help countries convert research reactors to particle accelerators wherever practical, accomplishing similar research and isotope production with reduced proliferation risk, as well as reduced fuel supply and waste management challenges.[225] The United States should offer to buy HEU from anyone willing to sell (and willing to promise not to make or get more).

Russia and the United States should each prepare a plan for achieving the science, training, and isotope production they need at minimum cost and risk, with minimum use of HEU or plutonium—plans for "Neutrons for America" and "Neutrons for Russia." This is important because Russia now has roughly two-thirds of the world's HEU-fueled critical assemblies, and two-thirds of the world's HEU-fueled pulse reactors (both of which often

222 For other recommendations on coping with civil HEU, see, for example, Andrew J. Bieniawski and Miles A. Pomper, *A Roadmap to Minimize and Eliminate Highly Enriched Uranium* (Washington, D.C.: Nuclear Threat Initiative, James Martin Center for Nonproliferation Studies, and Fissile Material Working Group, May 2015); Fissile Materials Working Group, The Results We Need in 2016; and Alan J. Kuperman, ed., *Nuclear Terrorism and Global Security: The Challenge of Phasing Out Highly Enriched Uranium* (New York: Routledge, 2013).

223 There are over 240 research reactors in the world (roughly half of them still fueled with HEU), and IAEA experts have estimated that the world only needs 30–40 such reactors for the long term. International Atomic Energy Agency, "New Life for Research Reactors? Bright Future but Far Fewer Projected" (Vienna: IAEA, March 8, 2004).

224 Bunn and Harrell, *Consolidation: Thwarting Nuclear Theft*, pp. 38–40.

225 Israel, for example, is replacing its Soreq research reactor with a particle accelerator, and expects to be able to accomplish even better scientific research than before. For a brief discussion of the potential role of accelerators as an alternative to many research reactors, see David Nusbaum, "Smashing Atoms for Peace: Using Linear Accelerators to Produce Medical Isotopes Without Highly Enriched Uranium" (Cambridge, MA: Project on Managing the Atom, Belfer Center for Science and International Affairs, Harvard Kennedy School, October, 2013), http://belfercenter.ksg.harvard.edu/publication/23513/ (accessed January 21, 2016).

have hundreds of kilograms or even tons of high-quality HEU), while the United States has several aging high-performance research reactors that cannot be converted to LEU with existing fuels. Neither country has a long-term plan for their research reactor fleets. If Russia and the United States are able to renew nuclear security cooperation, they should discuss the specifics of these plans, and ways they might work together (for example sharing certain facilities where scientific objectives overlap).

Finally, in cases where an HEU-fueled reactor is still needed, and it is projected to take many years before conversion can occur, states should: provide stringent security measures for the HEU; and consider converting 30-45 percent enriched HEU as an interim step to reduce risk until full conversion can be accomplished, as a recent National Academy of Sciences panel has recommended.[226]

Civil Plutonium

The United States and other countries should undertake new efforts to consolidate civilian separated plutonium and limit the buildup of ever-larger stockpiles. In particular, they should seek to get countries to commit to:

- Eliminate any unneeded sites with separated plutonium (as Switzerland and Sweden, among others, have done in recent years);
- Avoid expanding the number of plutonium reprocessing facilities, and the number of places where separated plutonium is stored and used;
- Reprocess no more plutonium than they use each year, so that stocks remain stable or decline, rather than increasing;
- Handle plutonium as much as possible in forms mixed with other materials, requiring chemical separation before they could be used in a bomb; and
- Maintain high standards of security and accounting throughout all storage, transport, processing, and use of separated plutonium.

226 National Academies of Sciences, Engineering, and Medicine, *Reducing the Use of Highly Enriched Uranium in Civilian Research Reactors*.

Military Stocks

At the same time, the United States, Russia, and other interested countries should expand cooperative efforts to consolidate military stocks of nuclear weapons, separated plutonium, and HEU. Russia and the United States, in particular, as the countries whose nuclear stockpiles are dispersed at the largest number of buildings and bunkers with nuclear weapons or weapons-usable material, should each develop a national-level plan for accomplishing their military and civilian nuclear objectives with the smallest practicable number of locations with nuclear weapons or weapons-usable material.[227]

Recommendations for the Next U.S. President

The next U.S. president should:

- Launch a comprehensive consolidation effort, covering bulk-processing facilities, civil HEU, civil plutonium, and military stocks, as described above.
- Make consolidation a major priority of the U.S. nuclear security program.
- Work with Congress to ensure that efforts to consolidate nuclear weapons and weapons-usable nuclear materials are not slowed by lack of funds.

5. Develop Approaches to Confirm That Effective Nuclear Security Is in Place

Insecure nuclear material anywhere is a threat to everyone, everywhere—and all countries have a national security interest in seeing that all countries with nuclear weapons or weapons-usable nuclear materials protect them effectively. Today, however, few mechanisms are in place to give countries confidence that such effective protection really is in place.

The United States and other interested states should establish an experts group to work out approaches to providing assurances that would build real confidence without unduly compromising sensitive information. For example, states could:

227 The United States has already gone much farther in consolidating its stocks than Russia, but may have more to do. In the 1990s, Russia's Ministry of Atomic Energy committed to developing a consolidation plan for civilian nuclear material, but this was never accomplished.

- Invite review of their nuclear security arrangements by international teams, whether led by the IAEA, by a state partner in technical cooperation, by a nuclear supplier, or by others. Actual visits to facilities, including discussions with the people there, can provide insights not available by another means. Review and advice from experts outside the group that designed and is implementing nuclear security systems can often be extremely helpful in finding areas for improvement. In particular, states should request IPPAS missions to review security for their civilian infrastructure.
- Publish at least general information about the kinds of threats operators are required to protect nuclear weapons, HEU, or separated plutonium against—for example, confirming that these threats include a group of well-armed and well-trained outsiders, an insider, and a broad range of possible tactics and approaches.
- Publish regulations (as many states do already), and expert analyses of what they mean.
- Publish detailed descriptions of how the state inspects and tests to ensure security is meeting requirements. This could be supplemented by allowing representatives from other countries to take part in or observe some of these inspections or tests.[228] Publish at least general information about how well its operators performed on these inspections and tests (for example, for years, DOE published the percentage of its sites that had been rated in the highest category in its security inspections, with fairly detailed descriptions of what items were included in these inspections).
- Publish detailed information about how weaknesses or problems were found and fixed, along with lessons learned and steps taken to ensure the weaknesses did not arise again.

