Threat Perceptions and Drivers of Change in Nuclear Security Around the World: Results of a Survey

The Project on Managing the Atom

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HARVARD Kennedy School
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Cover Photo
Casks containing highly enriched uranium being loaded into shipping containers at the Nuclear Research Institute in Rez, Czech Republic, March 22, 2013. (Photo: US Department of Energy, NNSA)

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Abstract

Leaders at the 2010 nuclear security summit agreed on the goal of securing all vulnerable nuclear material in four years. This goal implied that many countries would change their nuclear security policies. But the factors that drive changes in nuclear security policies, and that constrain those changes, are not well understood. We conducted a survey of selected nuclear security experts in countries with nuclear weapons, highly enriched uranium (HEU), or separated plutonium, to explore this issue. The survey included: (a) perceptions of which threats are credible; (b) approaches to nuclear security based on a design basis threat (DBT); (c) changes in nuclear security policy in the last 15 years; (d) factors causing and constraining changes in nuclear security policy; and (e) policy on how much information to release about nuclear security. This paper describes the survey, its results, and implications for next steps to strengthen global nuclear security.

Introduction

In April 2009, President Obama warned that terrorists were trying to get nuclear weapons or the materials needed to make them, a danger he called "the most immediate and extreme threat to global security."[1] In response, he called for the international community to join in an effort "to secure all vulnerable nuclear material around the world in four years." This four-year effort was endorsed unanimously by the UN Security Council in Resolution 1887 and by nuclear security summits in Washington in April 2010 and Seoul in March 2012.[2]

A global effort to improve nuclear security requires convincing many countries to strengthen their nuclear security practices.[3] But no one really knows what factors convince countries to make such changes. We undertook a survey of nuclear security experts in countries with weapons-usable nuclear material to examine whether countries have made significant changes in their nuclear security and accounting practices in the past 15 years, and what the major drivers of change and the major constraints on change have been. Our survey had three goals: (1) to explore perceptions in different countries of what threats are credible and must be taken into account in nuclear security planning; (2) to learn what nuclear security changes countries have made in the last 15 years; and (3) to identity what has caused, and what has constrained, changes in nuclear security arrangements in the last 15 years.

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

[2] "Resolution 1887" (New York: UN, 2009); http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N09/523/74/PDF/N0952374.pdf; "Communiqué of the Washington Nuclear Security Summit" (Washington D.C.: The White House, Office of the Press Secretary April 13, 2010); http://www.whitehouse.gov/the-press-office/communiqu-washington-nuclear-security-summit; "Seoul Communiqué: 2012 Seoul Nuclear Security Summit" (Seoul: Ministry of Foreign Affairs, Republic of Korea, March 27, 2012); http://www.thenuclearsecuritysummit.org/userfiles/Seoul%20Communique_FINAL.pdf.

[3] By "nuclear security," in this context, we mean the complex of measures intended to ensure that nuclear material is not stolen from nuclear facilities or transports, including physical protection measures; material control and accounting; steps to limit access to nuclear material to small numbers of people who have been determined to be trustworthy; and police and other measures to respond to prevent and respond to potential theft attempts.

In this paper, we outline the methodology we used, summarize the results, provide some analysis of those results, and draw conclusions for policy. Appendix A provides the full text of each question on the survey, with the detailed results for each. Appendix B offers a discussion of the variation in views between experts within countries.

Methodology

We conducted a survey of nuclear security experts in countries where nuclear weapons or significant amounts of weapons-usable nuclear material exist. Because the specifics of nuclear security arrangements are generally considered secret or sensitive, the survey did not focus on what nuclear security measures are in place today, but on what kinds of changes have been made in recent years, and the key factors that led to or constrained those changes. The survey was designed to cover only non-sensitive information, but since judgments as to what is sensitive vary from country to country and person to person, each question offered an explicit option of declining to answer because the information was too sensitive (somewhat to our surprise, respondents used this option very rarely.) We discussed early drafts of the survey with experts from several countries, and made substantial changes in response to their suggestions.

The survey included sections exploring (a) perceptions of the adversary threat that nuclear security systems must protect against; (b) general security requirements and procedures for establishing them; (c) changes that countries have made in their nuclear security requirements and practices in the last 15 years; (d) factors that have caused or constrained these changes; (e) steps to consolidate nuclear material to fewer locations; (f) information that states make available to the public or to other states about their nuclear security practices; and (g) participation in international nuclear security cooperation. Some

Table 1: Survey Participation and Non-Participation

NPT Nuclear Weapon States	
United States	Y (2)
Russia	Y (3)
United Kingdom	Y
France	Y
China	Y
Non-NPT States	
India	Y
Pakistan	Y
Israel	N
N. Korea	N
NPT Non-Nuclear Weapon States with Category I Material	
Argentina	Y
Belarus	N
Belgium	Y
Canada	Y
Czech Republic	Y
Germany	Y
Hungary	Y
Iran	N
Italy	N
Japan	Y
Kazakhstan	Y
Netherlands	Y
Poland	N
South Africa	N
Switzerland	N
Uzbekistan	N
Vietnam	N
Additional Participating States with Category II Material	
Australia	Y
Norway	Y

respondents provided written answers, while others responded orally (in person or by telephone or video chat).

We approached nuclear security experts in all 26 of the countries that possessed either nuclear weapons or enough weapons-usable nuclear material to require the highest standards of security under international guidelines (so-called "Category I" material) as of the time of the survey.[4] We received responses from 16 of these countries, and from two countries with a few kilograms of HEU, below the "Category I" threshold (Norway and Australia). The responses we received covered all of the nuclear Non-Proliferation Treaty (NPT) recognized nuclear weapon states; all of the other states with two tons or more of weapons-usable nuclear material; and a selection of non-nuclear-weapon states with smaller quantities of nuclear material. Participating countries included both developed and developing states. All but a few non-participants were countries with only a single site with a modest stock of HEU. Non-participants with particularly significant stocks of weapons-usable nuclear material included the two states with the most secretive nuclear weapons programs (Israel and North Korea), along with Belarus and South Africa. See Table 1.

We chose participants based on their expertise in nuclear security in their country. This was determined based on reviews of published papers and reports in which they participated, consultations with nuclear security experts in other countries who had worked with them, and recommendations from other nuclear officials and experts within their own countries. Most respondents were either involved in managing security at a site with HEU or separated plutonium or managers at national regulatory agencies focused on nuclear security. A few were recently retired. We promised respondents anonymity, to allow them to be candid when discussing the nuclear security situation in their countries. We conducted the survey during 2012.

In general, we sought one expert response from each country. But to explore the degree of consistency among expert judgments on the topics covered in our survey, we surveyed two experts for the United States and three for Russia; these are the two countries with the largest stocks of nuclear weapons and weapons-usable material and the largest number of different buildings or bunkers where such items exist.[5]

In the US case, the two experts had identical judgments on the overall magnitude of recent security changes, and identical or similar judgments on the importance of all but a few of the causes of, and constraints on, changes in nuclear security. The two US experts also had generally similar judgments on the credibility of different threats, and on many other matters covered in the survey. Converting the answers to a 0-4 scale, the most common difference between the two US experts was zero (identical answers), and the next most common was one, but there were a few cases of differences in the 3-4 range (the maximum possible disagreement).

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[4] The Convention on Physical Protection of Nuclear Materials and IAEA recommendations specify that any stock of material that contains 5 kilograms or more of U-235 in HEU, or 2 kilograms or more of plutonium separated from fission products, should be considered "Category I," requiring the highest level of security. See International Atomic Energy Agency, *Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities*, INFCIRC/225/Rev.5 (Vienna: IAEA, 2011); http://www-pub.iaea.org/MTCD/publications/PDF/Pub1481_web.pdf. Since the time of our survey, the Czech Republic eliminated the last of the HEU on its territory.

[5] See Matthew Bunn and Eben Harrell, *Consolidation: Thwarting Nuclear Theft* (Cambridge, Mass.: Project on Managing the Atom, Harvard University, March, 2012); http://www.nuclearsummit.org/files/Consolidation_Thwarting_Nuclear_Theft.pdf. One of the US participants had substantial experience at both the US Nuclear Regulatory Commission and the US Department of Energy, and provided separate answers for each agency. Thus the results in Appendix A include three sets of responses for the United States.

There was more difference of view among the three Russian experts. For them, the most common difference was one, not zero. In both cases, there were at least some points (including the importance of some of the causes or constraints on change) where the different experts discussing the same changes in the same country drew significantly different conclusions. (See Appendix B for more detail on the differences between the experts' responses for the United States and Russia.)

Tracing the causes of policy changes is one of the most difficult problems in social science, and the credibility of different threats is uncertain and often debated; thus, some variation in judgment among these experts is not surprising. Had we asked other experts in each country, we would likely have received answers that were broadly similar on the majority of points, but differed in some specifics. Judgments in the survey about the relative importance of different causes and constraints on change, and the relative credibility of different types of threats are likely to be more reliable when averaged across all the experts participating in the survey than they are in representing the common view of nuclear security experts in any particular country.

We believe selection bias resulting from some countries not participating is likely to be limited. As noted above, the countries that did respond included a majority of those with Category I quantities of weapons-usable nuclear material, and all of those with especially large quantities. Several respondents were from developing countries, though developing countries (and particularly developing non-nuclear-weapon states) are under-represented in our overall sample. Our sample is somewhat over-represented by countries that have participated actively in international nuclear security cooperation, as such cooperation leads to personal relationships with the authors that increased the probability of a response to our survey. One element of bias that is likely to be significant is that experts from countries that had made significant progress in nuclear security were probably more likely to participate in our survey than countries that had not; hence, progress in nuclear security may not be as nearly universal as our survey suggests.

Results

Threat Perceptions

Experts from all responding countries indicated that their countries had processes in place to assess the threats to nuclear facilities and to regularly update these assessments. Indeed, they all reported that their countries used a regulatory approach based on defining a set of adversary capabilities and tactics that nuclear operators are required to protect against, known as the "design basis threat" (DBT).

