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BUILDING A SAFER WORLD

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Radiological Security Progress Report

PREVENTING DIRTY BOMBS— FIGHTING WEAPONS OF MASS DISRUPTION

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About the Nuclear Threat Initiative

The Nuclear Threat Initiative (NTI) works to protect our lives, livelihoods, environment, and quality of life now and for future generations from the growing risk of catastrophic attacks from weapons of mass destruction and disruption (WMDD)—nuclear, biological, radiological, chemical, and cyber. Founded in 2001 by former U.S. Senator Sam Nunn and philanthropist Ted Turner, NTI is guided by a prestigious, international board of directors. Joan Rohlfing serves as president.

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"Radioactive sources are used in every country in the world, whether in industry, medicine, agriculture, or research. At the same time, high-activity radioactive sources can be used for malicious acts."

—2014 Nuclear Security Summit Communiqué

OVERVIEW

The ingredients for a radiological dirty bomb—the very same isotopes that can make life-saving blood transfusions and cancer treatments possible—are located at thousands of sites in more than 100 countries, many of them poorly secured and vulnerable to theft. The vulnerability of these radiological sources, such as cesium-137 and cobalt-60, has caused concern for years, but today the risk is growing. The probability of a terrorist detonating a dirty bomb is much higher than that of an improvised nuclear device (IND) because of the widespread availability of radiological sources. Recent reports out of Iraq warn that Islamic State extremists may have already stolen enough material to build a bomb that could contaminate major portions of a city and cost billions of dollars in damage.

World leaders at the 2014 Nuclear Security Summit (NSS) recognized the growing threat and put an important spotlight on the issue of radiological security with a commitment from 23 countries to secure their most dangerous radiological sources by the end of 2016. This NTI *Radiological Security Progress Report* finds that 22 of those countries have met their commitment or are on track to do so by the end of the year—noteworthy progress toward reducing the risk. In addition, over the past decade, progress has been made on better securing radiological sources through efforts by the International Atomic Energy Agency (IAEA) and various national and international programs.

At the same time, much more needs to be done—and it won't be easy. The existing global system for securing dangerous radiological materials has significant gaps, and the 23 countries that agreed to secure their radiological sources represent only about half of those participating in the Nuclear Security Summits and just 14 percent of IAEA Member States.

To address these and other significant challenges, governments and the private sector must work in tandem to raise awareness about the threat, develop a more effective system for securing radiological sources, and replace the use of dangerous isotopes with alternate technologies, where feasible, for permanent threat reduction.

THE THREAT

The ingredients for a radioactive dirty bomb are in tens of thousands of radiological sources located in more than 100 countries around the world. They are used in medicine and science at hospitals, universities, and research centers. They are used in agriculture, in industry, and by governments for various purposes. And in all these settings, they are too often poorly secured and vulnerable to theft and sale on the black market.

In its Global Incidents and Trafficking Database,[1] the James Martin Center for Nonproliferation Studies (CNS) reports that in 2013 and 2014, there were 325 publicly reported incidents in which nuclear or other radioactive material was lost, stolen, or otherwise determined to be outside of regulatory control. Most—about 85 percent—of recorded incidents in the database involved non-nuclear radioactive material, or the ingredients for a dirty bomb.

Meanwhile, the threat posed by increasingly violent radical terrorist organizations—groups bent on killing and wreaking havoc on a massive scale—is growing with new and ever-more brutal attacks in the Middle East, in Europe, and beyond. Reports that such organizations are seeking materials to build a radiological dirty bomb are chilling—but should not be shocking.

Moreover, the probability of a terrorist detonating a dirty bomb is much higher than that of an IND because of the widespread availability of radiological sources. Whereas highly enriched uranium (HEU) is located in fewer than 25 countries, radiological sources are located at thousands of sites in more than 100 countries. Unlike a nuclear weapon, a radioactive dirty bomb would not cause catastrophic levels of death and injury, but depending on its chemistry, form, and location, it could leave billions of dollars of damage due to the costs of evacuation, relocation, and cleanup—and the inevitable follow-on threats could have severe economic and psychological repercussions. Buildings could have to be demolished and the debris removed. Access to a contaminated area could be denied for years as a site is cleaned up well enough to meet even minimum environmental guidelines for protecting the public. As a result, dirty bombs are often referred to as "weapons of mass disruption."

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[1] James Martin Center for Nonproliferation Studies, "CNS Global Incidents and Trafficking Database, April 2015," available at www.nti.org/media/pdfs/global_incidents_and_trafficking2015_2.pdf.

RADIATION USES AND DEVICES

Radionuclide and Emission	Half-Life	Chemical Form (typical)	Typical Use and Activity	Common Radiation Uses
Cobalt-60 (b,g)	5.3 yr	Hard Metal	Teletherapy (1,000s Ci)	Radiation used to treat cancer tumors
Cesium-137 (b,g)	30.1 yr	Salt Powder	Irradiators (1,000s Ci)	Radiation used to irradiate blood prior to transfusion
Iridium-192 (b,g)	74 days	Hard Metal	Radiography (~100 Ci)	Radiation is used to determine the quality of a particular material and detects areas of varying density and composition
Americium-241/ Beryllium (a,g)	432.2 yrs	Mixture of Oxide/Metal	Well Logging (~10 Ci)	Radiation is used to measure properties of the geologic strata through which a well had been or is being drilled to examine earth formations

FINDINGS

The NTI *Radiological Security Progress Report* reviews progress that 23 states have made in meeting their commitments in accordance with the 2014 Nuclear Security Summit Joint Statement on Enhancing Radiological Security (NSS Joint Statement).

Those commitments include a pledge to secure their IAEA Category 1 materials by the end of 2016 and to implement other commitments to improve radiological security.

Information for the report was primarily drawn from responses by the 23 states to an NTI questionnaire, 2014 NSS documents, the IAEA's Code of Conduct Technical and Review Meetings, Nuclear Security Summit National Progress Report Statements, and other IAEA reports.

Key Findings:

- All but one of the 23 countries have met or will meet the commitment to secure their IAEA Category 1 sources by the end of 2016. The Czech Republic is still working to meet the commitment.
- Most countries have met or will meet the additional radiological security commitments and the additional best practices. Of the 23:
  - Nineteen countries have a national strategy for regaining control over orphan sources and improving control over vulnerable sources, including disused sources.
  - Eighteen countries have developed a plan for notifying neighboring countries regarding sources out of regulatory control.
  - Eighteen countries have assessed the domestic threat to radioactive materials, have evaluated the implications for the design basis threat (and keep it up to date), and have developed a national response plan to any attempted or actual unauthorized access to radioactive material.
  - Sixteen countries have made arrangements, in accordance with their national laws, to provide cooperation and assistance in the location and recovery of lost, missing, or stolen radioactive material to any requesting state.