If other countries knew that a country required operators to protect nuclear weapons, HEU, and separated plutonium against a robust range of potential adversary threats; understood the inspection and testing program used to confirm that operators were meeting these requirements; knew that a large fraction of the facilities had been shown in inspections to meet these standards; and understood that thorough and effective corrective actions were taken in response to any weaknesses identified, this could increase confidence in nuclear security substantially.

228 The United States, for example, has on several occasions allowed representatives from other countries to observe force-on-force exercises at U.S. facilities, and U.S. experts have observed nuclear security exercises in a number of other countries. In the 1990s, in some of the non-Russian states of the former Soviet Union, U.S. adversary teams carried out such tests at nuclear facilities. Technical cooperation programs sometimes include observers from another country taking part in nuclear security and accounting inspections.

There is also likely to be information that countries might be willing to exchange with one or a few other states, or with the IAEA, that they are not willing to make public. As discussed earlier, for example, states should work out ways to exchange information about the kinds of threats their nuclear security systems are designed to protect against, most of which should not be made public (to avoid giving information to adversaries about the kind of security measures they would have to defeat at nuclear sites).

There are a variety of particular forums where such information could be published or exchanged. If a group of countries joins in a nuclear security commitment such as that described earlier, for example, the participating countries (or subsets of them) could exchange such information amongst each other. Although the CPPNM and its 2005 amendment do not require national reporting of implementation steps, there would be nothing preventing a group of states from publishing detailed national reports (as states are obligated to do for the nuclear safety convention), and encouraging other states to do likewise. If a group of leading countries began providing such reports regularly, it could increase the pressure on others to do the same. Another approach would be for the IAEA to establish a Nuclear Security Register on its website for states to voluntarily register their achievements (along the lines of the Agency's Nuclear Safety Dashboard and the UN's Arms Trade Register).[229] Another possibility would be for states to include some of the information described above as part of their UNSCR 1540 reports. Whatever the particular forum, donor states and international organizations should be prepared to provide assistance in drafting these detailed reports to states with limited capacity. The IAEA or the WINS could provide guides that would suggest a common format and categories of information that might be included.

There may be a need for alternative measures for stocks that states judge to be particularly sensitive. In particular, it is unlikely that states will invite IAEA-led reviews of security for their nuclear weapons or military nuclear materials (and given the IAEA's civilian mandate, there is some doubt about whether it could realistically respond to such a request). States that have such stocks should work together to develop ways to provide assurance that they are protecting them effectively, including developing approaches to exchanging peer reviews of defense-oriented sites.

Operators need to build confidence with local communities and other stakeholders, just as they need to build confidence in safety. Nuclear operators should engage with a full spectrum of stakeholders to build confidence, address concerns, and gain ideas for strengthening their security programs. They should protect genuinely sensitive

229 Findlay, "Beyond Summitry."

information as needed, but share other information with key stakeholders to build confidence in the effectiveness of security implementation.

Recommendations for the Next U.S. President

The next U.S. president should:

- Establish a policy of the United States providing sufficient information about nuclear security to give other states a good understanding of the strengths of the U.S. nuclear security system, and the challenges still to be addressed.
- Request an IPPAS mission at a substantial U.S. nuclear facility (more substantial than the research reactor that the first U.S.-hosted IPPAS mission reviewed), such as the plutonium storage area at the Savannah River Site.
- Work with other countries to develop approaches to building confidence in states' nuclear security arrangements, as discussed above, and then work to get them broadly adopted.
- Work with countries holding U.S.-origin material to ensure that U.S. experts regularly visit all locations with U.S.-origin HEU or separated plutonium.[230] Continue an effective nuclear security dialogue after the summits end.

6. Continue an Effective Nuclear Security Dialogue After the Summits End

It is essential that nations come together and establish an effective ongoing dialogue on nuclear security after the summits come to an end. The end of the nuclear security summits will leave a serious gap, as there is no other forum at present to discuss next steps in nuclear security at the highest levels. Realistically, no forum can fully replace the three key things the nuclear security summits provided: attention from the highest levels of government; a decision-forcing schedule; and ongoing senior dialogue between meetings.

But a number of forums will continue to exist that may be able to fill parts of the gap, and the United States and other interested countries should work to ensure that they grow into

230 As the Government Accountability Office has noted, some 3.5 tons of U.S.-origin HEU, including 2.3 tons of material that has never been irradiated (the majority of the unirradiated U.S.-origin HEU) is located at sites U.S. teams have not visited in over 20 years. GAO, *DOE Made Progress,* p. 25.

truly effective forums for nuclear security decision-making. The 2016 summit is expected to lay out suggested "action plans" for five international organizations or coalitions: the IAEA; the UN and its UNSCR 1540 committee; GICNT; the GP; and Interpol. Each of these will clearly have their role to play, most prominently the IAEA. In each case, there is more to be done to strengthen the forum as a place where governments can come together for serious discussions and decisions. And there are other forums that may be able to contribute as well.

- *IAEA nuclear security meetings.* The IAEA's nuclear security meetings—planned every three years—are likely to be the most prominent regular international meeting focused on nuclear security. Countries should work together to turn these into working meetings intended to reach decisions on particular actions, as well as opportunities for technical exchange. A process similar to the Sherpas meeting between summits could be used to hash out initiatives to be agreed on—or announced by subgroups of states, as in the summit "gift basket" process—at the next IAEA meeting.[231] In addition, a subgroup of "friends of nuclear security" could meet to hash out recommendations more informally, which could then be acted on in the larger group. States interested in promoting new steps on nuclear security could use these meetings as occasions for announcing new steps they had taken—creating at least a part of the schedule-driving effect of the nuclear security summit process.

