Defence Against Terrorism Review
Vol. 2, No. 2, Fall 2009, 49-58
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ISSN: 1307-9190

Atoms for Peace and the Nonproliferation Treaty: An Unintended Consequence

Charles STREEPER
Los Alamos National Laboratory, New Mexico, USA

Abstract: *Radioactive sealed sources have a long history of use and a much wider distribution worldwide than weapons-grade fissile materials. Through comparing such materials to sources, this paper will provide five key reasons for enhanced policy attention on safe and secure source management. 1) Weaponisation: Sources, used in the form of a radiological dispersal device (RDD), could have potentially devastating economic and public health impacts, yet creating an RDD is much easier than fashioning a nuclear weapon from raw materials or stealing one intact. 2) Incidents: There are many well-documented accounts of diversions and misuse of radioactive materials from regulatory control. Of further concern, the number of radiological diversion incidents is probably under-reported and rising, IAEA reporting requirements are inadequate. 3) Security of Materials: The burden of securing sealed sources often falls on the owner of the source, who may lack a viable disposal pathway at the end of the lifecycle. International variances in requirements for source management make their security much more difficult. 4) Accountancy: Unlike weapons-useable materials, it is difficult or impossible to determine the total amount of sources manufactured and distributed in each country, much less worldwide. 5) Import/Export Controls: Unlike weapons-useable materials, disused sources are constantly found illegally transiting borders, with little media attention and varying penalties. Also the supply and demand of sources, being market-based, are very dynamic, and the regulations are designed for their rapid commercial distribution.*

Keywords: *Radioactive sealed sources (sources), weapons-useable materials, source management, IAEA, NPT.*

Introduction

In April 2009, US President Barack Obama revived nonproliferation and arms control efforts with a speech calling for the worldwide abolition of nuclear weapons. His speech rightly acknowledged

the threat of nuclear terrorism and the vulnerabilities of related unsecured nuclear materials. Unfortunately, the Obama administration and many policy-makers worldwide have not provided the appropriate emphasis on the threat posed by at-risk radioactive materials. Scant attention has been given to the threat posed by the enormous quantities of radioactive sealed sources (sources)[1], which have already been widely distributed globally; this threat has been allowed to increase for decades and has only recently become of political interest as a security issue. Though they continue to remain a perilous threat to the international community, disused or orphan sources and the inherent threat they pose have scarcely been reported by news organizations and have been excluded from most nonproliferation policy discussions.

Background

Starting in the mid 1950s, US President Dwight D. Eisenhower's Atoms for Peace initiative promoted the spread and use of the paradoxically beneficial yet destructive properties of the atom. Sources have a long history of use and a much larger distribution worldwide than weapons-grade fissile materials (weapons-useable materials).[2] Pair this with their broad ranges in isotopes/activities along with minimal mechanisms and barriers facilitating their safe and secure management, and it is not difficult to envision a deadly threat.

Nonproliferation efforts have a well-documented history of focusing on weapons-useable materials and other key materials (chemical and biological) and associated technologies used in a Weapon of Mass Destruction (WMD). One example of how nuclear weapons can overshadow other important threats is how nuclear topics have remained the focus of negotiations and the public war of words with the Democratic People's Republic of Korea (DPRK, or North Korea), while the topic of the perilous threat of the DPRK's stockpiles of chemical/biological weapons is rarely broached.[3] Such intense focus on WMD-related materials/technologies is essential for international safety and security; however, the perception that high-activity sources are of little concern is dangerous. In fact, in the not-so-distant past, radiological weapons were once considered potential WMD material, and the United States and Soviet Union both proposed their prohibition in both the United Nations General Assembly and the then Committee on Disarmament. Nonproliferation threat perceptions appear to be based solely on the scale of the consequences of a WMD event and proliferation concerns without significant consideration of the likelihood of a non-state actor or insider acquisition and misuse of the materials.

Arguments that attempt to minimize or divert attention away from sources may have the effect of distracting necessary policy attention on preventing/mitigating radiological dispersal events. The terrorist attacks on 9/11 should be a clear reminder of the inherent danger of downplaying

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1 High-activity sources are IAEA Category 1 and 2 sources; Category 1 sources are those that if mismanaged with short-term exposure give an acute dose resulting in death or permanent injury; Category 2 sources have the same effect, but require longer-term exposure.