Notable Country Accomplishments

Norway: The Norwegian government required that all cesium-137 blood irradiators be phased out by 2015. As a result, 13 cesium-137 irradiators in Norway were removed and shipped back to their manufacturer in Canada.

Australia: Australia conducts annual threat assessments associated with the malicious use of radioactive materials. Each license holder must implement scalable security measures commensurate with the relevant threat environment.

United Arab Emirates: UAE requires license holders to provide a rapid response that is able to interdict unauthorized access to radioactive sources. Annual drills are required and the responses are evaluated.

Hungary: Hungary conducts a national threat assessment and has a design basis threat that includes a threat assessment of radioactive materials.

Canada: The Canadian Nuclear Safety Commission implemented a financial guarantee for licensees to ensure there will be sufficient resources to safely dispose of radiological materials.

Canada is also the first country with a large nuclear program in which the International Physical Protection Advisory Service (IPPAS) Module 4 was implemented to review the security of radioactive sources after publication of updated IPPAS guidelines.[2]

SIGNATORIES TO THE 2014 NSS JOINT STATEMENT ON ENHANCING RADIOLOGICAL SECURITY

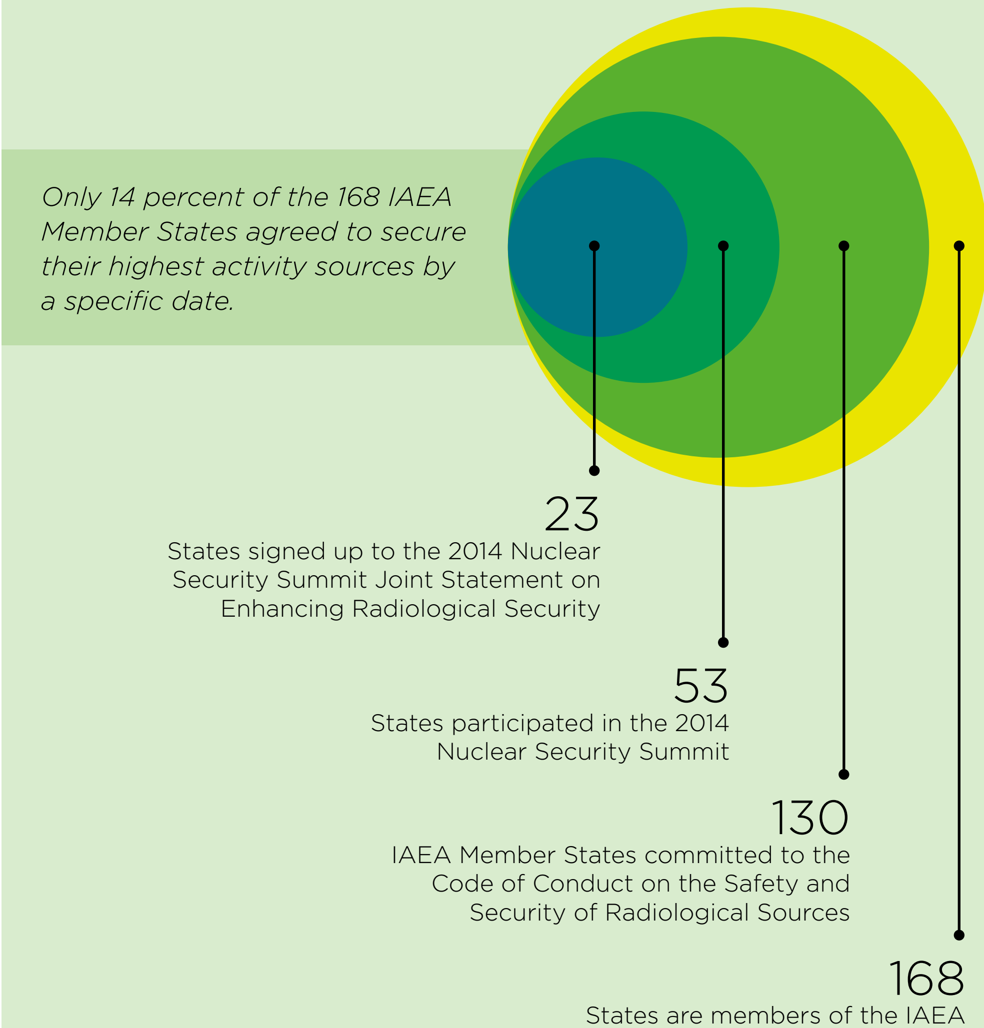
- Algeria
- Armenia
- Australia
- Canada
- Czech Republic
- Denmark
- Georgia
- Germany
- Hungary
- Italy
- Japan
- Kazakhstan
- Lithuania
- Morocco
- Netherlands
- New Zealand
- Norway
- Republic of Korea
- Sweden
- Turkey
- United Arab Emirates
- United Kingdom
- United States

[2] The International Physical Protection Advisory Service (IPPAS) was created by the IAEA to assist states in strengthening their national nuclear and radiological security regime. IPPAS provides peer advice on implementing international instruments and IAEA guidance on the protection of nuclear and other radioactive material and associated facilities. Recently, the IAEA added a new module to the IPPAS (Module 4), which reviews a state's radiological security system at a nationwide and facility-specific basis.

These accomplishments offer good examples of steps countries can take to improve radiological security—but they represent only a beginning. Much more needs to be done by many more governments and by the private sector to effectively secure and prevent the theft of radiological sources.

The following chart highlights how few countries have committed to take steps to address radiological security by a specific date. The 23 countries that signed the NSS 2014 Joint Statement represent only 43 percent of the 53 countries participating in the Nuclear Security Summit process, and only 14 percent of the 168 IAEA Member States. In addition, although 130 out of 168 IAEA Member States have signed the Code of Conduct—which, along with the supplementary IAEA Guidance on the Import and Export of Radioactive Sources,[3] is a non-binding instrument that contains voluntary provisions to be implemented by subscribing states—there is no specific requirement to secure their highest activity sources by a specific date.

RADIOLOGICAL SECURITY NEEDS GLOBAL COVERAGE



3 See "Code of Conduct on the Safety and Security of Radioactive Sources," and supplementary "Guidance on the Import and Export of Radioactive Sources," available at www-ns.iaea.org/tech-areas/radiation-safety/code-of-conduct.asp.

CHALLENGES

Despite important progress on the goals set at the 2014 Nuclear Security Summit, significant challenges remain to properly securing—and where possible replacing—dangerous radiological materials. Those challenges include:

- **The legal architecture for radioactive materials is weak.** The Code of Conduct contains basic principles suggesting that states "…take appropriate measures to ensure that the radioactive sources within their territory are safely managed and securely protected during their lifetime." It also calls for effective national legislation and regulatory controls over radioactive sources.
- **Lack of universal coverage and implementation of the Code of Conduct.** To date, only 130 of 168 IAEA Member States have committed to the Code of Conduct (77 percent), and many of these countries have not met all of their political commitments to follow its provisions. Therefore, a vast number of radiological sources are outside of existing international and national security mechanisms. To ensure that sources are secure, additional states must join the Code of Conduct and follow through by codifying it into domestic law.