- *Physical protection convention reviews.* Once the amendment to the physical protection convention enters into force—which may finally occur in 2016—there will be a requirement to hold a review conference of the convention, and if a majority of parties wants them, such conferences could be held every five years. This would be another international forum focused specifically on nuclear security, with considerable political legitimacy. And such conferences, too, could be an occasion for announcing new nuclear security commitments.[232]

- *An expanded Global Initiative.* The participants in the GICNT could create an additional working group focused specifically on nuclear security. Remarkably, although security for nuclear materials is one of the Global Initiative principles, it has never been a major focus of the group. But that could change, especially if the summit participants, who are a majority of Global Initiative members, decided they needed

231 Findlay, "Beyond Summitry," p. 22. The United States has proposed that interested states work together to develop proposals to strengthen the IAEA's role and the international nuclear security framework. By allowing proposals to be discussed and developed in what would probably be a like-minded group of relatively modest size, this could increase the efficiency of concept development—and those ideas could then be addressed by the full IAEA membership.

232 Herbach and Pitts-Kiefer, "More Work to Do."

an ongoing forum to replace part of what the summits did. The Global Initiative is still co-chaired by the United States and Russia, and despite their tense relationship—and the breakdown of most U.S.-Russian nuclear security cooperation—both counties still take the Global Initiative seriously. Such a group would provide a working forum with flexible procedures that enable them to make decisions, which could focus on working out commitments to key nuclear security principles, exchanging best practices, working with states to help put particular security measures in place, and more. Plenary meetings of the Global Initiative often take place at the level known as Undersecretaries in the United States, roughly equivalent to deputy ministers in other countries—high enough to bring some political clout, but low enough to home in on specific action.

- *G7 and G20 summits.* Most of the world's weapons-usable nuclear material is in G7 countries, and the G7 has for many years included statements on nonproliferation, disarmament, and nuclear security at each summit—including the launch of the GP at the 2002 summit. The G7 summits could be an occasion for leaders to approve work done in an experts group, and to announce new initiatives and commitments.[233] The exclusion of Russia from the group, however, with its vast stocks of nuclear weapons and materials, would undermine the G7's promise as a forum for nuclear security progress. Nevertheless, the G7 summits could be another occasion for new commitments and announcements on nuclear security. Russia, China, India, and other important states are included in the G20, but to date the G20 has remained a forum focused almost exclusively on economic issues, rather than political and security issues.[234]

Recommendations for the Next U.S. President

The next U.S. president should:

- Work with other countries to ensure that an active, high-level dialogue on nuclear security, structured in a way that allows it to be effective in discussing and adopting

233 The G7 already makes an annual statement on nonproliferation, disarmament, and nuclear security, put together by the G7 Nonproliferation Directors. In 2015, this statement was issued well before the summit, in advance of the NPT Review Conference. See "G7 Statement on Nonproliferation and Disarmament." The G7 also has a Nuclear Safety and Security Group, but this group is not widely known or strongly influential, and in recent years it has focused primarily on safety. See, for example, "Report of the G7 Nuclear Safety and Security Group (NSSG) During the German Presidency in 2014/2015" (Schloss Elmau, Germany, June 7–8, 2015), http://www.g8.utoronto.ca/summit/2015elmau/2015-G7-nssg-report.pdf (accessed January 23, 2016).

234 See David Shorr, "A Bigger Table, A Broader Agenda," in John Kirton and Madeleine Koch, eds: *G8 & G20: The 2010 Canadian Summits* (Toronto: University of Toronto, 2010), http://www.g8.utoronto.ca/newsdesk/g8g20/g8g20-shorr.html (accessed March 6, 2016).

Preventing Nuclear Terrorism: Tools Beyond Nuclear Security

Preventing nuclear theft is the most important, but not the only, step that must be taken to reduce the risk of nuclear terrorism. Nuclear security will never be perfect, and there may well already be nuclear material that has been stolen and not recovered. A multifaceted international effort to reduce the risk of nuclear terrorism is essential.[i] Whatever other disagreements they may have, countries should be able to agree that terrorist groups must never be permitted to gain access to nuclear weapons or their essential ingredients.

Countries—and in particular the United States and Russia—should expand police and intelligence cooperation targeted on identifying and countering groups with nuclear aspirations and intercepting nuclear smuggling. The United States, in particular, should expand its intelligence collection and analysis focused on terrorist nuclear, chemical, and biological efforts to the kind of focused, well-resourced effort that existed in the years after the 9/11 attacks.

Countries should ensure that their legal systems impose significant penalties for participating in theft or smuggling of nuclear material or any assistance to nuclear terrorists—and that states have national police or intelligence units trained and equipped to deal with nuclear smuggling cases. States should establish a tip line and reward system to encourage people to blow the whistle on nuclear thieves or smugglers. (Such tips have led to some of the most important past seizures of plutonium and HEU.)

While it is extremely unlikely that states would intentionally transfer nuclear weapons or materials to terrorists, the United States and its international partners should attempt to reduce the likelihood of such an act even further by creating international packages of incentives and disincentives with enough impact and credibility to convince North Korea, in particular, that it should cap its nuclear program and that the consequences of ever transferring nuclear material or technology to non-state actors would be severe.

Much of this work is already happening, though there is more to be done. The killing of Osama Bin Laden and other members of the leadership of "core" al Qaeda has reduced the risk that al Qaeda would again attempt a nuclear bomb program. At the same time, as discussed earlier in this report, despite an international coalition attacking the IS, the group still has worrisome resources and capabilities should it ever turn seriously to seeking nuclear weapons. As noted elsewhere in this report, other terrorist groups have pursued nuclear weapons in the past and

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i For a list of the steps along a terrorist pathway to the bomb, and recommendations for the steps beyond improved nuclear security, see Mathew Bunn, *Securing the Bomb 2010*, pp. 8, 106–109. For a useful effort to think through a systems approach to reducing the risk, see Michael Levi, *On Nuclear Terrorism* (Cambridge, MA: Harvard University Press, 2009). For a joint U.S.-Russian description of next steps that should be taken, see Matthew Bunn *et al*, *Steps to Prevent Nuclear Terrorism: Recommendations Based on the U.S.-Russia Joint Threat Assessment.*

may do so in the future. Focused efforts to scan for signs of nuclear, chemical, or biological ambitions and activities—and to take action when such signs are found—are needed.