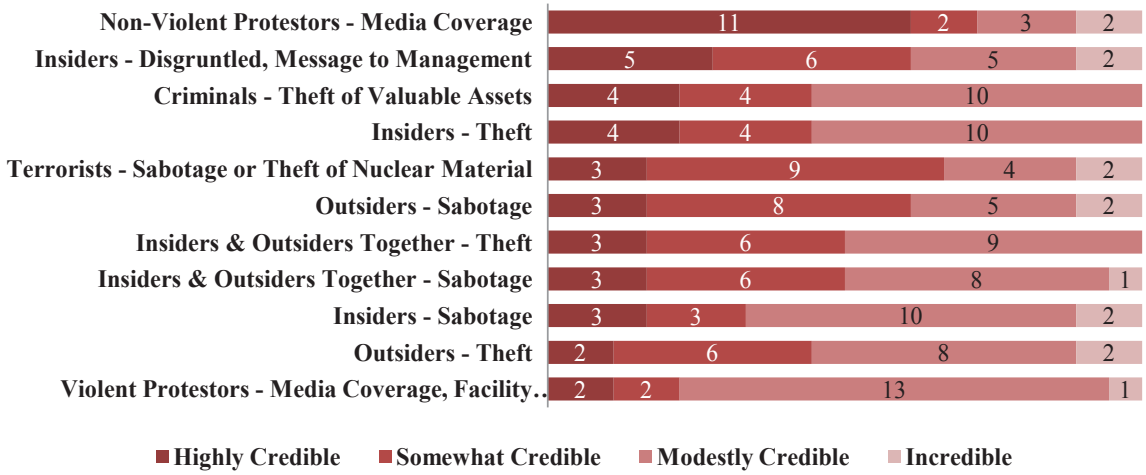
The survey provided a summary of the information that has been openly published on the DBT established by the US Nuclear Regulatory Commission (NRC) and asked if the DBT in the respondent's country was more capable; generally comparable; less capable; or different in important respects, but neither more nor less capable overall. In general, nearly all respondents indicated that they believed their country's DBT for Category I nuclear material facilities was comparable to that of the US NRC.[6] Five respondents (two from Russia and experts from Pakistan, France, and the US Department of Energy) argued that their DBTs were more stringent than the NRC's; three

[6] We expected that this question would be particularly sensitive, and that many respondents might choose not to answer it. Only two of them did so.

respondents (from Canada, Argentina, and Kazakhstan) chose the option of different in important respects; only one (Australia, which has only Category II material) indicated that its DBT was less capable than the NRC's.[7]

There was, however, considerable divergence of views on which adversary capabilities and tactics were most credible and should be the focus of concern in designing nuclear security systems. We asked respondents to rate a wide range of potential adversary characteristics as "incredible," "modestly credible," "somewhat credible," or "highly credible." Figure 1 (below) summarizes the experts' views of the credibility of types of adversaries and objectives ranging from nonviolent protesters to armed outside attackers.

Figure 1: Credibility of Different Types of Adversaries and Objectives



Note: the numbers inside the bars represent the number of countries whose experts gave potential adversaries that credibility rating. In order to avoid giving the United States and Russia undue influence on the results, the answers from the US experts and from the Russian experts were averaged to provide one answer from each country. Resulting intermediate answers were rounded to the nearest integer.

The experts judged non-violent protestors to be the most credible threat, but a significant number saw sabotage and theft threats by both outsiders and insiders as credible as well.

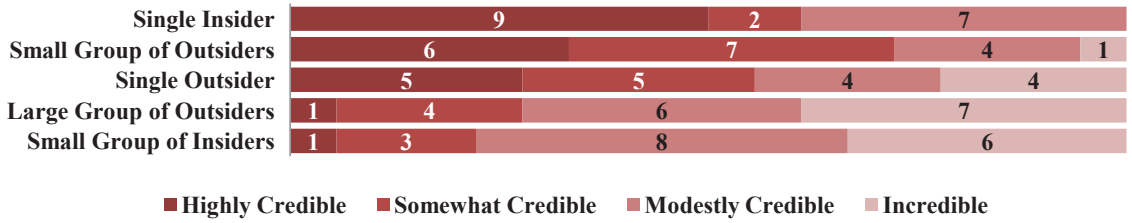
Most respondents found the possibility of adversaries using stealth, deception, and armed attack each to be either somewhat credible or highly credible, though for each of these tactics there were exceptions who saw these threats as not credible. Most respondents saw a single insider as a somewhat or highly credible threat, but viewed a group of insiders working together as either not credible or only modestly credible.

The credibility of an outsider threat based on only a single individual provoked one of the widest divergences of opinion in the survey, with many rating this as highly credible and four (the Pakistani, Belgian and French experts and one of the Russian experts) considering it not credible at all, with the other experts between these extremes. Based on conversations with respondents,

[7] In fact, under NRC regulations, operators do not have to protect Category II material against any DBT at all, so Australia's rules, calling for protection against a DBT less capable than the NRC DBT for Category I material, are more stringent than the NRC rules, not less.

this divergence (and some of the other variation in this part of the survey) appears to be based on different views of the meaning of credibility. Many of those who rate this threat as incredible were saying, in essence, that their nuclear sites' security is good enough that a single outsider would pose no credible threat of being able to carry out theft or sabotage. Those rating this threat as highly credible were saying, in essence, that many of the adversary actions that take place in society (shootings, bombings, etc.) are perpetrated by lone individuals, so it should be expected that lone individuals might attack nuclear facilities as well. There was greater consensus on the credibility of a small group of outsiders, a threat rated by most as either somewhat or highly credible (with the curious exception of Russia, where one respondent dismissed this threat as not credible at all). Figure 2 (below) summarizes the experts' range of views on the credibility of different adversary groupings.

Figure 2: Size of Adversary Groups



Note: the numbers inside the bars represent the number of countries whose experts gave potential adversaries that credibility rating. In order to avoid giving the United States and Russia undue influence on the results, the answers from the U.S. experts and from the Russian experts were averaged to provide one answer from each country. Resulting intermediate answers were rounded to the nearest integer.

The experts judged threats from a single insider or a small group of outsiders to be much more credible than threats from insider conspiracies or large groups of outside attackers.

The possibility that outsiders might have insider knowledge of the facility and its security system provoked another divergence of opinion. Nearly half of the respondents rated this threat as highly credible – among the items receiving the largest number of highly credible ratings – but the others largely rated it as only modestly credible. There were similarly strong divergences of opinion on the credibility that adversaries would use explosives to, for instance, blow through barriers or security doors or that they would have the capability to hack into a security system's computers to disrupt the defenses.

With respect to weaponry, there was near-consensus that adversaries might have automatic weapons, but another wide gap of opinion on rocket-propelled grenades, with several respondents rating these as either highly or somewhat credible, and most others dismissing them as not credible. There was near-consensus that adversaries would be capable of using four-wheeled vehicles, but many respondents doubted that they would use helicopters or other forms of aerial attack. Attacks using boats also provoked varying views, with many respondents seeing this as highly credible, and others dismissing it entirely.

In general, as might be expected, participants from countries with recent experience of highly capable terrorist attacks saw a wider range of threats as being credible than did participants from countries with little recent terrorist experience. The respondents from Hungary and Kazakhstan in particular were striking in their lack of concern, believing that almost all of the potential adversary capabilities were either incredible or only modestly credible.

Recent Changes, Causes, and Constraints

Nuclear security appears to be improving across the board. With four exceptions, every expert responding to the survey indicated that nuclear security rules and practices in their country had become "much more stringent" in the last 15 years. (The exceptions, who said their nuclear security approaches had become "modestly more stringent," were the expert from Australia, which eliminated its HEU-fueled reactor during that period, and has only a few kilograms of HEU remaining; the expert from Argentina, which also has a modest stock remaining; one of the Russian experts; and the expert from Kazakhstan.)

In most countries, major incidents are the biggest drivers of nuclear security changes. The 9/11 attacks in the United States in 2001 appear to have been the most important single factor in the nuclear security changes of the last 15 years. All but three respondents rated "incidents in other countries" as either a three or a four on a 0-4 scale (primarily four), with zero being "not important at all" as a cause of the changes, and four being "the dominant cause" of the changes. The exceptions were the Indian expert (who reported that 9/11 did not change Indian thinking, as sophisticated terrorist attacks occurred in India before 2001); the expert from Argentina; and the expert from Kazakhstan. (Note that Argentina and Kazakhstan were among the countries whose experts reported that nuclear security rules had become only modestly more stringent.) Respondents frequently mentioned the 9/11 attacks as an important cause of their countries' nuclear security changes.

Incidents within respondents' own countries were the next most important cause of nuclear security changes. Respondents mentioned various types of terrorist or criminal incidents in their countries as having contributed to changing perceptions of the threats that must be defended against. Experts' ratings for the importance of internal incidents covered a broader range, however. Experts from the United States, Pakistan, India, and China each rated domestic incidents as the dominant cause of nuclear security changes in their countries, while respondents from Germany, France, Kazakhstan and Japan argued that incidents within their countries had played no role at all in their recent nuclear security changes.[8]

Beyond security incidents, the next most important sources of change were (a) security reviews at nuclear sites, which in some countries led to the conclusion that existing measures were inadequate and substantial improvements were needed, and (b) recommendations from the International Atomic Energy Agency (IAEA) (which were seen as significantly more important than recommendations from other states). Experts from Russia, Hungary, Germany, and Norway rated results of security reviews as one of the dominant causes of change in nuclear security in their country; several other countries saw them as an important contributor to change; and only one country (Belgium) said such reviews had played no role in the decisions to upgrade nuclear security. Experts from seven countries (the Czech Republic, Hungary, Japan, Kazakhstan, France, Norway, and one of the Russian experts) rated IAEA recommendations as one of the dominant causes of their nuclear security changes, while experts from China, the Netherlands and another Russian expert considered them quite important.

[8] Our Japanese expert argued that the dominant causes of changes in Japan were incidents in other countries (primarily the 9/11 attacks) and IAEA recommendations. The German respondent highlighted incidents in other countries and reviews of security at German facilities as the dominant causes of change.

There were four sources of change that were judged to be of medium importance overall, with mean ratings of 1.6-2 on the 0-4 scale:

- International legal obligations, such as the amendment to the Convention on Physical Protection of Nuclear Materials or UN Security Council Resolution 1540 (rated a four by experts from France, China, the Czech Republic, Kazakhstan, and one of the Russian experts, and a three by the Netherlands and Belgium);
- Technical cooperation or assistance from other states (rated as either three or four by all of the Russian experts; as a four by experts from Hungary and the Czech Republic; and as a three by experts from Canada, China, and Kazakhstan);
- "Other events" that shaped perceptions of adversary capabilities, not listed among the drivers of change we suggested (which received no ratings of four, but was rated three by experts from seven countries, with a variety of particular events specified); and
- Pressure from the legislature, press, or public (which received a rating of four from the Hungarian participant and ratings of three from one US expert and experts from Belgium, Canada, and Pakistan).[9]

Finally, the sources of change that the experts identified as least important (though still significant in some cases) were:

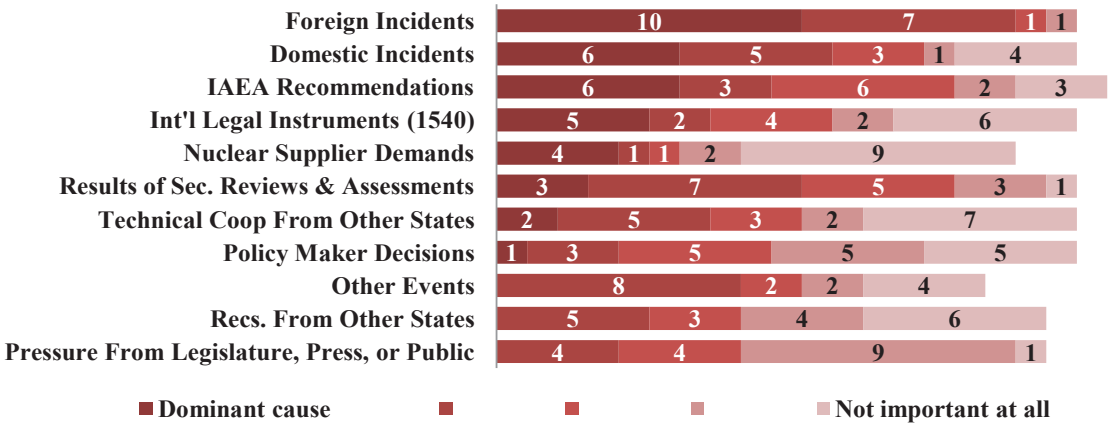
- Decisions reached by individual policymakers for their own reasons (one rating of four, from one of the US experts; three ratings of three; five ratings of two; and the rest zero or one);
- Recommendations from other states (five ratings of three, with most of the rest zero or one);
- Demands from a nuclear supplier (four ratings of four, from France, China, Belgium, and the Czech Republic; one rating of three; one of two; and the rest zero or one).[10]

Figure 3 (opposite) summarizes the data on the different drivers of change in nuclear security policies. The experts identified operator concerns over the costs and impacts of increased security measures as the most important constraint on changes in their countries' nuclear security rules and procedures. Complex decision-making processes were the next most important constraint identified, with one of the US experts, one of the Russian experts, the British expert, the Canadian expert, the French expert, and the Kazakh expert identifying this factor as important. Experts from other countries were distributed roughly evenly between zero, one, and two for this factor. In general, as might be expected, experts from countries with larger nuclear bureaucracies were more likely to identify complex decision-making processes as a key issue. Experts from three countries identified the belief that existing security measures were sufficient as a dominant constraint (ratings of four from Pakistan, Canada, and Germany), while experts from Belgium, China, India, Kazakhstan, Argentina and the United States saw no constraint from this factor at all; other countries typically rated this as a two or a three.