OBJECTIVES OF THE IAEA CODE OF CONDUCT

- ✔ Help states to reach and maintain a high level of safety and security of radioactive sources, including at the end of their useful lives.
- ✔ Prevent unauthorized access, damage, theft, or unauthorized transfer of radioactive sources.
- ✔ Prevent malicious use of radioactive sources; mitigate and minimize the consequences of any accident or malevolent act involving radioactive sources.
- ✔ Support states in establishing national legislative and regulatory system of control.

- **Unsecured and open facilities pose a security challenge.** In many states, the institutional framework for the physical control and accounting of radioactive sources is insufficient. In contrast to nuclear material, which is usually stored in government-owned and secured facilities, radioactive material is typically used and stored by the private sector in facilities with minimal or no physical protection. Furthermore, medical, academic, and research sites are open environments accessible to large numbers of people. These open facilities, which typically have no trained on-site security forces, could be viewed as soft targets by potential adversaries.
- **Cradle-to-grave controls on radioactive materials remain weak.** Poor chain-of-custody procedures and insufficient or non-existent regulatory controls in many states have led to the loss of control over thousands of radiological sources. Even in states with regulatory controls in place, high disposal costs and a lack of repositories have led some end-users to abandon radioactive sources at the end of their life cycle. These "orphaned" radioactive sources, whether abandoned or disposed of illegally, present both a safety and security risk and may cause significant economic losses.

RADIOLOGICAL CASE STUDY: GOIÂNIA, BRAZIL

In the late 1980s, a widely publicized incident in Brazil highlighted the importance of properly securing dangerous radiological sources.

A private radiotherapy institute in Goiânia relocated, leaving behind a cesium-137 teletherapy unit without notifying the licensing authority, as required by law. Two people subsequently entered the vacant premises and, not knowing what the unit was but thinking it might have some scrap value, tried to steal the unit. In their attempt, the radiological source capsule was ruptured and radioactive chloride salt readily dispersed. The environment was contaminated, and several people were irradiated at the site.

Parts of the disassembled unit were then sold for scrap to a junkyard owner who noticed some of them glowed blue in the dark. Over a period of days, friends and relatives came to see the phenomenon, and fragments of the glowing source the size of rice grains were distributed to several families. This activity went on for five days, by which time a number of people were showing gastrointestinal symptoms due to their exposure to radiation.

The incident and the aftermath caused approximately $36 million in damages to the region in medical costs and long-term environmental problems. There were 28 radiation injuries, 20 people hospitalized, and at least four deaths. More than 112,000 people were monitored for contamination. Furthermore, 101 homes were significantly contaminated, and 41 homes were evacuated. The decontamination process required houses and other buildings to be demolished and generated 123,600 cubic feet of radioactive waste (enough to fill more than three U.S. football fields from goal post to goal post).[4]

[4] See "The Radiological Accident in Goiânia," available at www-pub.iaea.org/mtcd/publications/pdf/pub815_web.pdf; Marlese Simons, "Radiation Fears Infect Brazil After Accident," *New York Times* (December 2, 1987), available at www.nytimes.com/1987/12/02/world/radiation-fears-infect-brazil-after-accident.html.

It is important that states strengthen international and domestic regulatory and legal frameworks for radiological security, but radiological security is more than just a government responsibility.

- **Tracking radioactive sources is a major challenge.** The use of radioactive sources is widespread and frequently involves transboundary movement of sources, making it difficult for states to keep track of radioactive sources and leaving them vulnerable to theft, particularly while in transit.

To address these challenges, leaders from government and the private sector must work together to raise greater awareness about the threat, to develop an effective system for securing radiological materials just as they are doing for dangerous weapons-usable nuclear materials, and to replace the use of dangerous isotopes with alternative technologies where possible for permanent threat reduction.

It is important that states strengthen international and domestic regulatory and legal frameworks for radiological security, but radiological security is more than just a government responsibility. The private sector—the owners and operators of radiological sources—must advocate for and implement tighter security around these potentially dangerous sources in tandem with governments.

RECOMMENDATIONS FOR IMPROVING RADIOLOGICAL SECURITY

An effective, international radiological security regime would require states to take measures to secure their radiological sources, implement harmonized regulatory requirements, coordinate with other states to share knowledge and experiences, and strengthen collaboration with the private sector as well as with international organizations, such as the IAEA.

There are numerous recommendations for states to implement individually and collectively to improve the security of radiological sources. Below is a list of key recommendations for states to adopt at the 2016 Nuclear Security Summit and beyond.

1. Strengthen the International Framework

The IAEA Code of Conduct is a primary instrument aimed at enhancing the security of radioactive sources, though there is no accountability mechanism to ensure that recommended standards are being met. Political commitments to the Code of Conduct have been instrumental in raising awareness, establishing best practices, and gaining acceptance, but it should be recognized that the Code of Conduct is nevertheless a non-legally binding framework. A stronger international framework for radiological material governance and accountability is needed if the international community is serious about countering the threat posed by radiological materials. The development of an international global standard or convention for radiological security would help to ensure that controls are in place for the life cycle management of these sources and that all users, exporters, and recipients of sealed sources[5] abide by a harmonized set of standards and legally binding obligations for securing their material. It might be possible for such a development to proceed in parallel with the continued implementation of the Code of Conduct.

[5] A sealed source is radioactive material that is (a) permanently sealed in a capsule or (b) closely bonded and in a solid form; see "Code of Conduct on the Safety and Security of Radioactive Sources," and supplementary "Guidance on the Import and Export of Radioactive Sources," available at www-ns.iaea.org/tech-areas/radiation-safety/code-of-conduct.asp.

At the upcoming 2016 Nuclear Security Summit, world leaders should commit to developing stronger global standards and determine the most appropriate forum to create the necessary political momentum beyond 2016.

A stronger framework for radiological security and control would also fill a gap in international instruments aimed at preventing terrorists' use of chemical, biological, radiological, and nuclear weapons (CBRN). Currently, legal instruments include the Biological Weapons Convention, Chemical Weapons Convention, Treaty on the Non-Proliferation of Nuclear Weapons, Convention on the Physical Protection of Nuclear Material, and the International Convention for the Suppression of Acts of Nuclear Terrorism. Multilateral export control regimes include the Nuclear Suppliers Group, Zangger Committee, Wassenaar Arrangement, and Australia Group. None of these are dedicated instruments or regimes for addressing threats posed by radiological materials.