Many countries are also strengthening their ability to deter and interdict nuclear smuggling. Following up on UNSCR 1540, countries have put in place stronger criminal laws imposing severe penalties for crimes related to nuclear theft, smuggling, and terrorism. National nuclear forensics programs—designed to contribute to identifying the source of nuclear material—have also been strengthened, though there is a great deal still to be done. Many countries have installed radiation detectors at key ports, airports, and border crossings, often with U.S. help and financing.

Unfortunately, however, the vast length of national borders, the immense legitimate traffic across them, the pervasive smuggling of many other types of contraband that exists worldwide, the corruption of some border officials, and the difficulty of detecting nuclear bomb material make intercepting nuclear smuggling an enormous challenge. Uranium and plutonium, while radioactive, are not radioactive enough to be difficult to carry or easy to detect. Most of the detectors that have been installed around the world would have a good chance of detecting plutonium or gamma-emitting radiological sources, but would not be likely to detect well-shielded HEU.

Moreover, the news on interdicting nuclear smuggling has not all been positive. Genuine cooperation among intelligence agencies of different countries—particularly between Russia and the United States—on the nuclear smuggling threat remains scarce. Some very important borders—such as those of Afghanistan and Pakistan—are effectively impossible to control in current circumstances. Russia and the United States worked together to complete the installation of radiation detectors at all of Russia's official border crossings, but Russia's customs union with Kazakhstan and Belarus made many of those border crossings effectively irrelevant. That pushes the real border out to the edges of Kazakhstan and Belarus, and not all of their border crossings yet have radiation detectors. The freeze in US-Russian relations makes it more difficult to address these gaps.

Radiation detection is only one of many tools for reducing the risk of nuclear terrorism, and not the most effective one—but at sites where there is good reason to believe nuclear smuggling is a real risk and the geography suggests it would be difficult for smugglers to go around the official border crossing, it makes sense to install effective radiation detection. At areas with broad border areas through which smugglers might pass, or within countries, mobile detectors may be more effective. Such radiation detection programs should always be designed for sustainability—and must also address the corruption so often found in border control agencies. Ultimately, radiation detection should be only one part of a broader effort to counter nuclear smuggling that includes targeted police and intelligence efforts, nuclear forensics, and a strong component of international cooperation.

next steps to strengthen nuclear security, continues after the summit process comes to an end.

Making Nuclear Security a Priority

Together, these steps could help the international community get onto the upward nuclear security path envisioned earlier in this report, building a commitment to continuous improvement in the never-ending search for nuclear security excellence. To achieve that goal, the next U.S. president and the leaders of other interested states will have to continue to make nuclear security a priority, ensuring that their governments are continuing to find and fix weaknesses and overcoming obstacles to progress.

In particular, the next U.S. president should make clear that effective security for nuclear weapons and weapons-usable materials remains a top priority of the U.S. government, and take steps to back that rhetoric with action. Such steps should include:

- Designating a senior director on the National Security Council staff to lead efforts to strengthen nuclear security and prevent nuclear terrorism.
- Developing a clear strategic plan for nuclear security for the entire presidential term, integrating the actions of all relevant departments in a whole-of-government approach.
- Putting nuclear security high on the diplomatic agenda, as an item to be raised with every relevant country, at every level, whenever it would contribute to progress toward the nuclear security goal.
- Working with Congress to ensure that no effort that could significantly reduce the danger of nuclear terrorism is slowed by lack of funds.

Appendix: Evolving Perceptions of the Threat of Nuclear Terrorism

While there is growing international agreement today that the threat of nuclear terrorism is real, this was not always the case. Both the nuclear terrorism threat and perceptions of it evolved over time and continue to evolve. Understanding how the threat and perceptions of it evolved clarifies the challenges faced by governments today.

Early Fears of Nuclear Terrorism

Fear that a small group of individuals might assemble and explode a nuclear device in a major city is not novel.[235] A year after the first atomic detonations, this dread manifested itself at a closed U.S. Senate hearing, when the Manhattan Project's director, J. Robert Oppenheimer, was asked, "whether three or four men couldn't smuggle units of an [atomic] bomb into New York and blow up the whole city." His answer was, "Of course it could be done, and people could destroy New York."[236] Oppenheimer was not alone in his opinion. In a 1946 essay, "The New Technique of Private War," physicist Edward U. Condon warned that a bomb equivalent to "twenty thousand tons of TNT can be kept under the counter of a candy store."[237]

In the 1940s and 1950s, however, the means to make nuclear weapons resided at the far horizon of technology, where they were bemisted by secrecy and comprehended only by cognoscenti backed by powerful states. Nuclear weapons were the province of governments, not individuals. Consequently, the prevalent scenario for a terrorist nuclear attack was that an enemy of the United States, i.e., the Soviet Union, could supply individuals with the means to conduct an unconventional nuclear strike. Of course, such an attack would be backed by the vast Soviet nuclear weapons enterprise, and would thus be the work of a few individuals only at the point of delivery.

235 As the United States has been the country most focused on the risk of nuclear terrorism and most open in releasing information about its intelligence assessments of the topic, much of the official analysis of the nuclear terrorism threat comes from an American perspective. Nonetheless, as will be discussed below, an international consensus has formed that it is plausible that terrorists could make crude nuclear bombs if they got the needed nuclear material, and that the consequences of nuclear terrorism would be global.

236 Kai Bird and Martin J. Sherwin, *American Prometheus: The Triumph and Tragedy of J. Robert Oppenheimer* (New York: Alfred A. Knopf, 2005), p. 349.

237 Edward U. Condon, "The New Technique of Private War," in Dexter Masters and Katharine Way, eds., *One World or None: A Report to the Public on the Full Meaning of the Atomic Bomb* (New York: Whittlesey House, 1946), p. 40.