[9] The rating of three on this driver of change from Pakistan is especially surprising; viewed from outside, the legislature, press, and public appear to have very little role in affecting the decisions on nuclear security arrangements made by the Strategic Plans Division, which manages Pakistan's nuclear forces.

[10] There have been incidents since 2001 when the United States pressured both Belgium and France to improve particular elements of physical protection as a condition of further supply, but the high ratings for this driver from China and the Czech Republic are somewhat more mysterious.

Figure 3: Causes of Nuclear Security Changes



Note: the numbers inside the bars represent the number of countries whose experts gave a potential cause of change that importance rating. In order to avoid giving the United States and Russia undue influence on the results, the answers from the U.S. experts and from the Russian experts were averaged to provide one answer from each country. Resulting intermediate answers were rounded to the nearest integer; in a small number of cases where experts offered an assessment equidistant between two points, responses were rounded up (e.g., 2.5 became 3).

Nuclear security changes were most often responses to incidents, but IAEA recommendations and security reviews were also important, and many other drivers had major impacts in at least a few countries.

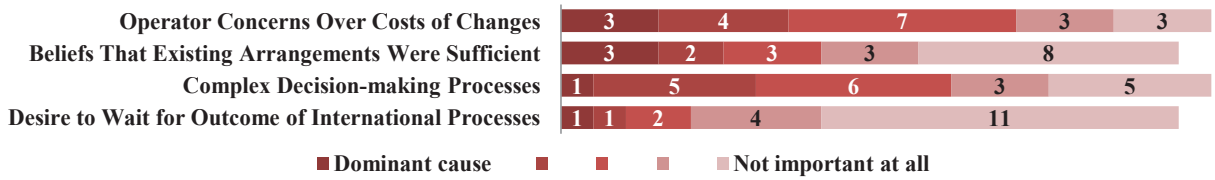
Waiting for the outcome of international processes (such as the latest revision of IAEA security recommendations) was the least important of the constraints we offered as options in the survey. Only one expert (one of the Russian experts) rated this factor as a four, and only one other (representing Hungary) rated it as three, while many put it at zero.

Experts from two countries, Belgium and Australia, identified other factors that had been major constraints on nuclear security changes in their own countrty. In Belgium, the issue was hesitance among the public about arming private security guards at nuclear sites—guns are largely seen as weapons that should only be available to government officials. As a result, Belgian nuclear facilities, like those in several other countries, especially in Europe, do not have on-site armed guards, but rely on off-site armed response in the event of an emergency. In Australia, the constraint was the resources available to the regulator for developing, promulgating, and implementing new nuclear security rules. Figure 4 (pg 10) summarizes the data on the obstacles to changes in nuclear security policies.

What Nuclear Security Measures Countries Changed

Overwhelmingly, the experts reported that their countries had made major changes in the DBT that operators were required to protect against. Two-thirds of our sample rated the changes made in the DBT in their countries as either a three or a four on a 0-4 scale, with four representing "dramatic changes." Only the experts from Belgium and Hungary rated the change in their countries' DBT as one on this scale.

Figure 4: Constraints on Nuclear Security Changes



Note: the numbers inside the bars represent the number of countries whose experts gave a potential constraint on change that importance rating. In order to avoid giving the United States and Russia undue influence on the results, the answers from the U.S. experts and from the Russian experts were averaged to provide one answer from each country. Resulting intermediate answers were rounded to the nearest integer; in a small number of cases where experts offered an assessment equidistant between two points, responses were rounded up (e.g., 2.5 became 3).

Nuclear security changes were most often responses to incidents, but IAEA recommendations and security reviews were also important, and many other drivers had major impacts in at least a few countries.

The experts indicated that the next largest area of change was in the numbers, training, and equipment of guard forces. Experts from five countries (Pakistan, China, the UK, Canada, and one of the US experts) rated these changes as "dramatic" (four), while experts from five more countries gave them a rating of three. There was a broad split on this area of potential change, as experts from most other countries gave this area either a zero or a one.

Other areas of nuclear security saw substantial change in less than half the countries responding, with minor or no change in many of the others. These included:

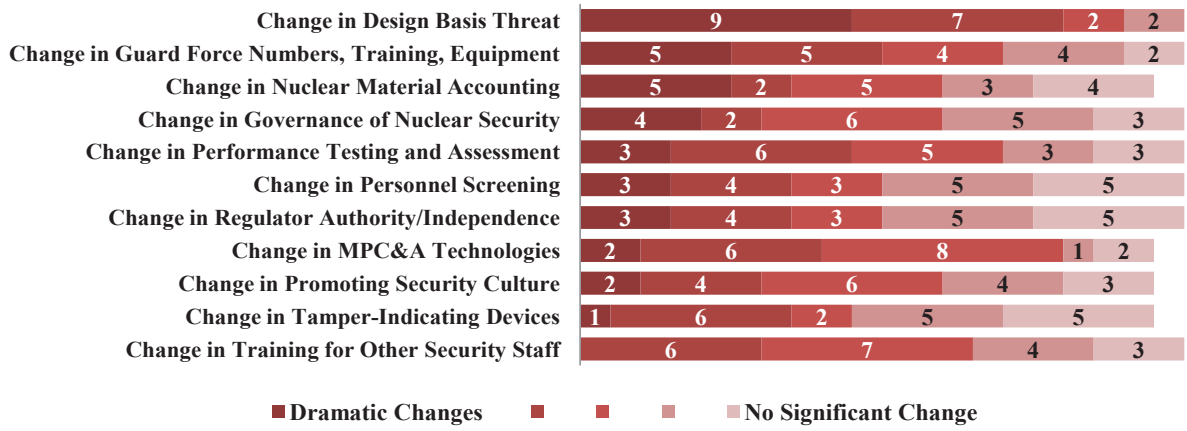
- Requirements for performance testing and assessment. Experts from three countries (Canada, China, and one of the US experts) considered the changes their countries had made dramatic (four), while one of the Russian experts and experts from five other countries rated the changes in this element as three on a 0-4 scale.
- Nuclear material accounting. Here, two of the experts from Russia, one of the US experts, and the experts from Pakistan and China saw their countries' changes in requirements and approaches as dramatic, while ratings from other countries largely ranged from zero to two.
- Use of modern material protection, control, and accounting (MPC&A) technologies. Only the Chinese expert and one of the US experts saw the changes in their country as dramatic (four), but experts from five countries rated changes in this area at three, and experts from eight countries at two.
- Promoting nuclear security culture. Experts from China and Pakistan reported that their countries had made dramatic changes in this area; experts from other countries were spread on this point, with answers ranging from zero to three.
- Governance of nuclear security. Here, experts from China, Canada, France and Pakistan reported dramatic changes, and the U.K. expert and one of the Russian experts rated their countries' changes at three.
- Screening of personnel for trustworthiness. On this point, experts from Pakistan and Canada, along with one of the US experts, reported dramatic changes, and experts from Belgium, France and Russia described their countries' changes as substantial.

- Independence and authority of agencies regulating nuclear security. Here, experts from China, France and the U.K. reported dramatic changes, and experts from Russia, Pakistan, and Canada reported substantial changes.
- Use of tamper-indicating device. On this element, one of the Russian experts reported dramatic changes and experts from Canada, China and Pakistan all reported changes they rated at three. Tamper-indicating devices and regulator independence had the largest number of countries reporting no change at all.

Another approach to strengthening nuclear security, which we asked about separately, is reducing the number of places where nuclear weapons or weapons-usable nuclear material exist, so higher security can be achieved at lower cost by defending fewer locations. Almost half of the respondents reported that their countries had carried out a "substantial reduction" in the number of locations where nuclear weapons, HEU, or separated plutonium were located, and only a few reported no change.

In the United States, the high cost of meeting stringent security and accounting rules for HEU and separated plutonium has motivated nuclear managers to try to eliminate these materials wherever possible; hence, we asked respondents about whether such financial incentives for consolidation existed in their country. Respondents from five countries said their countries' regulations created strong incentives to eliminate material from particular sites, but the remaining experts reported that their countries' regulations either created no significant incentive for consolidation or actually created incentives to maintain the material at a site (the latter reported by experts from Russia, Pakistan, India, Canada, and Australia). As might be expected, countries whose experts reported incentives not to reduce the number of sites with nuclear weapons or weapons-usable materials

Figure 5: What Nuclear Security Measures Changed



Note: the numbers inside the bars represent the number of countries whose experts gave a type of change that magnitude rating. In order to avoid giving the United States and Russia undue influence on the results, the answers from the U.S. experts and from the Russian experts were averaged to provide one answer from each country. Resulting intermediate answers were rounded to the nearest integer; in a small number of cases where experts offered an assessment equidistant between two points, responses were rounded up (e.g., 2.5 became 3).

Almost every participating expert reported major changes in their country's design basis threat (DBT). Experts also reported major changes in a variety of other nuclear security measures.

were heavily represented among the countries that reported no such reduction had occurred - including India, Pakistan, and Canada.

In an effort to judge the overall magnitude of nuclear security changes, we asked experts to estimate the impact of recent changes on the costs of implementing nuclear security. Many of the experts found this a difficult question to answer. Some experts from regulatory agencies, for example, reported that they were not fully aware of the costs their regulations had imposed on licensees; some experts from nuclear sites reported that they were aware of the particular steps that had been taken, but not of their overall impact on costs; and a few experts simply chose not to answer this question. Of the experts who did answer, more than two-thirds, representing six countries, estimated that recent changes had increased the cost of nuclear security in their countries by 20 percent or more; experts from only two countries (Pakistan and Kazakhstan) picked the 5-20 percent increase range; and experts from two more countries (Argentina and the U.K.) reported no significant change (less than 5 percent) in nuclear security costs. No one reported that nuclear security costs had gone down.