At the upcoming 2016 Nuclear Security Summit, world leaders should commit to developing stronger global standards and determine the most appropriate forum to create the necessary political momentum beyond 2016.[6] There are three mechanisms that should be used to strengthen the international framework. First, the IAEA's International Working Group on Radioactive Source Security could allow Member States to examine the advisability of establishing a stronger international instrument for radioactive sources that draws on the success of the Code of Conduct and is legally binding, similar to other CBRN materials of concern. Second, IAEA Member States could also identify ways to strengthen other conventions that support the Code of Conduct, such as the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, and the Global Initiative to Combat Nuclear Terrorism. Third, an International Workshop on the Safety and Security of Radioactive Sources will be held in Berlin, Germany, in September 2016. This workshop, which will be coordinated in cooperation with France, Germany, and the United States, will review the adequacy and sustainability of the Code of Conduct and identify areas where additional supplemental guidance is required.[7] All three of these activities should feed into the recommendations and conclusions that will be presented at the December 2016 IAEA Ministerial Conference on Nuclear Security for further action.

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[6] One of the findings from the Abu Dhabi 2013 International Conference on the Safety and Security of Radioactive Sources was a recommendation to convene a working group to assess the merits of developing a convention on the safety and security of radioactive sources and make recommendations so that an informed decision can be made by the IAEA. A working group has not yet been established.

[7] The IAEA is evaluating the development of guidance and recommendations on the long-term management of disused sources in order to identify appropriate storage and disposal practices, and encourage a policy of returning materials to supplier.

Making a political commitment to support the Code of Conduct is only the first step. More targeted efforts will be necessary.

2. Broaden Universal Coverage for the Code of Conduct

The Code of Conduct was drawn up by the IAEA to assist states in developing and maintaining high levels of safety and security for radioactive sources. It provides a basic governance framework for radioactive sources composed of key safety and security requirements that states should ensure are addressed in their laws and regulations as well as by their administrative bodies. It is important to emphasize that adherence to the Code of Conduct is voluntary and that many states have not yet signed on to its framework. In addition, it does not provide a detailed or exhaustive list of measures. Because the use of radioactive sources frequently involves the transboundary movement of sources, members of the international community also endorsed the first international export control framework for radioactive sources, contained in the non-legally binding IAEA Guidance on the Import and Export of Radioactive Sources (supplemental Guidance). The supplemental Guidance was developed in 2004, and subsequently revised in 2011, to track cross-border movements of sources and to better ensure that the recipient is authorized to possess the sources.

The IAEA has also worked extensively to encourage universalization of the Code of Conduct by all IAEA Member and Non-member States, and to encourage countries to implement (and politically commit to) the Code of Conduct and the associated supplemental Guidance through regional workshops and regular activities within its legislative assistance program. These activities have succeeded in raising global awareness of the need to better protect those potentially dangerous sources.

Over the past decade, the international community has made measurable strides in improving the security of radioactive sources. However, making a political commitment to support the Code of Conduct is only the first step. More targeted efforts will be necessary to focus on what states have done to implement the Code of Conduct within their national legislatures and to strengthen measures to protect radiological materials from theft.[8] To date, only 130 of 168 Member States (77 percent) have made a political commitment to the IAEA Director General to follow the Code of Conduct, of which only 101 have made a commitment to follow the supplementary Guidance. To facilitate the timely review of export authorizations and to further harmonize the application of the supplemental Guidance, 89 Member States made available to the IAEA through official channels their responses to their Importing and Exporting States Questionnaire[9] as well

[8] Paragraphs 18 and 19 of the Code of Conduct on the Safety and Security of Radioactive Sources propose elements for a legislative framework for the safety and security of radioactive sources. Paragraphs 20–22 propose elements for a regulatory body, including powers and responsibility.

[9] See "Guidance on the Import and Export of Radioactive Sources, Annex I," available at www-pub.iaea.org/MTCD/Publications/PDF/8901_web.pdf.

as any updates of those responses.[10] To ensure that radiological sources are secure, 38 additional IAEA Member States must join the Code of Conduct and follow through by codifying it into domestic law.

This lack of states' commitment illustrates clear gaps in national and international coverage for the Code of Conduct and its provisions. These gaps will require the international community, along with the IAEA, to work together to provide the financial, technical, and political resources to assist states in implementing the Code of Conduct through bilateral and/or regional partnerships, training, and information exchanges as well as raising awareness to other states that complacency undermines the effective protection of high activity radioactive sources globally.

3. Build and Strengthen the Regulatory Framework

An effective regulatory infrastructure also forms the basis for effective control of radioactive sources. A legislative and regulatory framework for radiological security ensures that all competent authorities have sufficient legal authority to fulfill their assigned radiological oversight responsibilities and to enforce security at sites. The Code of Conduct and its supplementary Guidance, together with IAEA safety standards, provide the international requirements and recommendations for developing and harmonizing policies, laws, and regulations on the safety and security of radioactive sources. They provide a basic governance framework for radioactive sources made up of key safety and security requirements that states should ensure are addressed in their laws and regulations as well as by their administrative bodies.

The Code of Conduct does not, however, provide a prescriptive or exhaustive list of measures. This has resulted in the lack of uniformity in the interpretation and application of international guidance and standards. This has also resulted in regulatory gaps in the effective management of radiological sources both at the national and the international levels. Establishing an effective regulatory framework to ensure that states protect the highest activity radiological sources as well as developing a strong national regulatory infrastructure for sustaining security of sources over the long term will require several key regulatory elements:

- First, a state's regulatory body must have the necessary independence to perform its radiological security responsibilities and functions. This requires standards of professional competence of the regulatory staff, the availability of adequate and independent financial resources, and the establishment of a security culture in both the regulatory body and the licensees. The absence of a dedicated body responsible for both security and safety has the potential to compromise one for the other.

- Second, a mature regulatory framework for securing radiological sources requires states to establish a comprehensive life cycle management of radioactive sources. Such a framework, at a minimum, addresses national

[10] The objective of the IAEA "Guidance on the Import and Export of Radioactive Sources" is to improve the safety and security of imports and exports of radioactive sources in accordance with the provisions laid down in paragraphs 23–29 of the Code of Conduct. With this objective in mind, this supplementary Guidance is not intended to impede international cooperation or commerce, as long as these do not contribute to the use of such sources for purposes that threaten safety and security. States should consider this Guidance in a manner consistent with their national legislation and relevant international commitments.

Radiological security is the responsibility of each individual country and the private sector, but international cooperation is vital to support states in establishing and maintaining effective radiological security regimes.

source tracking, orphan source identification and recovery capabilities, import and export, and end-of-life management capabilities. A national registry allows a regulatory body to follow transactions of high-risk radioactive sources from origin, through transfer to another licensee, to final disposition. These systems typically ensure that national radioactive source authorization, possession, and transaction information is available to all government agencies that protect the country from radiological threats and alert regulators to track discrepancies if sources become lost, stolen, abandoned, or disused. Additionally, establishing an effective import and export control regime represents the first line of defense in ensuring that only authorized recipients can receive and possess radioactive sources. All states should have the regulatory capacity to authorize imports and exports for Category 1 and 2 sources. Similarly, developing a national policy to manage sources at the end of their life cycles should consider establishing a dedicated storage facility for radioactive sources, creating contractual and financial provisions for end-of-life disposal of radioactive sources, preparing for bankruptcy situations, and emphasizing record keeping and inventory.