2 For the purposes of this article, weapons-useable materials are uranium (U) with concentration of over 90% of the isotope ^{235}U (HEU) and plutonium with more than 90% of the isotope ^{239}Pu.

3 Ashton B. Carter and William J. Perry, *Preventive Defense: A New Security Strategy for America*, Brookings Institution Press, Washington, DC, 1999.

perceived lower-level threats. While attention should not be diverted from vulnerable weapons-useable materials, the existence of unregulated sources should be a top concern in every country's evaluation of global threats. Through comparison of weapons-grade, weapons-useable materials and source management, this paper will provide five key, yet not all inclusive, reasons for enhanced policy attention on safe and secure source management.

Weaponisation

There are many security (i.e. Permissive Action Links, or PALS) and technical complications (i.e. Criticality) associated with fashioning weapons-useable materials into and detonating a nuclear weapon.[4] Mitigating all possible or likely terrorist attacks is impossible; however, weaponised sources, in the form of radiological dispersal or radiation-emitting devices (RDD/RED), have been a declared target material of Al-Qa'ida.[5] An RDD is a device or mechanism that is intended to spread radioactive material from the detonation of conventional explosives or other means. RDDs are considered weapons of mass disruption; few deaths would occur due to the radioactive nature of the event, but significant negative social and economic impacts could result from public panic, decontamination costs, and denial of access to infrastructure and property for extended periods of time. An RED is a device whose purpose is to expose people to radiation, rather than to disperse radioactive material into the air, as an RDD would. Several expert studies have demonstrated the potentially devastating economic, psychological and public health impacts of terrorist use of an RDD in a metropolis.[6] The development of such a weapon, from the acquisition of the radioactive material to the technical knowledge needed to fashion it into an RDD, is much easier than diverting enough weapons-useable materials for the fabrication or theft of an intact nuclear weapon.

Incidents

Undoubtedly, weapons-useable materials that are unaccounted for, especially in a form amenable to the development of a nuclear weapon, are of grave concern. Losses of control of weapons-useable materials or even intact weapons have occurred, and these incidents are rightly given utmost priority. However, there are many well-documented accounts of accidental and purposeful

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4 Michael Levi, "Using Murphy's Law Against Terrorists", in *On Nuclear Terrorism*, Boston, Harvard University Press, 2007, p. 224.

5 In January 2003, British officials discovered Al-Qa'ida training manuals on detonating a dirty bomb along with actual radioisotopes necessary for this at a nuclear laboratory in Herat, Afghanistan. Statements from Abu-Zubaydah that Al-Qa'ida already had this capability were made in 2002.

6 Examples are the following: B. Reichmuth, S. Short, and T. Wood, "Economic Consequences of a Rad/Nuc Attack: Cleanup Standards Significantly Affect Cost", PNNL-SA-45256, Richland, Washington, USA, Pacific Northwest National Laboratories, 2005. Tom Cousins and Barbara Reichmuth, "Preliminary Analysis of the Economic Impact of Selected RDD Events in Canada", presentation at the CRTI Summer Symposium 2007, Gatineau, Quebec, 11-14 June 2007 (CRTI 05-0043RD).

diversions of radioactive materials from regulatory control.[7] As of the end of 2008, the International Atomic Energy Agency's (IAEA) Illicit Trafficking Database logged 1,562 incidents, of which 18 included weapons-grade nuclear materials. As much as 66% of the radioactive material involved in these incidents had not been recovered. Since 2004, there has been a 75% increase in reported incidents of unrecoverable radioactive material, much of which is labelled "dangerous" with the potential for deterministic health effects if misused. [8]

One study looking at five known databases that track diversions of radioactive materials determined that the majority of reported events involve unknown materials of unknown origin.[9] Although withholding details of a reported theft or loss of sources could be intentional, it might also be the result of poor regulatory reporting or a lack of concrete information about many individual events. The incidents reported to the IAEA database rely solely on voluntary state reporting; therefore, the actual number of lost or stolen sources is likely much higher. As it would improve the IAEA's ability to trend incidents and facilitate the modelling of illicit trafficking pathways, IAEA member states should be required to report losses of control of sources or weapons-useable materials to the IAEA database.