Oppenheimer's and Condon's warnings provoked two efforts to assess U.S. vulnerabilities to smuggled nuclear weapons and how best to mitigate them—Projects Screwdriver and Doorstop—and a National Intelligence Estimate (NIE) titled *Soviet Capabilities for Clandestine Attack against the US with Weapons of Mass Destruction and the Vulnerability of the US to Such Attack (mid-1951 to mid-1952).* The NIE concluded that an atomic bomb could be disassembled into its requisite parts—including the nuclear material—and smuggled into the United States in stages. Each component could be packaged in a way that would avoid radiation detection and not draw undue attention. While reassembling the components into a bomb would be difficult, it would not be impossible.[238] The NIE also judged that such an attack would be unlikely because of its complexity and the number of individuals that would need to be involved.[239]

Nonetheless, by 1953, Committee B, or the Committee on Countermeasures, was formed within the U.S. government "to consider ways and means of safeguarding against the clandestine introduction of nuclear weapons."[240] It reported to the National Security Council until 1962, when President Kennedy transferred its oversight to the Attorney General.[241] This appears to reflect a lowering of the priority of the mission, or at least of attention to it by senior policy makers (which has not been fully recovered, even today). Thus, while efforts were made to detect clandestine movement of nuclear material, the threat was not judged to be a high priority, at least in relation to the nuclear weapons aimed at the United States and its allies by the Soviet Union using aircraft and missiles as delivery systems.

As late as 1970, U.S. intelligence analysts seemed to judge that the primary threat of a smuggled nuclear weapon emanated from states, in particular the Soviet Union and China. Further, they evinced confidence that this would not occur except under the direst of circumstances. An NIE from July concluded:

> "In considering the clandestine introduction of nuclear weapons into the U.S., leaders of any nation would have to weigh any possible advantages against the

238 *Soviet Capabilities for Clandestine Attack against the U.S. with Weapons of Mass Destruction and the Vulnerability of the U.S. to Such Attack (mid-1951 to mid-1952),* National Intelligence Estimate 31 (Washington, D.C.: Central Intelligence Agency, September 4, 1951), p. 4.

239 CIA, *Soviet Capabilities for Clandestine Attack,* p. 1.

240 Memorandum from the Joint Chiefs of Staff to Secretary of Defense McNamara, "Clandestine Introduction of Nuclear Weapons to the United States," JCSM-3-68, January 2, 1968, https://fas.org/irp/threat/jcs1968.pdf (accessed December 30, 2015).

241 Joint Chiefs of Staff, "Clandestine Introduction of Nuclear Weapons."

> grave consequences which would follow discovery. Despite all precautions there would always be risk of detection arising not only from US security measures, but also from the chance of US penetration of the clandestine apparatus, the defection of an agent, or sheer accident. The enemy leaders would almost certainly judge that use of this tactic would be regarded by the US as a warlike act, if not as a cause for war, and that it would precipitate an international political crisis of the first magnitude."[242]

The NIE concluded that no nation would consider introducing nuclear weapons into the United States through clandestine means unless it were planning an attack on the United States, deterring the United States, or as a means of framing a third party. Thus, policymakers could regard the nuclear terrorism threat as a lesser-included case addressed by their broader policies to deter nuclear war.

The 1960s and 1970s: Terrorists Could Make a Nuclear Bomb—But Would They Want To?

Elsewhere in the government, however, the late 1960s saw the first stirrings of genuine concern over the possibility that terrorists not directed by a government might be able to make and use a nuclear bomb. After the apparent loss of a large amount of HEU from the Nuclear Materials and Equipment Corporation (NUMEC) in Apollo, Pennsylvania in 1965, the U.S. Atomic Energy Commission (AEC) tasked an advisory group to review its security program, and in 1967 the group recommended major improvements in security and accounting, warning—apparently for the first time ever in a U.S. government report—that unless the AEC took action, terrorists might be able to get weapons-usable nuclear material and make a crude nuclear bomb.[243] The AEC centralized its nuclear security pro-

242 *The Clandestine Introduction of Nuclear Weapons into the U.S.,* National Intelligence Estimate 4-70 (Washington, D.C.: CIA, July 7, 1970), www.foia.cia.gov/sites/default/files/document_conversions/89801/DOC_0000273219.pdf (accessed December 30, 2015), p. 3.

243 See discussion of this report in William J. Desmond, Neil R. Zack, and James W. Tape, "The First Fifty Years: A Review of the Department of Energy Domestic Safeguards and Security Program," *Journal of Nuclear Materials Management*, Vol. 26, No. 2 (Spring 1998), pp. 17–22. The result of the review was published in March 1967 as Ralph F. Lumb, Francis P. Cotter, Gerald Charnoff, Paul Grady, Aston J. O'Donnell, Jr., Louis H. Roddis, and Fred H. Tingey, *Report to the Atomic Energy Commission by the Ad Hoc Advisory Panel on Safeguarding Special Nuclear Material* (Washington, D.C.: Atomic Energy Commission, 1967). The unclassified introduction and summary of recommendations are reproduced in U.S. Senate, Committee on Government Operations, *Peaceful Nuclear Exports and Weapons Proliferation: A Compendium* (Washington, D.C.: Government Printing Office, 1975), pp. 555–562. It is striking that this report was written *before* the rise of the modern era of international terrorism, beginning after the 1967 Arab-Israeli war. For a more recent account of the NUMEC affair, see Victor Gilinsky and Roger J. Mattson, "Revisiting the NUMEC Affair," *Bulletin of the Atomic Scientists*, March 1, 2010, http://thebulletin.org/2010/march/revisiting-numec-affair (accessed February 9, 2016).

gram and established the first-ever U.S. rules requiring private owners of weapons-usable nuclear material to provide security for it.[244]

By the 1970s and 1980s, terrorism—kidnappings, political murders, bombings, and hijackings—reemerged as a serious threat in Europe and North America. The Baader-Meinhof Group (aka the Red Army Faction), the Black September Organization, the Palestine Liberation Organization, Libyan government-sponsored terrorists, the Red Brigades, the Irish Republican Army, and the Weather Underground organization, among others (sometimes with training or support from the Soviet Union or its allies[245]) inflicted violent attacks on Europe and the United States. Guerilla attacks in Vietnam made it clear that even well defended sites such as U.S. airbases might be attacked. Moreover, according to Walter Laqueur, "During the 1970s, there were 175 cases of threatened violence at nuclear plant facilities."[246] Furthermore, just as the September 11, 2001 attacks would later galvanize concern that terrorists might turn to nuclear weapons, the assault on Israeli athletes at the 1972 Munich Olympics made clear that the possibility of a group of well-trained, well-armed terrorists striking in the heart of a major developed country was not a Hollywood fantasy, but a real possibility.