- Third, efforts to enhance the security of radiological materials over the long term cannot be solved by only implementing physical protection. The broader strategy must recognize that indigenous laws, regulations, and authorities need to be a fundamental part of a comprehensive and sustainable strategy. This will require states to acknowledge that a strengthened national regulatory framework contributes to and strengthens the global architecture.

4. Strengthen the Role of the IAEA

Radiological security is the responsibility of each individual country and the private sector, but international cooperation is vital to support states in establishing and maintaining effective radiological security regimes. The IAEA's role reflects its broad membership, its mandate, its unique expertise, and its substantial experience of providing technical assistance and practical guidance to states. The IAEA should continue to play a central role in promoting and strengthening the global radiological security architecture.

The central role of the IAEA in facilitating such cooperation, and providing assistance to states, is well recognized. The IAEA provides guidance in developing and implementing effective nuclear and radiological security measures, and supports national efforts to enhance nuclear security through nuclear and radiological security guidance documents and associated support and review programs (e.g., assessments through self-assessment and peer review missions). The IAEA can perform assessment missions, but these must be at the request of the specific country. Recently, the IAEA included a module on radiological security within the framework of IPPAS. Member States should request more of these peer review missions and share the report findings and recommendations with other states.

The IAEA also serves as a coordinating body for nuclear and radiological security, encouraging continued pledges and universalization of the Code of Conduct. States that publicly express their full support and endorsement of the Code of Conduct must undertake to formally support (in writing) their commitment to the IAEA.

The IAEA can continue to play a centralized role in enhancing the security of radiological sources by raising awareness, developing standards and guidance documents, convening international conferences and workshops, and providing assistance and review services to national infrastructure for radiological sources. This will require political support as well as predictable programmatic funding to support the IAEA's core nuclear and radiological functions within the IAEA's Division of Nuclear Security. To date, the IAEA has relied on extra-budgetary contributions to implement its nuclear security action plan through the Nuclear Security Fund and to fulfill requests from Member States for radiological security support, including training, equipment, and physical protection upgrades.

In order to ensure that the IAEA continues to grow in strength and effectiveness, the upcoming NSS should also reinforce the IAEA's "essential role" in coordinating global nuclear and radiological efforts. The IAEA ministerial-level nuclear security conference in 2013 sent a strong message that nuclear and radiological security is recognized globally as a priority. The results of the conference also served as important input for the IAEA Nuclear Security Action Plan (2014–2017). The next IAEA Ministerial Conference on Nuclear Security will take place in December 2016, and radiological security should continue to be a prominent part of the agenda for this meeting.

A core group of like-minded countries should take advantage of this unique opportunity for action, in consultation with the IAEA, on radiological security. A roadmap of actions could be proposed in the short term to, among other topics, strengthen and expand support for the international framework of conventions and IAEA guidelines relevant to the safety and security of high activity radioactive sources; support the development and use of alternatives to high activity radioactive sources; and enhance the efforts of the Ad hoc Meeting of States that are Major Suppliers of Radioactive Sources[11] and their respective industry to further strengthen and harmonize supplier state activities to improve the safety and security of high activity radioactive sources.

5. Increase Voluntary Actions

Outside of the Nuclear Security Summit process of national reports and statements, a formalized process for information sharing was introduced in 2006 at the IAEA General Conference (GC (49)/RES/9/A9), and it provides a forum for the evaluation of progress made by states toward implementing the Code of Conduct. This mechanism

[11] The Ad hoc Meeting of States that are Major Suppliers of Radioactive Sources is an informal group that meets annually on the margins of the IAEA meeting on the Code of Conduct.

was established to encourage annual information exchange meetings, ad hoc regional meetings, and triennial international meetings organized by the IAEA Secretariat.[12]

One of the key objectives of instituting a formalized process for information sharing is to assist states in their national implementation of the Code of Conduct and supplementary Guidance by enabling them to learn from the experiences of others, and to evaluate their own progress on implementation. In addition to submitting topical papers, states participating in the international meeting are encouraged to prepare a national report to share their experiences and lessons learned in implementing the Code of Conduct and supplementary Guidance. The next Code of Conduct review meeting is scheduled for May 2016. The IAEA also convenes an International Working Group of Radioactive Source Security to bring together technical experts on security. To date, four international meetings have been held.

However, in line with the non-legally binding and flexible nature of the Code of Conduct and other technical meetings, both participation from Member States and presentations are voluntary in nature and vary in level of attendance and information exchange.[13] The formalized process allows for intergovernmental organizations to attend as observers, but only a handful have attended previous meetings. Moreover, these meetings typically do not engage a broad spectrum of the private sector that have a stake in supporting radiological security.

Another major shortcoming is that while these annual meetings typically produce a Chairman's summary report that identifies key shortcomings, the report is not formally adopted by participating states, and the IAEA Director General does not submit the report to the IAEA's policy-making organs for information and action. Additionally, support for these meetings and recommended actions are funded through extra-budgetary contributions.

In order to strengthen the current information sharing mechanism post-2016, Member States should fund the IAEA's formalized process for information sharing through the IAEA's regular budget, and consider submitting the recommendations and findings of the Chairman's report to the IAEA's policy-making organs for information and action. Member States should also amend and finalize guidelines used to provide national reports in order to improve the current structure and promote consistency and more detailed information sharing prior to the May 2016 Code of Conduct review meeting.

Additionally, Member States should expand support for information exchange through broader stakeholder representation. This could be achieved, in parallel to the current process, by establishing an inaugural conference—akin to the Reduced Enrichment for Research and Test Reactors (RERTR) conferences for minimizing HEU use in research and test reactors—to explore securing radiological sources, repatriating sources, replacing them with non-isotopic alternatives, removing disused sources, etc. This conference could encourage a broader range of stakeholders (e.g., government,

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12 In 2006, the IAEA and Member States formalized a process for a periodic exchange of information and lessons learned: (1) an international meeting held every three years to review progress in implementing the Code of Conduct at an international level, including sharing experiences, lessons learned, and good practices and to identify existing and future challenges with regard to ensuring the safety and security of radioactive sources; and (2) regional meetings held on an as needed basis to share information on experiences on implementing the Code of Conduct and supplementary Guidance.

13 The IAEA annual meetings on the Code of Conduct routinely draw experts from roughly 80 countries. However, only a limited number of NGOs attend as they may only attend as observers.

Improving security around many radiological sources is often the preferred option—but for some sources, there is a better option: replacing them with new, non-radiological technologies.

industry, end users, academia, and non-governmental organizations) and be a major international annual conference to share best practices and technology solutions, catalyze actions to discuss radiological terrorism, and bring high-level political attention to these important issues.