Information Made Available to the Public or to Other Countries

Inevitably, important information about nuclear security is kept secret to avoid giving adversaries information about how to overcome defenses. At the same time, publics and the international community want to have grounds for confidence that nuclear security is being implemented effectively, as a nuclear theft or sabotage anywhere could potentially have consequences on the other side of the world. Because of the desire to keep information from adversaries, there are also categories of information that countries are not willing to make public, but may still be willing to exchange with trusted partners.

Our survey documented the wide variation in different countries' approaches to transparency in nuclear security. Experts from five countries reported that they make "substantial" information about their nuclear security practices available to the public, while protecting sensitive information, but experts representing four countries and one of the Russian experts reported that their countries make "little if any" information available to public, given the sensitivity of the issue. Most of the remaining experts reported that their countries published enough general information to give the public "a good general overview" of what their countries do to ensure nuclear operations are effectively protected.

Since the most important information exchanged between countries often comes in the context of various types of visits, our survey explored what types of nuclear security visits different countries had hosted. Experts from nearly all of the countries participating reported that their countries had hosted either a visit from another country (such as a nuclear supplier state) to review nuclear security, or a visit from an IAEA-led security review team such as the International Physical Protection Advisory Service (IPPAS). Pakistan, India, and the United States are notable exceptions.[11]

[11] Two of the experts from Russia and the expert from Germany also reported that their country had not hosted such visits, but this is incorrect in both cases. Russia has hosted a large number of visits by US experts, now including all but a few of the sites where nuclear weapons, HEU, and separated plutonium exist, as part of U.S.-Russian nuclear security cooperation (and has hosted smaller numbers of visits from a number of other countries as well). It is possible that the Russian experts interpreted the question as not including these types of visits. Germany has routinely hosted visits from US experts to review nuclear security in Germany as part of the U.S.-German nuclear cooperation

Participation in Cooperative Nuclear Security Programs

Experts from more than half of the countries participating in the survey reported that their countries had received cooperation or assistance from the IAEA Office of Nuclear Security, from U.S.-funded nuclear security programs, or from nuclear security programs funded by other countries or organizations. All but one of the countries participating in such cooperation took part in U.S.-funded programs; most took part in IAEA efforts; and several took part in other programs. Except for Japan (whose expert reported participating only in U.S.-funded programs) and Argentina (whose expert reported participating only in IAEA-led programs), countries who participated in one of these types of cooperation participated in others as well.

In general, experts were reasonably satisfied with the effectiveness of these programs. Of the eleven countries whose experts reported participating in such programs, experts from five countries described these programs as "highly effective," and five as "moderately effective." Only one expert (from India) considered international cooperation programs only partly effective, and that judgment applied to programs focused on security of radiological sources, as India has not yet participated in programs designed to improve the security of its HEU and separated plutonium.

Analysis

This survey documents several important points about the global effort to improve nuclear security. First, this effort has made substantial progress over the last decade and a half. All but four of the countries participating reported that they had taken steps to make their nuclear security procedures and approaches much more stringent over the last 15 years.

Second, incidents – both within countries and outside their borders – are by far the biggest drivers of changes in nuclear security policies and approaches. The attacks of September 11, 2001 in particular, were the most important incidents driving recent changes in nuclear security. These attacks had several effects. They highlighted the possibility of attack by a highly capable and determined adversary group; they led to the establishment of the IAEA Office of Nuclear Security; and they increased the funding and attention focused on nuclear security from the United States and other donor states. The 9/11 attacks highlighted the following possibilities among adversary characteristics: (a) a large group, capable of operating as multiple teams; (b) willingness to die to accomplish the objective; (c) desire to cause mass destruction; (d) extensive intelligence collection, training, and planning prior to the attack, including acquisition of specialized skills (such as piloting large aircraft); and (e) an ability to prepare in secret for an extended period without detection. Several of these characteristics – especially the willingness to die in the operation – had not previously been taken seriously in many countries' planning for nuclear security. As noted earlier, several respondents mentioned the 9/11 attacks in particular in describing the drivers of change in nuclear security.

Third, policies intended to influence nuclear security decisionmaking can lead to improved nuclear security. While they cannot control when major incidents occur, policymakers can have a major influence over how countries respond to them. Moreover, other factors that are controllable by

agreement. One of the US experts reported incorrectly in the opposite direction, reporting that the United States had hosted an IPPAS mission; the US IPPAS mission did not occur until October 2013, after the survey was completed.

policymakers (such as security reviews) can also be very important in driving changes in nuclear security. It is notable, however, that the desire to comply with international agreements was not among the most important factors contributing to nuclear security changes; this is probably because the existing legal instruments are quite vague, having few specific provisions that would require countries to change their nuclear security arrangements substantially to comply.

Fourth, there has been remarkable progress in convincing countries to adopt approaches based on requiring operators to provide effective protection against a specific set of threats – the concept of the DBT. Experts from every one of the participating countries reported that their country uses some variant of the DBT approach. This is a comparatively recent phenomenon. The IAEA first recommended that countries establish DBTs in 1999, and many countries took some years to do so.[12] In Japan and China, to take just two examples, DBTs were first established in the mid-2000s.[13] Good security requires a specific set of threats that the system must guard against – and regularly adjusting it as the threat environment evolves; such a system makes it possible to base security on performance in defeating a threat rather than soley on compliance with particularly rules (such as high how or how strong fences should be).. As one US expert put it, "if you haven't got a DBT, you haven't got good security."[14] Hence, this apparently widespread adoption of the DBT approach is a positive result.

Fifth, experts from almost all of the participating countries reported that the sets of threats their countries require operators to protect against are comparable to or more capable than the published version of the US NRC's DBT for theft. We saw this, too, as a positive result, indicating a significant international convergence around the idea that wherever nuclear weapons or substantial amounts of the materials needed to make them exist, protection against a significant range of adversary threats is required.[15] In our view, however, readers should not read too much into this result of the survey. In several cases where experts reported DBTs comparable to the NRC's DBT, conversations with the respondents and other available information make clear that the nuclear security measures operators are required to take are nonetheless much less than those the NRC requires operators of Category I facilities to take, making their facilities potentially substantially more vulnerable than those regulated by the NRC. It may be that countries have established DBTs similar to those used in the United States, while having a lower estimate of what is required to defend against such threats.

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[12] International Atomic Energy Agency, *The Physical Protection of Nuclear Material and Nuclear Facilities* INFCIRC/225/Rev.4 (Corrected) (Vienna: IAEA, 1999); http://www.iaea.org/Publications/Documents/Infcircs/1999/infcirc225r4c/rev4_content.html.

[13] In Japan, regulations requiring licensees to defend against a specified DBT were established in 2005. See Nobumasa Sugimoto, "Developing of Design Basis Threat and Current Physical Protection Measures," P*roceedings of the International Regulators Conference on Nuclear Security,* Rockville, Md., December 4-6 (Rockville, Md.: US Nuclear Regulatory Commission, 2012); http://www.nrcsecurityconference.org/slides/Dec4/Japan.pdf. In China, DBT regulations were put in place in 2008, but there is still not a national DBT – each operator develops a DBT for its own sites, which is then reviewed and approved by national regulators. See Hui Zhang, "Approaches to Strengthen China's Nuclear Security," *Proceedings of the 53rd Annual Meeting of the Institute for Nuclear Materials Management,* Orlando, Florida, July 15-19 (Northbrook, Ill.: INMM, 2012); http://belfercenter.hks.harvard.edu/files/ChinaNuclearSecurity-hzhang.pdf.

[14] Personal communication with Byron Gardner, Sandia National Laboratories, February 1995.

[15] 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.

Two issues are of particular note in this respect: armed guards and performance testing. The NRC requires Category I facilities to have both armed guards and a well-armed and well-trained tactical response team intended to be able to fight and defeat the adversaries envisioned in the DBT. At least two of the countries participating in the survey whose experts judged their DBTs comparable to the NRC DBT have a policy of having no armed guards at their nuclear facilities, relying on off-site armed response instead. In US force-on-force tests, in which a mock attack team stages a raid to probe a facility's defenses, events often unfold so quickly that adversaries have reached areas where a plant could be sabotaged or material could be stolen within a few minutes after the test begins, leaving no time for off-site armed response to reach the site and stop the adversaries.

Performance testing is also a key issue. Most countries require at least testing of individual components, such as whether an alarm detects an intruder penetrating a fence, or how long it takes response forces to respond to an alarm. But only a few countries require realistic tests in which a group pretending to be adversaries tries to find and exploit any weak points in the system. These force-on-force exercises have been extremely important in the United States in identifying vulnerabilities, training and motivating guard forces, and convincing policymakers that action to improve security was needed.[16] The most recent revision of the IAEA's core physical protection recommendations, for the first time, call on states to carry out such exercises.[17] Several of the countries whose experts participated in our survey and identified their countries' DBTs as being comparable to NRCs either do not conduct such tests or are just beginning to do so. In the absence of such tests, countries may be more confident in their security systems' ability to defeat intelligent adversaries looking for ways to overcome them than they should be.

Sixth, it was striking that experts from half of the participating countries indicated that nuclear security rules and other policies in their country either created no incentive to reduce the number of locations with HEU or plutonium or positive incentives not to do so. In the United States, by contrast, the high cost of meeting stringent nuclear security rules if HEU or separated plutonium are present creates strong incentives for operators to eliminate these materials wherever possible.

Seventh, some of the experts' views about the credibility of different types of threats seem to us to reveal undue complacency about potential adversary capabilities. Few, for example, thought that multiple insiders working together was a credible threat – yet in thefts from secure non-nuclear facilities, multiple insiders working together is a fairly common occurrence.[18] Many experts did not believe that adversaries using rocket-propelled grenades was a credible threat – yet such weapons are frequently used by terrorists, are available in bazaars all over the world, and are not difficult to smuggle across borders. Similarly, many experts did not believe adversaries using helicopters or light aircraft was a credible threat; yet criminals regularly use helicopters in jail breaks or robberies.

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[16] See, for example, Oleg Bukharin, "Physical Protection Performance Testing: Assessing US NRC Experience," *Journal of Nuclear Materials Management,* Vol. 28, No. 4 (Summer 2000), pp. 21-27. For an interesting discussion of how not to regulate security, and in particular how not to manage such exercises, the Congressional investigation of NRC's security approaches before the 9/11 attacks is instructive. See US Congress, General Accounting Office, *Nuclear Regulatory Commission: Oversight of Security at Commercial Nuclear Power Plants Needs to Be Strengthened,* GAO-03-752 (Washington, D.C.: GAO, September, 2003); http://www.gao.gov/new.items/d03752.pdf.

[17] International Atomic Energy Agency, *INFCIRC/225/Rev.5*.

[18] Bruce Hoffman et al., *Insider Crime: The Threat to Nuclear Facilities and Programs* (Santa Monica, Calif.: RAND, 1990).