In response, President Richard Nixon appointed a Cabinet-level committee to combat terrorism, including addressing the nuclear issue.[247] Naturally, those with the responsibility to analyze and defend against current and emerging threats wondered if the merely vicious could become catastrophic—whether assassinations could turn to nuclear mass murder. James Schlesinger, then Chairman of the AEC, and later the leader of the CIA and the Defense and Energy Departments, raised questions about the plausibility of nuclear terrorism, but ultimately was reportedly insistent on the need to guard against armed terrorists stealing fissile material and fashioning it into a bomb.[248] The AEC established new and tougher rules for physical protection and material control and accounting, and

244 Previously, there had been literally *no rules at all* requiring security for plutonium or HEU in private hands. The philosophy was that the commercial value of the material would motivate companies to provide security for it in their own financial self-interest—ignoring the fact that the potential danger to society from a loss of such material was many orders of magnitude larger than the potential financial loss to the company. See, for example, U.S. Nuclear Regulatory Commission, *Rulemaking for Enhanced Security of Special Nuclear Material: Regulatory Basis Document*, 3150-AJ41 (Rockville, MD: NRC, 2015), http://pbadupws.nrc.gov/docs/ML1432/ML14321A007.pdf (accessed February 9, 2016), pp. 3–4. For an overview of the history of U.S. nuclear security policy and concerns about nuclear terrorism, see Matthew Bunn, "Beyond Crises: The Unending Challenge of Controlling Nuclear Weapons and Materials," in Henry D. Sokolski and Bruno Tertrais, ed., *Nuclear Weapons Security Crises: What Does History Teach?* (Carlisle, PA: U.S. Army Strategic Studies Institute, 2013).

245 Walter Laqueur, *The Age of Terrorism* (Boston: Little, Brown and Company), p. 270.

246 Laqueur, *The Age of Terrorism,* p. 314.

247 Ralph E. Lapp, "The Ultimate Blackmail," *New York Times Magazine*, February 4, 1973, p. 29; Jeffrey T. Richelson, *Defusing Armageddon: Inside NEST, America's Secret Nuclear Bomb Squad* (New York: W. W. Norton and Company, 2009), pp. 25–26.

248 Richelson, *Defusing Armageddon,* p. 25.

designated Sandia National Laboratory as the lead lab to develop new approaches to securing potential nuclear bomb material. Both Congress and the media became concerned, particularly given the projection that the United States would soon be operating scores or hundreds of plutonium-fueled reactors, requiring an industry in which tens of thousands of people would have direct access to plutonium.[249]

Concern about nuclear terrorism also broadened from Americans worried about Soviet attacks to a warning by the Soviet Union that independent actors might strike. In 1972 at the United Nations, a Soviet Foreign Ministry legal expert, Dmitri N. Kolesnik, debated a Saudi counterpart who had ridiculed the threat from terrorists, comparing them to the merry men of Sherwood Forest. Kolesnik argued, "Robin Hood was armed with bows and arrows, but modern terrorists prefer to have rifles and bombs, and tomorrow it's quite possible they will have death-carrying germs or maybe stolen atomic bombs. And with the help of these bombs, they can blackmail any government."[250]

Even before Kolesnik made his dramatic appeal, a U.S. AEC staffer addressed a symposium on preventing nuclear theft and offered the following scenario: a terrorist could send a note to the mayor of New York saying, "I've got two bird cages [specialized shipping containers] of plutonium and if you don't release all your prisoners and leave Vietnam, I'll blow up New York City."[251]

After positing that scenario in a 1973 *New York Times Magazine* article, Ralph Lapp, himself a nuclear physicist and Manhattan Project veteran, disclosed that, "I have visited one nuclear site, which will go unnamed, where I have concluded that a small force of armed men could in the future easily overpower unarmed guards and, with a little inside help, spirit away 100 pounds of plutonium without exposure to lethal radioactivity."[252] Lapp then detailed how a terrorist band he called "Group X" could plausibly fabricate a weapon from stolen plutonium.[253]

Theodore B. Taylor, one of the leading U.S. nuclear weapons designers, had been raising similar concerns both within the AEC and in public since the 1960s. But in December 1973, *The New Yorker* published an alarming series of articles by journalist John McPhee

249 See discussion in Bunn, "Beyond Crises."

250 Lapp, "The Ultimate Blackmail," p. 13.

251 Lapp, "The Ultimate Blackmail," p. 29.

252 Lapp, "The Ultimate Blackmail," p. 31.

253 Lapp, "The Ultimate Blackmail," pp. 31–32.

outlining the danger of nuclear terrorism, based on interviews with Taylor. These articles were later published as a book: *The Curve of Binding Energy: A Journey into the Awesome and Alarming World of Theodore B. Taylor.* In one scene that later seemed nearly prophetic, McPhee and Taylor sat at what was then the construction site for the towers of the World Trade Center while Taylor described how terrorists could make a crude nuclear bomb to kill everyone in them.[254]

Such concerns, coupled with relentless Congressional investigations—which revealed, among other things, walls protecting weapons-usable nuclear material areas so thin investigators cut them with a tin snip—led to a series of steps to further strengthen U.S. nuclear security regulations.[255] But there were others who thought the concern was overblown. In 1975, Brian Jenkins, a terrorism expert at the RAND Corporation, authored a short paper titled "Will Terrorists Go Nuclear?" While warning that his views were highly speculative and might be "dead wrong," Jenkins argued that terrorists "may try to take advantage of the fear that the word 'nuclear' generates without taking the risks or making the investment necessary to steal plutonium and build a working bomb. . . . While we cannot rule out the possibility of a 'large-scale Lod,' or holding a city for ransom with a nuclear weapon, the detonation of a nuclear bomb appears to be the least likely terrorist threat."[256] His conclusion was based on the premise that "Mass casualties simply may not serve the terrorists' goals and could alienate the population. You don't poison the city's water supply in the name of the popular front."[257] (Jenkins had previously coined the often-used aphorism that "terrorists want a lot of people watching, not a lot of people dead.")