Promoting the establishment of such a conference with a wider stakeholder base would also establish a stronger "norm" for national reporting on radiological security progress as well as recognize industry and the non-governmental community as integral supporters and contributors to global radiological security efforts. Consideration should be given to holding such a conference on the margins of the IAEA Ministerial Conference in December 2016.

6. Accelerate the Development and Use of Alternative Technologies

Improving security around many radiological sources is often the preferred option—but for some sources, there is a better option: replacing them with new, non-radiological technologies. In recent years, there have been significant technological advances in developing alternative medical and research technologies (such as x-rays or linear accelerators) that do not use radiological isotopes but have equivalent outcomes. As progress in the technical, operational, and economic feasibility of these replacements continues, states and the private sector should move to permanent threat reduction by transitioning, where applicable, to alternative technologies. This is the case particularly for the use of one of the most dangerous isotopes—cesium–137, which is used primarily in medical equipment. X-ray technology, which does not require the use of radioactive sources, is the most common and widely available alternative to cesium–137 used in blood irradiation. All hospitals should replace these irradiators to reduce risk and potential liability if the radiological sources are stolen. Such actions would be consistent with the 2008 report by the U.S. National Academy of Sciences,[14] which called for eliminating all Category 1 and Category 2 cesium chloride sources in the United States and, if possible, elsewhere. Some countries have taken impressive steps to reduce the threat posed by cesium blood irradiators and are far ahead of efforts in the United States. For example, the Norwegian government required that all cesium-137 blood irradiators be phased out by 2015. Broader support for developing alternative technologies could be achieved by sharing national policies and experiences in substituting high activity sealed sources with alternative technologies as well as coordinating on research and development efforts.

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[14] See "Radiation Source Use and Replacement," available at www.nrc.gov/reading-rm/doc-collections/congress-docs/correspondence/2008/cheney-02-19-2008.pdf.

The private sector, in close coordination with national research and development efforts, can play a key role in promoting the development, certification, promotion, and demonstration of innovative technologies that do not require the use of high activity radiological sources.

Radiotherapy devices using cobalt-60 (Co-60) are commonly used around the world in to destroy tumors during cancer treatment. Other alternative technologies, such as linear accelerators (LINACs), can be used to replace them.

In the United States and other developed countries, nearly all Co-60 teletherapy devices have been replaced with LINACs, which are electric devices that produce high-energy x-rays without any radiological security risk. Unfortunately, Co-60 teletherapy devices remain common throughout the developing world. Replacing these internationally will involve strengthening infrastructure, addressing maintenance and warranty issues, providing training, funding the procurement of expensive LINACs, and providing for the disposition of the disused sources. The international community in coordination with the IAEA should develop a program to address these challenges and accelerate the transition from teletherapy to LINACs.

Parallel efforts also should be accelerated to develop and promote alternative technologies for a wide range of medical and industrial applications. The private sector, in close coordination with national research and development efforts, can play a key role in promoting the development, certification, promotion, and demonstration of innovative technologies that do not require the use of high activity radiological sources. Non-isotopic alternative technology has become increasingly available worldwide, and industry should continue to develop and explore applications that, in many cases, are on par with their isotopic counterparts. An enhanced effort in this area could be similar to industry's role in promoting the reduction of use of HEU through the conversion of HEU to low enriched uranium (LEU) in research reactors, where technically and economically feasible.[15]

7. Strengthen the Role of the Private Sector

The Nuclear Industry Summits (NIS) have succeeded in raising awareness of nuclear and radiological security issues among hundreds of senior executives across many industries. Since 2010, these industry summits have been an integral and official side event at the official Nuclear Security Summits. The role of the NIS in previous summits has been to enhance awareness in nuclear security and to establish commitments, worldwide, to improve governance and management arrangements.

[15] At the March 2014 Nuclear Security Summit, the United States introduced a commitment to "establish an international research effort on the feasibility of replacing high activity radioactive sources with non-isotopic technologies, with a goal of producing a global alternative by 2016."

The responsibility and accountability to secure radiological sources should be shared by the owners and operators of sources. Because radiological materials are mainly used by the private sector and are not under immediate government control (like nuclear material), industry represents the first line of defense to prevent radioactive material from falling into the hands of terrorists. This is why the private sector's role is critical to radiological security efforts—industry is required to translate legislation and regulations into concrete actions that are implemented by users in the private sector. These organizations using radioactive sources are both public and private and may be quite diverse, even for a given application.

The private sector also provides a vital contribution to modern society by supplying essential radioactive materials and sources for industry and tens of millions of patients each year. Similar to the nuclear industry, the radiological industry has a critical role in ensuring security at civilian medical, research, and industrial facilities that they operate, and/or the materials they supply. Supplier states and industry also cooperate between their suppliers and recipient states to develop common practices on exports and on the management of the end-of-life of high activity sources, especially on the return of disused material to a supplier.[16]

The private sector can play an important role in global radiological security efforts by advocating for best practices and ensuring corporate responsibility for radiological security, security culture, training for key personnel, and systems for testing security on a regular basis. Professionals with a role in radiological security should be cultivated through such means as qualification, education, and training programs. The private sector should also be encouraged to promote international exchange of experience on ways to develop, foster, and maintain a robust national radiological security culture, compatible with the state's nuclear security regime. The World Institute for Nuclear Security (WINS), which was established as an international forum for nuclear security professionals to exchange best practices, is just one forum for facilitating dialogue among the nuclear industry worldwide.

The Nuclear Security Summit in 2016 will continue to play an important role in facilitating dialogue among the nuclear industry worldwide. The NIS will emphasize three key priorities:

(1) Improving corporate governance (and the role of the nuclear industry in the security of its materials and technologies);

(2) Enhancing cybersecurity; and

(3) Strengthening control over the use, storage, and transport of strategic nuclear and radiological materials.

These objectives will greatly contribute to the security arrangements within national regulatory frameworks and reaffirm industry's role to partner with states to strengthen radiological security.

[16] The Ad hoc Meeting of States that are Major Suppliers of Radioactive Sources can be the appropriate forum to develop such common practices. Discussions have also included harmonizing import and export procedures and communications, repatriating vulnerable disused radioactive sources, and developing best practices for import/export.

8. Make New Commitments at the 2016 Nuclear Security Summit

Twenty-three countries took an important step on radiological security when they committed, at the 2014 Nuclear Security Summit, to secure their radiological sources. More countries should support and adopt a new joint statement on radiological security at the 2016 Summit. This new joint statement should include additional commitments to secure radiological sources, convert to alternative technologies (where feasible), encourage the creation of a working group to assess the merits of a legally binding convention, and other steps to strengthen the global radiological security regime. In addition, NSS countries should consider convening a meeting in the period between the Nuclear Security Summit and the December 2016 IAEA Ministerial Conference on Nuclear Security to further promote radiological security. Recommendations and actions could feed into both the December 2016 Ministerial Conference as well as the IAEA process so as not to lose any momentum on this urgent issue.