Conclusions

Over the past 15 years, countries around the world have taken substantial actions to improve nuclear security, as this survey documents. But there is a great deal left to be done. To reduce the risk of nuclear theft, all countries with nuclear weapons, HEU, or separated plutonium should:

- Require facilities and transporters with nuclear weapons, HEU, or separated plutonium to protect these items against at least (a) a modest group of well-armed and well-trained outsiders; (b) a well-placed insider; and (c) both outsiders and an insider working together, using a broad range of possible tactics. Countries facing more capable adversaries should provide higher levels of protection.
- Require these facilities and transporters to have well-equipped, well-trained professional on-site armed guard forces capable of defeating the DBT.
- 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.
- Put in place effective nuclear security and accounting rules, and give regulators the authority, independence, expertise, and resources to implement them effectively.
- Carry out regular, realistic tests of the performance of nuclear security systems, including force-on-force exercises.
- Ensure that all operators have the resources and plans to sustain effective nuclear security and accounting for the long haul.
- Review each site where nuclear weapons, HEU, or separated plutonium exist and remove these items from any site where the costs and risks of their presence outweigh the continuing benefits.
- Institute programs to assess and improve security culture, and to exchange and learn from best practices. The goal, ultimately, must be a culture of continual improvement and striving for excellence, just as it is in the case of nuclear safety.

Our survey makes clear that states around the world have made a good start in implementing steps such as these. Many are participating in international nuclear security cooperation, which can ease the path to achieving high nuclear security standards and help identify and implement best practices.

The fact that major incidents remain the largest driver of nuclear security changes, however, suggests that too many states continue to take a reactive approach, waiting for an incident to happen before implementing improvements. States should take a proactive approach, actively seeking to find and fix potential vulnerabilities, rather than waiting for "the day after" a disaster. The data in the survey suggest that both internal security reviews and international reviews and recommendations (such as those from the IAEA) are critical tools states can use to find areas where improvements are needed. (Beyond incidents, the experts identified security reviews and IAEA

recommendations as the most important causes of changes in nuclear security arrangements.) This suggests that all countries with HEU, separated plutonium, or nuclear facilities whose sabotage could lead to catastrophic consequences should (a) establish regular processes to review the effectiveness of their nuclear security arrangements at each site, including realistic tests such as force-on-force exercises; and (b) host IAEA-led reviews of their nuclear security arrangements every few years. The importance of the IAEA's recommendations in these results suggests the IAEA deserves expanded support.

States should also implement other proactive policy levers that experts from some countries identified as important, including: (a) participating in nuclear security technical cooperation; (b) building opportunities for their legislatures, press, and public to provide responsible oversight of nuclear security; and (c) ratifying international legal instruments and actively reviewing how their terms could be implemented more effectively. Experts from a small number of countries indicated that pressure from a nuclear supplier led to substantial changes in nuclear security; this suggests that all suppliers should set high nuclear security standards and conduct regular reviews to confirm that recipients are implementing them, making recommendations for improvement where needed.

While the World Institute for Nuclear Security (WINS) was not specifically addressed in our survey, 84-85 percent of WINS members who responded to a membership survey in two successive years said that they had made changes to their nuclear security practices as a result of WINS activities.[19] Comparison to international best practices such as those WINS provides can and should be a key element of internal nuclear security reviews. All organizations working with HEU, separated plutonium, or nuclear facilities whose sabotage could lead to catastrophic consequences should be members of WINS and take an active part in its activities.

Given the importance of incidents in leading policymakers to make changes in nuclear security, it is critical that nuclear security managers and policymakers have access to complete and accurate data on relevant incidents that occur. Because of the pervasive secrecy surrounding nuclear security, this is simply not the case today. In nuclear safety, each safety-related incident is analyzed for root causes and lessons learned, and these analyses are distributed so that other operators can learn from them. Establishing such a mechanism for nuclear security could help states gain an accurate understanding of the global threat environment and tailor their nuclear security arrangements accordingly. For this reason, the international community should compile a database of incidents relevant to nuclear security, including actual or attempted incidents of nuclear theft or sabotage; incidents that revealed nuclear security weaknesses, and the lessons learned from them; and non-nuclear incidents that provided useful information on potential adversary tactics and capabilities (ranging from major terrorist attacks to bank robberies and diamond heists). As long as information on nuclear security weaknesses is not included until after they have been corrected, it should be possible to share such information internationally without compromising secrets that need to be protected. Such a database could be compiled by the IAEA—as a compliment to its illicit trafficking database—or by a different international organization such as Interpol or WINS. (As a first step, countries operating large numbers of facilities, such as the United States and Russia, should compile databases themselves of incidents that have occurred within their countries.) Ultimately, the key is that such information should be made available to all relevant stakeholders involved with security for nuclear weapons, HEU, separated plutonium, and major nuclear facilities

[19] World Institute for Nuclear Security, *Reaching New Heights: Annual Report 2013* (Vienna: WINS, 2013).

Consolidation is another area where the survey suggests a need for proactive policy actions. If nuclear weapons and their essential ingredients are to be consolidated at the minimum possible number of locations – making it possible to achieve higher security for these items at lower cost – countries must put in place policies that create incentives for operators to eliminate weapons-usable materials where practical. In particular, countries should put in place "graded security" requirements that require more effective (and expensive) security measures for HEU and separated plutonium than for low-enriched uranium or other materials that cannot be used to make a nuclear bomb, and establish policies that make the agencies overseeing the users of such materials bear the full costs of providing security for them.[20]

Beyond national steps, however, there is clearly a need to strengthen the international nuclear security framework – whose current weakness is highlighted by the survey result that compliance with international agreements was not among the more important motivations for states to change their nuclear security practices. As the next nuclear security summit approaches in 2014, countries should work together to identify:

- Pathways to building consensus on effective baseline standards of nuclear security that all countries with nuclear weapons, HEU, or separated plutonium should implement. One approach, for example, would be for a group of countries committed to nuclear security to make a political commitment to meet high standards of nuclear security (identifying a series of specifics such as those described above), and to develop measures to give each other confidence these agreed steps were being taken. These countries could then invite other countries to join them in this commitment, and offer to assist any country that needed help meeting those standards.

- Acceptable approaches to building confidence that countries are implementing effective nuclear security measures, without compromising information that must remain confidential. Countries could agree to: host international nuclear security peer reviews, such as the IPPAS missions some participants in our survey are already hosting, or visits from other countries to review security; publish reports detailing the steps they are taking to ensure effective nuclear security, as some countries do already; provide information about the kinds of inspections and tests their nuclear operators are subjected to, and the fraction of sites and transporters that do well in these inspections and tests; and more. Our survey reveals a broad divergence of views among states about how much information can be released; experts should begin discussing and reviewing potential measures to build real confidence in effective security without revealing sensitive information.

- Means to continue to focus high-level attention on identifying further steps to improve nuclear security after leaders are no longer gathering at the summit level. One approach would be ministerial-level meetings, perhaps hosted by the IAEA or associated with the Global Initiative to Combat Nuclear Terrorism.

- Steps to strengthen the nuclear security role of the IAEA. This could include an expanded program of peer reviews and assistance to states; a strengthened role in developing and promoting best practices, in concert with WINS; and a central role in whatever ongoing forum for discussion of nuclear security takes up the mantle after the nuclear security summits. This

[20] For discussion, see Bunn and Harrell, *Consolidation.*

should include ensuring that the IAEA has sufficient, predictable funds to implement its critical nuclear security activities.

In short, our survey confirms that the efforts of the last 15 years have led to major progress in improving nuclear security around the world – but that there is more to be done to achieve effective security measures focused on continual improvement over the long haul in all the countries where nuclear weapons and their essential ingredients continue to exist.

Appendix A: Complete Survey Results

The following is the full text of the survey instrument, with the answers received from each country. In calculating means, responses from countries with more than one expert responding were averaged, so that each country had equal weight in the average.

International Expert Survey: Perceptions of Threat and Drivers of Change in Physical Protection, Control, and Accounting for Nuclear Material

The purpose of this survey is to provide non-sensitive, high-level information on changes different countries have made in their approaches to nuclear material physical protection, control, and accounting over the past fifteen years, and on experts' perception of the credibility (or lack of credibility) of different types of adversary threats to nuclear operations and materials. This information will be used in a paper describing the results of the survey and in the ongoing analysis and development of policy recommendations related to nuclear security by Harvard University's Project on Managing the Atom.

The questions are designed to make it possible to answer them without compromising sensitive information. As judgments about what information is sensitive vary from country to country and person to person, each question offers an option not to answer because the question is too sensitive. All responses will be kept anonymous.

A. Security Requirements and Threat Assessments

A-1. Does your country have a formal process in place to assess the kinds of threats nuclear facilities should be protected against? (1=Yes, 2=No)	
Russia 1	1
Russia 2	1
Russia 3	1
U.S. DOE	1
U.S. DOE 2	1
U.S. NRC	1
Argentina	1
Australia	1
Belgium	1
Canada	1
China	1
Czech Republic	1
France	1
Germany	1
Hungary	1
India	1
Japan	1
Kazakhstan	1
Netherlands	1
Norway	1
Pakistan	1
U.K.	1

A-2. Does your country have a process in place to regularly update this assessment? (1=Yes, 2=No, 3=Too Sensitive to Answer)	
Russia 1	1
Russia 2	1
Russia 3	1
U.S. DOE	1
U.S. DOE 2	1
U.S. NRC	1
Argentina	1
Australia	1
Belgium	1
Canada	1
China	1
Czech Republic	1
France	1
Germany	1
Hungary	1
India	1
Japan	1
Kazakhstan	1
Netherlands	1
Norway	1
Pakistan	1
U.K.	1

A-3(1) – Adversary Types and Objectives: In the table below, please give your best judgment of the credibility of different potential adversary capabilities that might threaten nuclear facilities or materials in your country. This is intended to reflect your personal judgment about what threats are credible, which may or may not be similar to the types of threats your country's government takes into account in nuclear security requirements. Please give each potential adversary characteristic a 1-4 rating based on how credible you think adversaries with that characteristic are in your country, and therefore how important it would be for nuclear facilities to be protected against such adversaries. (1=Incredible, 2=Modestly Credible, 3=Somewhat Credible, 4=Highly Credible)

	Non-violent Protestors – Media Coverage	Violent Protestors – Media Coverage, Facility Shutdown	Criminals – Theft of Valuable Assets	Terrorists – Sabotage or Theft of Nuclear Material	Insiders – Disgruntled, Message to Management
Russia 1	2	2	4	3	3
Russia 2	1	1	2	2	3
Russia 3	2	2	3	2	1
U.S. DOE					
U.S. DOE 2	4	2	2	4	4
U.S. NRC	4	2	2	3	3
Argentina	4	2	2	3	1
Australia	4	2	4	2	3
Belgium	4	2	2	2.5	4
Canada	4	2	2	3	4
China	4	2	3	3	3
Czech Republic					
France	4	3	2	1	2
Germany					
Hungary	3	2	2	2	2
India	1	2	2	4	2
Japan	4	3	4	4	4
Kazakhstan	3	2	2	1	2
Netherlands	4	4	3	3	4
Norway	4	4	4	3	2
Pakistan	2	2	3	3	3
U.K.					
Mean	3.2	2.3	2.7	2.7	2.8