Jenkins' analysis proved highly influential. In 1977, the U.S. Office of Technology Assessment, drawing on the advice of a distinguished advisory panel and acknowledging assistance from RAND, concluded, "On the basis of the historical record and the theory of terrorism, it is not clear that causing massive casualties is attractive to terrorists; indeed it could even be regarded

254 John McPhee, *The Curve of Binding Energy: A Journey into the Awesome and Alarming World of Theodore B. Taylor* (New York: Farrar, Strauss, and Giroux, 1974).

255 For a photo of the wall being cut with a tin snip, see U.S. Congress, General Accounting Office, *Improvements Needed in the Program for the Protection of Special Nuclear Material* (Washington, D.C.: GAO, November 7, 1973), http://www.gao.gov/assets/200/198750.pdf (accessed July 6, 2015), p. 18.

256 Jenkins' "large-scale Lod" refers to the May 1972 terrorist attack on what was then Israel's Lod airport (now Ben Gurion airport), where 26 people were killed and some 80 injured. See Brian Jenkins, "Will Terrorists Go Nuclear?" (Santa Monica: The Rand Corporation, 1975), https://www.rand.org/content/dam/rand/pubs/papers/2006/P5541.pdf (accessed December 30, 2015), p. 6.

257 Jenkins, "Will Terrorists Go Nuclear?" p. 5.

as counterproductive."[258] This conclusion was hedged by the caution that, "Nihilist groups may emerge."[259]

At the same time, however, the study warned that the job of making a crude terrorist nuclear bomb was not as difficult as it was often made to seem:

> 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.[260]

In late 1985, the International Task Force on Prevention of Nuclear Terrorism convened 150 experts from 13 countries in Washington, and two years later published a report and background papers assessing terrorist motivations and capabilities, as well as measures that might be taken to defeat the threat.[261] The Task Force concluded that the probability of nuclear terrorism was "increasing . . . because of a confluence of factors:

- The growing incidence, sophistication, and lethality of conventional forms of terrorism, often to increase shock value.
- Apparent evidence of state support, even sponsorship, of terrorist groups.
- The storing and deploying of nuclear weapons in areas of intense terrorist activity.
- An increasing number of potential targets in civil nuclear programs—in particular facilities and shipments in which plutonium and uranium, in forms suitable for use in weapons, are present.
- Potential black and gray markets in nuclear equipment and materials."[262]

By 1986, both Jenkins' thesis that terrorists probably would not want to detonate a nuclear bomb and the conclusion that they might well have the technical capacity to do so if they got enough of the right kinds of nuclear material were accepted as the consensus view of the U.S. intelligence community. Elaborating on and largely consistent with an earlier

258 U.S. Congress, Office of Technology Assessment, *Nuclear Proliferation and Safeguards* (Washington, D.C.: OTA, June, 1977), pp. 26–27.

259 OTA, *Nuclear Proliferation and Safeguards,* p. 27.

260 OTA, *Nuclear Proliferation and Safeguards,* p. 140.

261 Paul Leventhal and Yonah Alexander, *Preventing Nuclear Terrorism* (Lexington, MA: Lexington Books, 1987), pp. x–xv.

262 Leventhal and Alexander, *Preventing Nuclear Terrorism,* p. 8.

Special NIE in 1978 and Memorandums to Holders in 1982, the 1986 National Intelligence Estimate found that:

- "High level terrorism [e.g., detonation of a nuclear device] may be within the capabilities of a few terrorist groups. The constraints that exist against it, therefore, probably are behavioral."
- "Most important, the fact that most terrorists place a high premium on the political consequences of their actions probably helps dissuade them from threatening terrorist acts that could lead to mass, indiscriminate casualties, because such a threat would alienate even those that they consider to be sympathizers among the affected public."[263]

For a decade and a half, this judgment held. In the best available, highly classified analyses used by the U.S. government, sophisticated terrorist groups were assessed to be capable of detonating a nuclear explosion if they were able to steal a weapon or sufficient nuclear material, but were also judged to be unlikely to do so, because it would defeat their political objectives.

Aum Shinrikyo and al Qaeda Change the Picture

By the late 1990s, U.S. government confidence that terrorists would restrain themselves from nuclear mass casualty attacks was dissipating. Aum Shinrikyo's nerve gas attack in the Tokyo subways in 1995 made clear that some terrorist groups *were* seeking to kill as many people as possible, and subsequent investigations made clear that Aum had actively pursued nuclear weapons.[264] Moreover, a new terrorist group was rising that called itself al Qaeda and appeared to be bent on committing mass casualty attacks against the United States and its allies.

Michael Scheuer, then head of the CIA team focused on bin Laden, reports that in 1996, "CIA's Bin Laden unit acquired detailed information about the careful, professional manner in which al-Qaeda was seeking to acquire nuclear weapons." He continued: "There could be no doubt after this date that al-Qaeda was in deadly earnest in seeking

263 *The Likelihood of Nuclear Acts by Terrorist Groups,* National Intelligence Estimate NIE 6-86 (Washington, D.C.: Central Intelligence Agency, April 1986), p. 1.

264 See, for example, 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, CA: RAND, 2005), http://www.rand.org/pubs/documented_briefings/2005/RAND_DB458.sum.pdf (accessed February 9, 2016).

nuclear weapons."[265] In January 1997, the CIA's Counterterrorist Center distributed a Top Secret commentary, "Terrorism: Usama Bin Ladin Trying to Develop WMD Capability?" The declassified version released to the public is heavily redacted, but refers to an "effort by Bin Ladin's agents in 1994 to purchase uranium." The memorandum also warns that, "Bin Ladin's stated intention to undertake hostile acts against the US presence in the Persian Gulf region—based as it is on an implacable antipathy toward the United States—could be abetted strongly by access to WMD material."[266] Importantly, the CIA assessed that al Qaeda was unbound by the political restraints against using nuclear weapons ascribed to earlier terrorist groups.[267]

Two years later, bin Laden would declare a "religious duty" to acquire weapons of mass destruction in an interview with *Time* magazine,[268] which followed an earlier fatwa urging his followers to kill Americans and their allies wherever they could be found, civilians and military alike.[269] That al Qaeda was seeking to cause such devastation to the United States and its friends and allies would remain largely unknown to the public until September 11, 2001, when nineteen men armed with box cutters killed almost 3,000 people.