Finally, it is essential to make broad and tangible progress on the IAEA Action Plan commitments and agree on how to sustain and expand these efforts going forward. With regard to the IAEA Action Plan and radiological security, adopting and implementing any portion of the action plan will occur through the decision-making processes of the IAEA, and will rely on the ability to attract support from IAEA Member States outside the summit process. Long-term and sustained high-level attention on radiological security will require a regular structured mechanism within the IAEA, or from a core group of states that can serve as a forum for future progress and accountability. Progress on radiological security should be reviewed at the December 2016 IAEA Ministerial Conference in Vienna, Austria.

“Given the stated interest by terrorist groups and the widespread availability of potentially dangerous radiological sources, it is nothing short of a miracle that we have not yet seen a dirty bomb terrorist attack. We must act before our luck runs out.”

— Sam Nunn and Andrew Bieniawski,
Washington Post op-ed, Aug. 21, 2015

APPENDIX A

Key Elements of the 2014 NSS Joint Statement

As noted, the 2014 NSS Joint Statement on Enhancing Radiological Security is an extremely valuable set of commitments that can make an important difference on securing radiological sources. The Joint Statement includes three main elements:

1. A commitment by 23 countries to secure their IAEA Category 1 sources by the end of 2016.
2. Additional commitments to improve radiological security by:
   - Supporting an independent regulatory body with effective authority;
   - Establishing a comprehensive life cycle management plan for sources (e.g., import/export controls, orphan source recovery, national registry);
   - Developing a comprehensive plan for sources out of regulatory control (e.g., search and secure);
   - Assessing the domestic threat and developing a national response plan;
   - Implementing site level security measures (e.g., physical protection measures, procedures, training, performance testing, maintenance, awareness, trustworthiness of individuals involved in the management of radioactive sources);
   - Providing rapid response to any attempted or actual unauthorized access; and
   - Cooperating with other states and multilateral organizations to complete the above-listed radiological security measures.
3. Additional best practices:
   - Robust physical protection access controls preferably with multifactor authentication to restrict access to radiological sources;
   - Monitoring systems designed with defense in depth;[17]
   - Enhanced delay measures to allow response forces to arrive in time to address the security threat;
   - Active involvement of off-site response forces in both maintaining awareness of radiological sources and threats as well as engaging sites with radiological sources in planning and training activities; and
   - A robust and holistic regulatory framework that governs secure source transportation, possession, and disposition.

[17] Defense in depth is a concept used to design physical protection systems that require an adversary to overcome or circumvent multiple layers of protection or obstacles in order to achieve his/her objective.

APPENDIX B

What is the IAEA Code of Conduct on the Safety and Security of Radioactive Sources?

Ensuring safety when using radiation sources and operating related facilities is of paramount importance for the protection of people and the environment from any associated radiation risks.

The Code of Conduct was drawn up to assist states and their regulatory bodies in developing and maintaining high levels of safety and security for radioactive sources. It provides a basic governance framework for radioactive sources made up of key safety and security requirements that states should ensure are addressed in their laws and regulations as well as by their administrative bodies. It does not, however, provide a detailed or exhaustive list of measures, and it is not legally binding.

Paragraphs 7–22 of the IAEA Code of Conduct propose elements for a legislative framework for the safety and security of radioactive sources and elements for a regulatory body, including its powers and responsibilities.

The Guidance on the Import and Export of Radioactive Sources, which is supplementary to paragraphs 23–29 of the Code of Conduct, provides non-legally binding guidance for states on how to regulate imports and exports of certain radioactive sources. It is intended to establish a "common framework" that states may apply to Category 1 and 2 radioactive sources, as well as to other types. However, paragraph 5 of the Guidance cautions that it "should not be construed to amend or supersede applicable guidance under other multilateral import and export arrangements."[18]

[18] www-ns.iaea.org/tech-areas/radiation-safety/code-of-conduct.asp.

APPENDIX C

Understanding Radiological Materials

Radiological Dispersal Device vs. Improvised Nuclear Device

The IAEA ranks radioactive sources in five categories. Sources in Category 1 are considered to be the most dangerous because they can pose a very high risk to human health; an exposure of only a few minutes to an unshielded Category 1 source may be fatal. Sources in Category 5 are the least dangerous; however, even these sources could give rise to doses in excess of the dose limits if not properly controlled. It is important to note that the system is based on safety concerns, not "area denial" consequences if used in a radiological dispersion device.

The terms *dirty bomb* and *radiological dispersal device* (RDD) are often used interchangeably. According to the Nuclear Regulatory Commission, a dirty bomb combines a conventional explosive, such as dynamite, with radioactive material that may disperse when the device explodes.[19]

Often referred to as a **"weapon of mass disruption,"** the effects of an RDD can vary depending on what type of radioactive material is used and how effectively it is dispersed. If there are casualties, they will likely be caused by the initial blast of the conventional explosive. In most plausible scenarios, the radioactive material would not result in acutely harmful radiation doses, and the public health concern from the radioactive materials would likely focus on the chronic risk among exposed individuals of developing cancer. The consequences of an RDD may range from a small, localized area (e.g., a street, single building, or city block) to large areas, conceivably several square miles. However, the economic effect of an RDD could result in economic losses in the billions of dollars in remediation and relocation costs, depending on the chemistry and form of the radioactive material, means of dispersion, and location of the event.

An improvised nuclear device is very different from an RDD. An IND uses highly enriched uranium or plutonium to generate a nuclear explosion, and its use would cause hundreds of thousands of casualties over a much larger area. It also would produce potentially lethal radioactive fallout, which could spread far downwind and deposit over very large areas (potentially hundreds of miles). An IND would result in catastrophic loss of life, destruction of infrastructure, and contamination of a very large area.

Although not as deadly as an IND, an RDD is technically much easier to construct, and the materials required to assemble the device are much more prevalent in civilian use than those needed for an IND. In evaluating the risk (probability multiplied by consequences) of an IND versus RDD incident, most experts have concluded that the risk of an RDD attack is much higher than that of an IND attack.

[19] www.nrc.gov/reading-rm/doc-collections/fact-sheets/fs-dirty-bombs.html.

APPENDIX D

Methodology

At the March 2014 Nuclear Security Summit, 23 countries supported an NSS "gift basket" on enhancing radiological security. This gift basket recorded the intent of Algeria, Armenia, Australia, Canada, Czech Republic, Denmark, Georgia, Germany, Hungary, Italy, Japan, Kazakhstan, Lithuania, Morocco, Netherlands, New Zealand, Norway, Republic of Korea, Sweden, Turkey, United Arab Emirates, United Kingdom, and the United States, to secure their IAEA Category 1 radioactive sources by the end of 2016 and to take a number of actions contained within the IAEA Code of Conduct on the Safety and Security of Radioactive Sources.

NTI developed this *Radiological Security Progress Report* to assess the progress of the 23 countries in securing their radiological sources. The framework and timeline for preparing this report is described below in more detail.