A-3(1): Continued.						
	Insiders – Sabotage	Insiders-Theft	Outsiders-Sabotage	Outsiders-Theft	Insiders and Outsiders Together – Sabotage	Insiders and Outsiders Together –Theft
Russia 1	2	2	3	2	2	2
Russia 2	2	2	1	1	2	3
Russia 3	2	3	2	1	2	2
U.S. DOE						
U.S. DOE 2	2	4	3	3	3	3
U.S. NRC	3	2	3	3	2	2
Argentina	2	2	2	3	2	2
Australia	2	3	3	2	2	2
Belgium	4	4	2.5	3	2.5	3
Canada	3	3	2	2	2.5	2.5
China	1	2	4	4	3	3
Czech Republic						
France	2	2	2	2	4	4
Germany						
Hungary	2	2	2	2	2	2
India	2	2	4	2	2	2
Japan	4	4	4	4	4	4
Kazakhstan	1	2	1	2	1	2
Netherlands	4	4	3	3	3	3
Norway	3	3	3	3	4	4
Pakistan	2	2	3	2	3	2
U.K.						
Mean	2.4	2.7	2.6	2.4	2.6	2.6

A-3(2) – Adversary Tactics: In the table below, please give your best judgment of the credibility of different potential adversary capabilities that might threaten nuclear facilities or materials in your country…. Please give each potential adversary characteristic a 1-4 rating based on how credible you think adversaries with that characteristic are in your country, and therefore how important it would be for nuclear facilities to be protected against such adversaries. (1=Incredible, 2=Modestly Credible, 3=Somewhat Credible, 4=Highly Credible)					
	Stealth (attempting to avoid detection)	Deception (e.g. uniforms, forged ID's, and paperwork)	Armed Attack	Truck or Boat Bombs	Aerial Attack
Russia 1					
Russia 2	1	2	1	1	2
Russia 3	1	2	1	2	2
U.S. DOE					
U.S. DOE 2	4	4	2	4	2
U.S. NRC	4	4	4	4	2
Argentina	3	3	3	3	1
Australia	4	2	2	2	1.5
Belgium	2	2	4	3	3
Canada	3	3	3	3	3
China	4	4	3	3	1
Czech Republic					
France	4	4	3	3	1
Germany					
Hungary	2	2	1	1	1
India	4	4	4	4	4
Japan	4	4	3	3	3
Kazakhstan	2	1	1	1	1
Netherlands	4	3	2	2	2
Norway	3	3	4	4	2
Pakistan	2	4	3	2	2
U.K.					
Mean	3.0	3.0	2.6	2.6	2.0

A-3(3) - Adversary Numbers: In the table below, please give your best judgment of the credibility of different potential adversary capabilities that might threaten nuclear facilities or materials in your country. …Please give each potential adversary characteristic a 1-4 rating based on how credible you think adversaries with that characteristic are in your country, and therefore how important it would be for nuclear facilities to be protected against such adversaries. (1=Incredible, 2=Modestly Credible, 3=Somewhat Credible, 4=Highly Credible)					
	Single Insider	Small Group of Insiders	Single Outsider	Small Group of Outsiders	Large Group of Outsiders
Russia 1	3	2	3	3	3
Russia 2	2	1	1	1	1
Russia 3	2	2	3	2	1
U.S. DOE					
U.S. DOE 2	4	4	4	4	2
U.S. NRC	3	2	2	3	3
Argentina	4	2	3	4	1
Australia	4	1	4	2.5	2
Belgium	4	3	1	4	1
Canada	4	2	4	3	2
China	4	2	4	4	4
Czech Republic					
France	2	3	1	3	3
Germany					
Hungary	2	1	2	2	1
India	2	1	3	4	2
Japan	4	2	2	4	3
Kazakhstan	2	1	2	2	1
Netherlands	4	3	4	3	2
Norway	2	1	3	2	1
Pakistan	4	2	1	3	2
U.K.					
Mean	3.1	1.9	2.6	3.0	1.9

A-3(4) - Adversary Training and Abilities: In the table below, please give your best judgment of the credibility of different potential adversary capabilities that might threaten nuclear facilities or materials in your country. …Please give each potential adversary characteristic a 1-4 rating based on how credible you think adversaries with that characteristic are in your country, and therefore how important it would be for nuclear facilities to be protected against such adversaries. (1=Incredible, 2=Modestly Credible, 3=Somewhat Credible, 4=Highly Credible)					
	Insider Knowledge of Facility, Security System	Use of Explosives to Breach Barriers, Vaults	Lock-picking Skills	Small-unit Military Tactics	Cyber-hacking Capabilities
Russia 1	3				
Russia 2	2	1	2	2	3
Russia 3	2	1	2	1	2
U.S. DOE					
U.S. DOE 2	4	3	4	4	4
U.S. NRC	2	4	1	4	3
Argentina	4	2	3	3	4
Australia	4	2	4	2	4
Belgium	4	4	1	4	1
Canada	2	3	1	2	4
China	4	3	3	1	1
Czech Republic					
France	4	2	2	2	3
Germany					
Hungary	1	1	2	1	1
India	3	3	2	2	4
Japan	4	4	4	3	3
Kazakhstan	2	1	2	1	2
Netherlands	4	4	4	4	4
Norway	4	2	4	1	2
Pakistan	4	2	1	3	1
U.K.					
Mean	3.2	2.5	2.5	2.4	2.7

A-3(5) - Adversary Weapons and Equipment: In the table below, please give your best judgment of the credibility of different potential adversary capabilities that might threaten nuclear facilities or materials in your country. …Please give each potential adversary characteristic a 1-4 rating based on how credible you think adversaries with that characteristic are in your country, and therefore how important it would be for nuclear facilities to be protected against such adversaries. (1=Incredible, 2=Modestly Credible, 3=Somewhat Credible, 4=Highly Credible)					
	Handguns	Automatic Weapons	Rocket-propelled Grenades	Hand-carried Explosives	Vehicle-born Explosives
Russia 1					
Russia 2	3	3	1	3	3
Russia 3	2	2	2	1	1
U.S. DOE					
U.S. DOE 2	4	4	3	4	4
U.S. NRC	4	4	4	4	4
Argentina	4	4	2	4	4
Australia	4	2	2	3	4
Belgium	4	4	3	4	3
Canada	2.5	2.5	1	3	3
China	4	4	1	4	4
Czech Republic					
France	4	3	3	2	2
Germany					
Hungary	1	1	1	1	1
India	4	4	4	4	4
Japan	4	4	3	4	3
Kazakhstan	1	1	1	1	1
Netherlands	4	4	3	4	4
Norway	4	3	2	2	2
Pakistan	2	4	4	2	2
U.K.					
Mean	3.3	3.1	2.4	2.9	2.9

A-3(5): Continued.				
	Ladders, Bolt-cutters, Hand Operated Tools	Lock-picking Equipment	Equipment for Blinding or Dazzling Camera's	Equipment for Disrupting Communications
Russia 1				
Russia 2	3	3	2	2
Russia 3	1	1	2	1
U.S. DOE				
U.S. DOE 2	4	4	2	4
U.S. NRC	4	1	2	3
Argentina	4	4	4	4
Australia	4	4	3	2.5
Belgium	4	1	1	4
Canada	3	1	2	3
China	4	4	3	4
Czech Republic				
France	1	1	2	2
Germany				
Hungary	2	2	1	2
India	2	2	3	3
Japan	4	4	4	4
Kazakhstan	2	2	1	1
Netherlands	4	4	4	4
Norway	4	4	3	3
Pakistan	3	1	1	1
U.K.				
Mean	3.1	2.5	2.4	2.8

A-3(6) - Adversary Vehicles: In the table below, please give your best judgment of the credibility of different potential adversary capabilities that might threaten nuclear facilities or materials in your country. …Please give each potential adversary characteristic a 1-4 rating based on how credible you think adversaries with that characteristic are in your country, and therefore how important it would be for nuclear facilities to be protected against such adversaries. (1=Incredible, 2=Modestly Credible, 3=Somewhat Credible, 4=Highly Credible)			
	Standard Four-wheeled Vehicles	Boats	Helicopters or Other Light Aircraft
Russia 1			
Russia 2	3	1	1
Russia 3	3	2	4
U.S. DOE			
U.S. DOE 2	4	4	3
U.S. NRC	4	4	2
Argentina	4	3	1
Australia	4	2	2
Belgium	4	4	3
Canada	4	3	2
China	4	1	1
Czech Republic			
France	2	1	1
Germany			
Hungary	2	1	1
India	4	4	3
Japan	4	4	3
Kazakhstan	1	1	1
Netherlands	4	4	4
Norway	4	4	2
Pakistan	3	1	3
U.K.			
Mean	3.4	2.6	2.2

A-4. Does your country use a regulatory approach that requires operators of some types of facilities and transports (or with some types of material) to protect against a specified set of threats? (This is often referred to as a "design basis threat" (DBT). (1=Yes, 2=No, 3=Too Sensitive to Answer)	
Russia 1	1
Russia 2	1
Russia 3	1
U.S. DOE	1
U.S. DOE 2	1
U.S. NRC	1
Argentina	1
Australia	1
Belgium	1
Canada	1
China	1
Czech Republic	1
France	1
Germany	1
Hungary	1
India	1
Japan	1
Kazakhstan	1
Netherlands	1
Norway	1
Pakistan	1
U.K.	1

A-5. In the United States, there are many debates about approaches to nuclear security. Some argue that U.S. nuclear security rules are too stringent, wasting money on requirements not rationally related to real risk. Others argue that the rules are too lenient, leaving too many potential threats unaddressed. The U.S. Nuclear Regulatory Commission has openly published a description of the DBT for theft that it requires operators to protect the most sensitive nuclear materials against, including three general categories of threats: (i) "determined, violent, external assault" (ii) "attack by stealth" or (iii) "deceptive actions." These actions might be perpetrated by (a) a "small group" of "well-trained…and dedicated individuals," capable of operating as "two or more teams," potentially armed with hand-held automatic weapons and other guns, hand-carried explosives and other equipment, using a four-wheeled vehicle, and potentially with "inside assistance" from a "knowledgeable individual"; (b) an employee "in any position"; and (c) a conspiracy between individuals in any position, who may have "access to and detailed knowledge of" the facility in question, along with items such as small tools or false documents to facilitate a theft. Would you say that, compared to this published version of the NRC's DBT for theft, the kinds of threats against which operators of facilities with substantial (Category I) quantities of HEU or plutonium in your country are required to protect are:					
	More Capable	Generally as Capable	Different in Significant Respects, but Neither More nor Less Capable Overall	Less Capable	Too Sensitive to Answer
Russia 1		●			
Russia 2	●				
Russia 3	●				
U.S. DOE		●			
U.S. DOE 2	●				
U.S. NRC		●			
Argentina			●		
Australia				●	
Belgium					●
Canada			●		
China		●			
Czech Republic					●
France	●				
Germany		●			
Hungary		●			
India		●			
Japan					●
Kazakhstan			●		
Netherlands		●			
Norway		●			
Pakistan	●				
U.K.		●			
Country Totals	3.00*	8.00*	3.00	1.00	3.00