That act, together with the horrific attack on a Russian school in Beslan in 2004, which killed nearly 400 children and parents, left no doubt that the rules had changed. The world had entered an age of mass casualty terrorism, in which certain groups sought to inflict maximum possible carnage to achieve their ends. Moreover, they were willing to commit suicide to do so. Were this motivation to be fused with a nuclear weapons capability, the results would be even more dire.

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265 Excerpts of the letter are reprinted in Anonymous [Michael Scheuer], *Through Our Enemies' Eyes: Osama bin Laden, Radical Islam, and the Future of America* (Washington, D.C.: Potomac Books, Inc., 2002). It is worth noting, however, that in his first book, Scheuer appears to take at face value a number of reports from this period that have since been called into question, including alleged al Qaeda cooperation with Iraqi intelligence on weapons of mass destruction. See Anonymous [Michael Scheuer], *Through Our Enemies' Eyes*, pp. 124–125, 189–193.

266 *Terrorism: Usama Bin Ladin Trying to Develop WMD Capability?* Counterterrorism Center Commentary, Central Intelligence Agency, January 6, 1997, pp. 2–3.

267 Unfortunately, this conclusion did not provoke a major effort to defeat the threat until after the 9/11 attacks. According to Rolf Mowatt-Larssen, "We were playing [a] frantic game of catch-up after 9/11 to find clues of activity that occurred years before 9/11. Had 9/11 not occurred, we would never have organized ourselves to go hunting for WMD terrorism programs; never have had the leadership attention and resources committed to the subject; and would never have had the means [provided by the aggressive response to 9/11]." Personal communication, January 2016.

268 Rahimullah Yusufzai, "Conversations with Terror," *Time,* January 11, 1999.

269 Rolf Mowatt-Larssen, *Al Qaeda Weapons of Mass Destruction Threat: Hype or Reality* (Cambridge, MA: Belfer Center for Science and International Affairs, January 2010), http://belfercenter.ksg.harvard.edu/files/al-qaeda-wmd-threat.pdf (accessed February 9, 2016), p. 13.

Post-9/11 Assessments

After the 9/11 attacks, U.S. intelligence focused intensely on al Qaeda's nuclear, chemical, and biological efforts. As noted in the main text, by October 2001, the U.S. intelligence community was assessing that making a crude nuclear bomb was "well within" al Qaeda's capabilities if it could obtain the needed nuclear material—separated plutonium or HEU.[270] In November, the CIA's Weapons Intelligence, Nonproliferation, and Arms Control Center and its Counterterrorist Center judged, in the words of a bipartisan commission that reviewed the intelligence, that al Qaeda "probably had access to nuclear expertise and facilities and that there was a real possibility of the group developing a crude nuclear device."[271]

Given these frightening conclusions—and similar fears about al Qaeda's biological and chemical efforts—the CIA established a team, led by long-time CIA officer Rolf Mowatt-Larssen, that focused specifically on learning everything possible about what al Qaeda had done in these fields. Following up on items seized in Afghanistan and other leads, this team made a series of alarming discoveries, as discussed in the main text, from senior Pakistani nuclear scientists working to help al Qaeda to conventional explosives tests for the nuclear program in the Afghan desert. The bipartisan commission that reviewed U.S. intelligence on weapons of mass destruction after the Iraq fiasco concluded that these new discoveries after the overthrow of the Taliban "brought to light detailed and revealing information about the direction and progress of al-Qa'ida's radiological and nuclear ambitions," which had not been available when the earlier judgments were made. The commission reported that U.S. intelligence analysts concluded that al Qaeda in Afghanistan had made "meaningful progress on its nuclear agenda."[272]

Al Qaeda's nuclear ambitions did not end with the loss of their Afghan sanctuary. Beginning in late 2002, U.S. intelligence detected efforts by al Qaeda's cell in Saudi Arabia to purchase three objects it believed were Russian nuclear bombs. The cell reportedly received instructions from al Qaeda leaders under loose house arrest in Iran—including Sayf al-Adl, recently released from Iran, and Abdel Aziz al-Masri, al Qaeda's nuclear chief,

270 Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction, *Report to the President* (Washington, D.C.: WMD Commission, 2005), http://www.gpo.gov/fdsys/pkg/GPO-WMD/pdf/GPO-WMD.pdf (accessed February 9, 2016), pp. 272, 277.

271 Commission on U.S. WMD Intelligence Capabilities, *Report to the President*, p. 271.

272 Commission on U.S. WMD Intelligence Capabilities, *Report to the President*, pp. 267, 271, 292.

whose whereabouts today are unknown—to go ahead and make the purchase, if the Pakistani expert with his equipment confirmed the items were authentic. As far as the authors are aware, U.S. intelligence has never managed to identify the Pakistani expert in whom al Qaeda had such confidence; he remains at large. At the same time, al Qaeda commissioned a fatwa, or religious ruling, from a radical Saudi cleric—Nasir bin Hamad al-Fahd, the "constant companion" of Abu Bakr, the cell leader negotiating to buy the weapons—authorizing the use of nuclear weapons against American civilians. Saudi Arabia moved to disrupt the Saudi cell, arresting both the cell leader and al-Fahd.[273]

Since then, as noted in the main text, core al Qaeda has suffered serious blows, and the IS has risen to the forefront of the violent jihadist movement. What impact this will have on the evolving threat of nuclear terrorism remains unknown.

273 For accounts of this episode, see Tenet, *At the Center of the Storm*, p. 272; Mowatt-Larssen, *Al Qaeda WMD Threat*, pp. 22, 26–27.

About the Project on Managing the Atom

The Project on Managing the Atom (MTA) is the Harvard Kennedy School's principal research group on nuclear policy issues. Established in 1996, the purpose of the MTA project is to provide leadership in advancing policy-relevant ideas and analysis for reducing the risks from nuclear and radiological terrorism; stopping nuclear proliferation and reducing nuclear arsenals; lowering the barriers to safe, secure, and peaceful nuclear energy use; and addressing the connections among these problems. Through its fellows program, the MTA project also helps to prepare the next generation of leaders for work on nuclear policy problems. The MTA project provides its research, analysis, and commentary to policy makers, scholars, journalists, and the public.

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