TIMELINE TO CREATE THE RADIOLOGICAL SECURITY PROGRESS REPORT

MAY 2015

Formed and convened an International Panel of Advisors in Vienna, Austria

JUNE 2015

Developed an NTI questionnaire and submitted to all 23 countries for input

AUG/SEPT 2015

Reviewed responses and conducted a quantitative assessment based on weight factors and key performance indicators

SEPT 2015

Briefed Sherpas in Vienna, Austria

JAN 2016

Briefed Sherpas at NTI Global Dialogue Meeting in San Francisco, CA

MID-MAR 2016

Publish NTI *Radiological Security Progress Report*

About the International Panel of Advisors

In developing the NTI *Radiological Security Progress Report*, NTI convened an international panel of advisors to review and provide input to validate the *Radiological Security Progress Report* methodology. This group of 12 highly respected nuclear and radiological security experts advised NTI on the framework for producing a radiological report, an agreed set of key performance indicators that were used to develop a self-assessment questionnaire, and the rating system. Input from the panel was instrumental in ensuring that the *Radiological Security Progress Report* has an international point of view and reflects the ongoing international discussion on radiological security priorities.

The International Panel of Advisors included representatives from Canada, France, Mexico, Sweden, and the United Kingdom, from various agencies and organizations, including WINS, the Stanley Foundation, the James Martin Center for Nonproliferation Studies (CNS) Middlebury Institute of International Studies, the International Irradiation Association, and the IAEA Office of Nuclear Security and Technical Cooperation.

About the Authors

Andrew J. Bieniawski joined the Nuclear Threat Initiative (NTI) as Vice President for Material Security and Minimization after 25 years of serving in senior-level positions with the U.S. Department of Energy and the National Nuclear Security Administration. Bieniawski leads key NTI projects related to nuclear materials security and minimization, including the Global Dialogue on Nuclear Security Priorities, the International IAEA LEU Bank, and the International Partnership for Nuclear Disarmament Verification. He is also an expert in radiological threat reduction.

Prior to joining NTI, Bieniawski served as the Acting Principal Assistant Deputy Administrator for NNSA's Office of Defense Nuclear Non-proliferation and earlier led the U.S. government's Global Threat Reduction Initiative (GTRI), providing direct oversight to ensure the safe and successful completion of 21 highly complex operations to remove vulnerable nuclear material in more than 15 countries. He received the DOE Distinguished Career Service Award and NNSA Gold Medal. Bieniawski has a bachelor's degree in Nuclear Engineering from Pennsylvania State University and a master of arts degree from the Paul H. Nitze School of Advanced International Studies (SAIS) at Johns Hopkins University.

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Michelle Nalabandian serves as Program Officer for NTI's Scientific and Technical Affairs Program. She manages operational elements of the program and focuses on the security of nuclear and radiological materials, cybersecurity for nuclear facilities, and biosecurity threats. Prior to joining NTI, Nalabandian worked in the financial sector for asset management firms Global Environment Fund and Sciens Capital Management. Nalabandian holds a bachelor's degree in biology from George Mason University and received a certificate of mastery from the John F. Kennedy School of Government at Harvard University. She is a 2015 PONI Nuclear Scholar and a 2015 Fellow of the Emerging Leaders in Biosecurity Initiative (ELBI).

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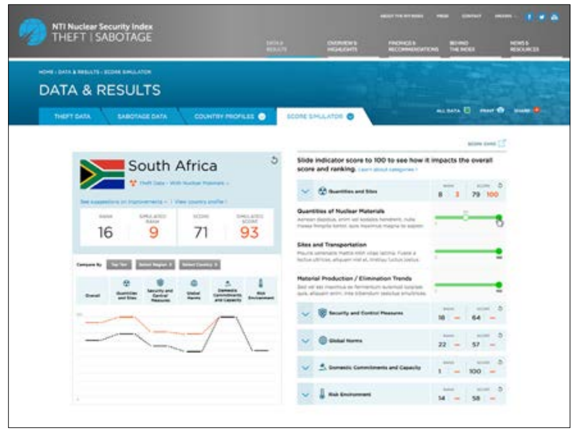
More Nuclear Security Summit Resources

Visit **www.ntiindex.org** to see all the data and new features of the *2016 NTI Nuclear Security Index: Theft/Sabotage*, including:

- A new interactive Score Simulator that allows visitors to test how score changes would alter a country's ranking—and its ability to protect against nuclear terrorism
- Full methodology, results, and data for all countries
- Translations of the NTI Index into Russian, Chinese, Arabic, French, Spanish (coming in 2016)
- Videos and infographics to share on social media
- *NTI Nuclear Materials Security Index*, 2012 and 2014 editions.



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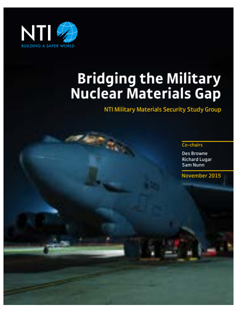

Drawn from input of former military and political officials from nuclear-armed states and co-authored by Des Browne, Richard Lugar, and Sam Nunn, ***Bridging the Military Nuclear Materials Gap*** offers recommendations for governments to tighten control and build confidence in the security of nuclear materials categorized as "military materials."

In ***The Case for Highly Enriched Uranium-Free Zones***, Andrew J. Bieniawski, Miles A. Pomper, and Elena Sokova call for the establishment of regional zones free of HEU.

In ***A Roadmap to Minimize and Eliminate Highly Enriched Uranium***, Andrew J. Bieniawski and Miles A. Pomper lay out a roadmap with five pathways to ending civilian HEU use and beginning the necessary research and development to minimize and ultimately eliminate HEU for naval use.

More Work to Do: A Pathway for Future Progress on Strengthening Nuclear Security by Jonathan Herbach and Samantha Pitts-Kiefer, published in *Arms Control Today*, explores how the 2005 amendment to the Convention on the Physical Protection of Nuclear Material (CPPNM) could create a much-needed forum for continuing discussions aimed at preventing nuclear terrorism after the Nuclear Security Summits.

Crossing the Finish Line: Ending the Civilian Use of HEU, developed for the Stanley Foundation by Miles A. Pomper and Philippe Mauger, describes steps that should be taken at the Nuclear Security Summit to build momentum toward the elimination of civilian HEU.

Global Dialogue on Nuclear Security Priorities at www.nti.org/globaldialogue

The papers below were created for the Global Dialogue, NTI's international, cross-sector discussion among leading government officials, experts, nuclear security practitioners, and other stakeholders.

Challenges and Opportunities for Strengthening the Global Nuclear Security System (September 2014)

High-Level Political Engagement to Strengthen Nuclear Security Beyond 2016 (January 2016)

Nuclear Security Primer: The Existing System (updated, January 2016)

Managing Stocks of Separated Plutonium to Mitigate Security Risks: Near-Term Steps, John Carlson (May 2015)

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