B. Recent Changes and Main Causes of Changes

B-1. In your country, have there been substantial changes in nuclear security and accounting requirements and approaches in the last 15 years?						
	Yes, the reqs. and approaches have become much more stringent	Yes, the reqs. and approaches have become modestly more stringent	No, current reqs. and approaches are comparable to previous ones overall (though there may have been some changes)	Yes, the reqs. and approaches have become modestly less stringent	Yes, the reqs. and approaches have become much less stringent	Too sensitive to answer
Russia 1	●					
Russia 2	●					
Russia 3		●				
U.S. DOE	●					
U.S. DOE 2	●					
U.S. NRC	●					
Argentina		●				
Australia		●				
Belgium	●					
Canada	●					
China	●					
Czech Republic	●					
France	●					
Germany	●					
Hungary	●					
India	●					
Japan	●					
Kazakhstan		●				
Netherlands	●					
Norway	●					
Pakistan	●					
U.K.	●					
Country Totals	14.66*	3.33*	0.00	0.00	0.00	0.00

B-2. If there have been substantial changes in nuclear security and accounting requirements in your country in the last 15 years, what were the most important factors that caused those changes to be made, in your personal judgment? (Please give each factor a 0-4 rating – with 0 not important at all and 4 the dominant cause of changes.)						
	Incidents that took place in your country (e.g. terrorist attacks or nuclear theft)	Incidents that took place in other countries (e.g. 9/11 attacks)	Other events that changed perceptions of adversary threat	Results of security reviews and assessments	Recs. from the IEAE (including revisions of INFCIRC/225)	Recs. from other states
Russia 1	3	3	3	1	2	3
Russia 2	3	3		4	3	3
Russia 3	1	4		3	4	2
U.S. DOE	4	3	3	1	0	1
U.S. DOE 2	4	4	0	3	0	0
U.S. NRC	4	3	3	1	0	1
Argentina		*	*	*	*	
Australia	2	3	1	2	1	1
Belgium	3	4	0	0	2	3
Canada	3	4	3	3	1	1
China	4	4	3	3	3	3
Czech Republic					4	
France	0	4	0	3	4	0
Germany	0	4	2	4	2	0
Hungary				**	**	
India	4	2	2	2	2	0
Japan	0	4	3	2	4	2
Kazakhstan	0	1	1	2	4	2
Netherlands	2	3	3	3	3	0
Norway	3	4	0	4	4	0
Pakistan	4	3	3	3	2	3
U.K.	2	4		2	2	
Mean	2.4	3.4	1.9	2.4	2.4	1.4

*The Argentinean respondent highlighted these categories as important drivers of change but did not provide numerical ratings for them.
**The Hungarian respondent highlighted these categories as important drivers of change but did not provide numerical ratings for them.

B-2. Cont.					
	Technical cooperation with or assistance from other states	Decisions reached by individual policy-makers for their own reasons	Pressure from the legislature, press or public	International legal obligations (e.g. physical protection convention and its 2005 amendment UNSCR 1540 or bilateral supply agreements)	Conclusion that changes were necessary for continued supply from a nuclear supplier
Russia 1	3	1	0	2	0
Russia 2	4	2	2	4	3
Russia 3	3	2	1	1	1
U.S. DOE	0	0	2	0	0
U.S. DOE 2	0	4	3	0	0
U.S. NRC	0	1	2	0	0
Argentina	*			*	
Australia	1	1	1	1	0
Belgium	0	3	3	3	4
Canada	3	0	3	0	0
China	3	2	1	4	4
Czech Republic	4			4	4
France	0	0	1	4	4
Germany	0	2	1	0	0
Hungary	**		**		
India	1	2	1	2	
Japan	2	0	2	2	
Kazakhstan	3	1	1	4	0
Netherlands	2	0	1	3	1
Norway	0	1	1	0	0
Pakistan	2	3	3	2	2
U.K.		3			
Mean	1.6	1.5	1.6	1.9	1.4

* The Argentinean respondent highlighted these categories as important drivers of change but did not provide numerical ratings for them.
**The Hungarian respondent highlighted these categories as important drivers of change but did not provide numerical ratings for them.

B-3(1). If there have been substantial obstacles to and constraints on changes in nuclear security and accounting requirements in your country in the last 15 years, what were the most important of these obstacles and constraints, in your personal judgment? (Please give each factor a 0-4 rating – with 0 not important at all and 4 the dominant cause of changes.)				
	Belief that existing agreements were sufficient	Operator concerns over costs or impacts of proposed changes	Complex decision-making and approval processes	Desire to wait for outcome of intl. processes (e.g. comp. of INFCIR/225/Rev.5 or Nuclear Sec. agreement with a foreign country)
Russia 1	2	3	2	0
Russia 2	3	3	3	1
Russia 3	1	1	2	4
U.S. DOE	0	2	0	0
U.S. DOE 2	0	3	3	0
U.S. NRC	0	0	0	0
Argentina	0*	0*	0*	0*
Australia	2	2	1	2
Belgium	0	2.5	2	0
Canada	4	4	4	0
China	0	4	2	1
Czech Republic				
France	1	2	3	0
Germany	4	4	0	0
Hungary	2	1	2	3
India	0	0	2	0
Japan				
Kazakhstan	0	2	3	1
Netherlands	1	1	1	0
Norway	3	2	1	1
Pakistan	4	2	0	2
U.K.		2	3	
Mean	1.4	2.0	1.7	0.8

* The Argentinean respondent did not provide explicit numerical ratings for these constraints, but indicated that there were "no constraints or opposition," to the changes in Argentina, though there were "limitations on the budgets" for equipment improvements.

B-4. If there have been substantial changes in nuclear security and accounting requirements in your country in the last 15 years, what security elements saw the most important changes? (Please give each factor a 0-4 rating – with 0 no significant change, and 4 dramatic changes.)						
	Change in design basis threat operators must protect against	Change in operator organization and/ or governance of nuclear security	Change in regulator authority and/or independence	Change in req./approaches for personnel screening	Change in req./approaches for performance testing and assessment	Change in req./approaches in guard force numbers, training, equipment
Russia 1	3	1	1	0	2	1
Russia 2	3	3	3	3	3	3
Russia 3	2	2	3	3	2	2
U.S. DOE						
U.S. DOE 2	4	2	1	4	4	4
U.S. NRC	4	0	0	2	1	3
Argentina	4	1	0	1	2	2
Australia	2	2	0	1	3	1
Belgium	1	2	2	3	1	0
Canada	4	4	3	4	4	4
China	4	4	4	2	4	4
Czech Republic						
France	3	4	4	3	3	3
Germany	3	0	0	1	0	1
Hungary	1	1	1	1	3	3
India	4	1	2	0	1	2
Japan	4	2	0	0	3	3
Kazakhstan	3	1	2	0	0	1
Netherlands	4	2	1	2	2	2
Norway	4	0	1	0	0	0
Pakistan	3	4	3	4	3	4
U.K.	3	3	4	1	2	4
Mean	3.2	2.0	1.8	1.8	2.2	2.4

B4. Cont.					
	Change in req./approaches for training of other security staff	Change in req./approaches for use of tamper-indicating devices	Change req./approaches for nuclear material accounting	Change in req./approaches in MPC&A technologies	Change in req./approaches for promoting security culture
Russia 1	1	3	4	2	2
Russia 2	2	4	4	3	2
Russia 3	3	3	3	3	2
U.S. DOE					
U.S. DOE 2	3	3	4	4	0
U.S. NRC	2	0	2		
Argentina	2	1	2	2	2
Australia	1	0	2	3	1
Belgium	0	0	0	0	3
Canada	3	3	2	2	3
China	3	3	4	4	4
Czech Republic					
France	3	2	3	3	2
Germany	1	1	0	0	0
Hungary	2	2	1	2	3
India	2	1	1	2	1
Japan	2	1	0	3	2
Kazakhstan	0	0	2	2	1
Netherlands	2	1	1	2	3
Norway	0	0	0	2	0
Pakistan	3	3	4	3	4
U.K.	1			1	1
Mean	1.8	1.6	2.1	2.3	1.9

B-5. If there have been substantial changes in nuclear security and accounting requirements in your country in the last 15 years, how much would you estimate they affected the costs of nuclear security, considering both the capital and operating costs resulting from the changes?						
	Increased Costs for Facilities with HEU or Separated Plutonium by >20%	Increased Costs for Facilities with HEU or Separated Plutonium by >5%	Costs for Facilities with HEU or Separated Plutonium Did Not Change by >5%	Decreased Costs for Facilities with HEU or Separated Plutonium by >5%	Decreased Costs for Facilities with HEU or Separated Plutonium by >20%	Too Sensitive to Answer
Russia 1	•					
Russia 2						•
Russia 3	•					
U.S. DOE						
U.S. DOE 2	•					
U.S. NRC	•					
Argentina			•			
Australia						
Belgium						
Canada	•					
China						•
Czech Republic						•
France						•
Germany						
Hungary						
India	•					
Japan						
Kazakhstan		•				
Netherlands	•					
Norway	•					
Pakistan		•				
U.K.			•			
Country Totals	5.66*	2.00	2.00	0.00	0.00	3.33*

C. Consolidation

C-1. Has your country reduced the number of locations with HEU or separated plutonium in the last 15 years? (Reducing the number of locations could occur at either defense or civilian facilities, and could involve either reducing the number of places where these materials are stored and handled at individual sites or reducing the number of sites):

	Yes, substantial reduction	Yes, modest reduction	No, no significant change	No, the number of such locations has increased	Too sensitive to Answer
Russia 1		●			
Russia 2	●				
Russia 3		●			
U.S. DOE					
U.S. DOE 2	●				
U.S. NRC	●				
Argentina	●				
Australia	●				
Belgium		●			
Canada			●		
China					●
Czech Republic	●				
France					●
Germany					
Hungary	●				
India				●	
Japan		●			
Kazakhstan	●				
Netherlands		●			
Norway			●		
Pakistan			●		
U.K.		●			
Country Totals	6.33*	4.66*	3.00	1.00	2.00

C-2. In the United States, security requirements have made it quite costly to store and use Category I quantities of HEU or plutonium, motivating many facility managers to find ways to operate without these materials. A typical U.S. facility with a Category I quantity of HEU or separated plutonium could save millions or tens of millions of dollars a year in the costs of required security measures if it eliminated those materials. In your country, do security requirements create a similar incentive to consolidate HEU or plutonium stockpiles in fewer locations?

	Yes, there are sig. cost savings if facilities eliminate their HEU or separated plutonium	No, for most facilities there would be modest or negligible savings from eliminating these materials.	No, other policies and circumstances create an incentive for most facilities to maintain their plutonium and HEU.	Too sensitive to answer
Russia 1			●	
Russia 2		●		
Russia 3			●	
U.S. DOE				
U.S. DOE 2	●			
U.S. NRC	●			
Argentina		●		
Australia			●	
Belgium		●		
Canada			●	
China				●
Czech Republic	●			
France				●
Germany				
Hungary	●			
India			●	
Japan	●			
Kazakhstan		●		
Netherlands	●			
Norway				
Pakistan			●	
U.K.		●		
Country Totals	5.00*	4.33*	4.66*	2.00

D. Public and International Information

D-1. In your country, what information about nuclear security and accounting is typically publicly available?					
	Little if any information is available to the public, given the sensitivity of the issue	General statements about nuclear security policies are published; texts of broad laws relating to nuclear security (though not specific regulations) are published	Reports from regulators or other state authorities, conference papers, and other public sources provide a good general overview of nuclear security and accounting approaches	Substantial information is made available to the public, while protecting sensitive information. (Information might include moderately detailed accounts of nuclear security regulations; general results of inspection activities (such as the percentage of facilities achieving high marks in inspections); accounts of particular issues and problems that had been resolved, etc.)	Too sensitive to answer
Russia 1				●	
Russia 2	●				
Russia 3		●			
U.S. DOE			●		
U.S. DOE 2				●	
U.S. NRC				●	
Argentina		●			
Australia		●			
Belgium		●			
Canada			●		
China	●				
Czech Republic					●
France		●	●		
Germany		●	●		
Hungary			●		
India		●	●		
Japan				●	
Kazakhstan		●			
Netherlands		●			
Norway				●	
Pakistan	●				
U.K.				●	
Country Totals	2.33*	8.33*	5.33*	4.00*	1.00

D-2. Has your country hosted one or more reviews of its nuclear security arrangements, either by another country (such as under the terms of a bilateral nuclear supply agreement or a cooperative threat reduction program) or by experts organized by the IAEA (such as an International Nuclear Security Advisory Service or International Physical Protection Advisory Service mission)?				
	Yes, our country has hosted physical protection review visits by one or more other countries	Yes, our country has hosted one or more IAEA-led physical protection reviews, such as the IPPAS	No, our country has not hosted such visits	Too sensitive to answer
Russia 1	●			
Russia 2			●	
Russia 3			●	
U.S. DOE				
U.S. DOE 2			●	
U.S. NRC		●		
Argentina		●		
Australia	●			
Belgium	●			
Canada	●			
China		●		
Czech Republic	●	●		
France		●		
Germany			●	
Hungary	●	●		
India			●	
Japan	●			
Kazakhstan	●	●		
Netherlands	●	●		
Norway		●		
Pakistan			●	
U.K.		●		
Country Totals	8.33*	9.50*	4.16*	0.00

E. Cooperation and Assistance Programs

E-1. As far as you are aware, has your country been a recipient of technical cooperation or assistance programs designed to improve nuclear security (check all that apply)?					
	No	Yes, programs from IAEA Office of Nuclear Security	Yes, programs sponsored by the United States	Yes, programs sponsored by other countries or organizations	Too sensitive to answer
Russia 1			●	●	
Russia 2			●	●	
Russia 3			●	●	
U.S. DOE					
U.S. DOE 2	●				
U.S. NRC	●				
Argentina		●			
Australia	●				
Belgium	●				
Canada		●	●	●	
China		●	●		
Czech Republic		●	●		
France	●				
Germany	●				
Hungary		●	●		
India		●	●		
Japan			●		
Kazakhstan		●	●	●	
Netherlands	●				
Norway	●				
Pakistan		●	●	●	
U.K.				●	
Country Totals	7.00*	8.00	9.00*	5.00*	0.00

E-2. If your country has been a recipient of such cooperation or assistance programs, how effective would you say these programs were in leading to sustainable improvements in nuclear security and accounting measures?					
	Highly Effective	Moderately Effective	Only Partly Effective	Largely Ineffective	Too Sensitive to Answer
Russia 1	●	●			
Russia 2	●				
Russia 3	●				
U.S. DOE					
U.S. DOE 2					
U.S. NRC					
Argentina		●			
Australia					
Belgium					
Canada		●			
China		●			
Czech Republic	●				
France					
Germany					
Hungary	●				
India			●		
Japan	●				
Kazakhstan	●				
Netherlands					
Norway					
Pakistan		●			
U.K.		●			
Country Totals	5.00*	5.33*	1.00	0.00	0.00

Appendix B: Analysis of Russian and US Respondents

This appendix highlights some of the most important similarities and differences between the US experts and among the Russian experts who participated in the survey.

The US Experts

Two US experts participated in our survey. One of them had recent experience working at both DOE and NRC, and provided two (almost identical) sets of answers, one applying to each of these agencies. The other was recently retired from DOE, and provided answers focused on DOE.

In the first part of the survey, focused on the credibility of different threats, their answers were very similar. There were notable differencse on the credibility of insider theft and of armed attack on nuclear facilities, with one participant in each case rating these threats as "modestly credible" and the other as "highly credible." With respect to adversary capabilities, the views were again generally similar, but where there were exceptions, one expert was consistently more pessimistic, rating theft attempts by groups of insiders, by single outsiders, and with insider knowledge of the security system as "highly credible," while the other expert rated these as "modestly credible." There were even larger differences on lock-picking ("highly credible" from one and "incredible" from the other). As noted in the main text, there was an important ambiguity in our survey that may be a driver of these differences: some participants interpreted a "credible" threat as an adversary capability or tactic that had a good chance of being present in a future incident, while others interpreted a "credible" threat as a capability or tactic that would have a good chance of defeating the security systems. Hence, the difference on lock-picking is likely a matter of interpretation, with one of the experts believing it is highly credible that adversaries would try it, and the other believing it is incredible this tactic would succeed, given the type of locks in use to protect plutonium and HEU in the US nuclear complex.

The US experts agreed that US nuclear security measures had become "much more stringent" since the 9/11 attacks, and had generally similar views on the causes of and constraints on change. There were a few significant differences, however. Where we offered participants the opportunity to mention other events that were important causes of change besides those listed in the survey, one did not suggest anything, but the other argued that there had been a major effect from US intelligence assessments of possible terrorist threats to nuclear facilities. Another large difference was on the importance of idiosyncratic decisions by individual policy-makers: one expert saw these as minor, while the other saw these as a dominant driver of change. Perceptions of how much complex decision-making processes constrained change also differed sharply: one expert saw such complexity as not a problem at all, while the other saw it as a major constraint on change.

The US experts often differed in their judgments of the scale of change in particular areas of nuclear security. They agreed that there had been dramatic changes (4 on a 0-4 scale) in the US DBT, but beyond that their judgments diverged, with one expert rating almost every type of change as more substantial than the other expert thought it was. Particularly striking differences included their view of the change in approaches to performance testing and assessment (rated a 1 by one expert, a 4 by the other)[1] and of the change in requirements for the use of tamper-indicating devices (rated a 0 by one expert, 3 by the other). On the other elements of the survey, focusing on matters such as consolidation efforts, publicly available information, and participation in international cooperation, the two expert's views were similar, though not always identical.

[21] We would argue that 3 might be closer to the mark; both NRC and DOE have made quite significant changes to their performance testing programs since 9/11, though the changes have arguably been larger at NRC, which had farther to go to establish a really effective program. For a discussion of some of the weaknesses in NRC's pre-9/11 approach, see US Congress, *Nuclear Regulatory Commission: Oversight of Security at Commercial Nuclear Power Plants Needs to Be Strengthened*.

Russian Experts

Three Russian experts participated in our survey. (We had intended to have two participants from each country, but after a long delay in getting a response from one Russian participant, we asked another to participate, and in the end both did so.) In general, the differences of opinion among the Russian experts were significantly greater than the differences between the US experts.

In the section of the survey focused on the credibility of different threats, their answers were generally similar, with a number of striking exceptions. There was only one threat where there was complete disagreement (difference of 3 points on a 0-4 scale): the possibility of adversary use of helicopters and light aircraft. In discussions with the participants, it became clear that this difference was driven by different interpretations of credibility, as discussed above: two participants gave such vehicles a low credibility rating in the belief that it was unlikely adversaries would use them, while the other gave them a high credibility rating in the belief that if adversaries did use them, they might be highly effective in overcoming security systems. (Indeed, that expert, using that interpretation of credibility, gave helicopters and light aircraft the highest credibility rating of any potential adversary threat.) There were numerous threats where there was a difference of 2 on a 0-4 scale – probably also driven in significant part by different definitions of credibility. Differences of 2 that do not appear to arise from that difference of interpretation include the credibility of: (a) criminals seeking to steal valuable items, rather than nuclear materials (rated 2, 3, and 4 by the different experts); outsiders seeking to sabotage nuclear facilities (rated 1, 2, and 3 by the different experts); and all sizes of outsider groups, from a single individual to a large group (with one expert consistently rating these as 1, and the others rating them as 2 or 3).

Two of the Russian experts argued that Russian security measures had become "much more stringent" over the last 15 years, while the third judged them to be only "modestly more stringent." They agreed that incidents in other countries (particularly the 9/11 attacks in the United States) had had a large effect on driving these changes, but there was striking disagreement on the importance of incidents within Russia. Two of the experts gave these a rating of 3 (on the 0-4 scale), while one gave them only a 1. Given that there have been a series of well-known incidents in which security at nuclear facilities was ordered tightened after Chechen terrorist attacks, we would argue that the majority of the Russian experts are closer to the mark. Two Russian experts did not mention anything when offered the opportunity to describe other events that had also affected security, while another offered the compelling point that the dramatic political, institutional, economic, and social changes following the collapse of the Soviet Union had a large effect. The importance of internal security reviews was the subject of strong disagreement (with ratings of 1, 3, and 4), as were the importance of international legal agreements (rated 1, 2, and 4) and demands from a nuclear supplier (rated 0, 1, and 3). Smaller disagreements centered on the importance of IAEA recommendations (rated 2, 3, and 4) and the influence of the legislature, press, and public (rated 0, 1, and 2).

Nor was there consensus among the Russian experts on the major constraints on change. There was near-agreement that complex decision-making processes were a moderately important constraint (rated 2, 2, and 3), but there was disagreement on the importance of other factors, including the belief that existing arrangements were sufficient (rated 1, 2, and 3), operator concerns over the cost and impact of proposed changes (rated 1, 3, and 3), and the desire to await the completion of international processes, which was subject to the strongest possible disagreement (rated 0, 1, and 4).

There was near-agreement among the Russian experts on the scale of changes in the DBT (rated 2, 3, and 3); in performance testing and assessment (rated 2, 2, and 3); in requirements for the use of tamper-indicating devices (rated 3, 3, and 4); in requirements for material control and accounting (rated 3, 4, and 4), in the use of modern material protection, control, and accounting technologies (rated 2, 3, and 3), and in measures to promote security culture (rated 2 by all three experts). But there were striking differences in other areas,

including their judgments of the scale of changes in requirements for training of security personnel and other staff (rated 1, 2, and 3); in guard force numbers and equipment (also rated 1, 2, and 3, though with different experts making the high judgment); in requirements for personnel screening (rated 0, 3, and 3); in regulatory authority and independence governance of nuclear security (rated 1, 3, and 3); and in governance of nuclear security (rated 1, 2, and 3). It is notable that in all of these cases of strong disagreement, it was the same expert who provided the lowest rating; he apparently sees recent changes as consistently less substantial than the others view them as being.

On consolidation, the Russian experts' perspectives were generally similar, with two of them saying the reduction in the number of buildings and sites with HEU or separated plutonium had been substantial, and other seeing a more modest reduction. Strikingly, two out of three said that the structure of Russian rules and policies gave facilities incentives to maintain whatever plutonium or HEU they had, rather than to eliminate it to reduce security costs; the third said they had little incentive to take action either way.

There were remarkably divergent opinions on how much information on nuclear security is available to the public in Russia, ranging from "little if any" to "substantial." This may reflect greater or lesser familiarity with documents that are obscure and hard to find, but in principle available to the public.

The Russian experts were in agreement on the types of international cooperation Russia has participated in, and they all saw this cooperation as either highly or moderately effective.

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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