Security of Materials

Aside from poorly secured HEU at the remaining research reactors that have yet to been converted to LEU and growing stockpiles of separated civilian plutonium, weapons-grade weapons-useable materials are usually protected through national security mechanisms. The burden of securing sealed sources, however, often falls upon the owner of the source. These source owners may not have a viable disposal pathway once the source reaches the end of its useful life. The disposal problem is exacerbated by some source owners lacking the resources or the will to maintain safe and compliant source storage. Variances in each nation-state's requirements for licensing, transporting, and enforcing proper source management throughout their lifecycle makes their security on a global scale much more difficult.

Accountancy

Scrupulous attention is paid to protecting and accounting for even gram quantities of weapons-useable materials. Although there are significant issues with weapons-useable materials, such as hold-up (i.e. materials unaccounted for in the U enrichment process), accounting for total legacy

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7 The Nuclear Regulatory Commission's "Event Notification Reports" are updated daily, and nearly every day of the year at least one source falls out of regulatory control (http://www.nrc.gov/reading-rm/doc-collections/event-status/event/2008/).

8 "IAEA Information System on Illicit Trafficking and Unauthorized Activities Involving Nuclear and Radioactive Materials", IAEA Fact Sheet, 2007, 18 August 2009 (http://www.iaea.org/NewsCenter/Features/RadSources/PDF/fact_figures2007.pdf).

9 Charles Streeper, Marcie Lombardi, and Lee Cantrell, "Nefarious Uses of Radioactive Materials", *Proceedings of the 48th Annual Institute of Nuclear Management Meeting, 13-17 July 2008: Session D Nonproliferation & Arms Control: Global Threat Reduction Initiative-Protect II*, INMM, Omnipress, 2007.

production of weapons-useable materials, etc., at least an attempt is made to scrupulously account for these losses. The US only started tracking high-activity Category 1 and 2 sources in 2009. It is difficult, if not impossible, to determine the total amount of sources manufactured and distributed in each country, much less worldwide. This inability to account for total source production is due at least in part to a lack of early production data or original records from source manufacturers that have gone out of business and a reluctance of current manufacturers to provide historic and current data on their source production for proprietary reasons. However, it is important to note that some past source manufacturers have been forthcoming in providing this information, and so efforts to encourage a methodology for governments to obtain this data from current manufacturers without compromising vital business information should be explored.

Export/Import Controls

Weapons-useable materials and technologies related to their development and delivery vehicles are controlled by a very limited set of restrictive supplier states/groups, and further controlled by international treaties, organizations, and nuclear weapon-free zones that tightly regulate supply and severely penalize their abuse. Not only is punishment meted out to those who attempt to circumvent these restrictions, but nation-states are also subject to international pressure and scrutiny based on breaking internationally established norms. In contrast, disused sources are constantly found illegally transiting borders, and their detection at most results in a news article or regulatory report followed by varying degrees of prosecution. Unlike weapons-useable materials, the supply and demand of sources, being market-based, are very dynamic. Exports and imports of sources are also regulated, but it is clear that the regulatory framework is designed for their rapid commercial distribution. Once the source has been distributed, more often than not, it becomes the property and responsibility of the recipient, and many countries' regulations have restrictions on the return import of the source, as they will not accept radioactive "waste" from other countries. Distribution of sources in a timely manner to the source owners is essential to public health, but timely return or proper disposal of those same sources, once they have outlived their usefulness, is also vital to international security. Concrete steps to ensure effective and economical source repatriation and disposal would be an excellent step towards responsible source management. Although this effort will require changes in the current policies and regulations of some source-manufacturing nations, the source owners should also be included in bearing some of the burden of repatriation.

Recycling

Weapons-useable materials – primarily HEU-downblended to low-enriched uranium (<20%) – also benefit from the capability to be reintroduced to the fuel cycle and burned in reactors. Although some sources can be recycled, this is often cost-prohibitive or unavailable, as when the manufacturer has gone out of business. The safe and secure removal of sources is often fraught with barriers such as a lack of disposal/storage pathways, transportation challenges, refusal of repatriation by the source manufacturer/nation-state, and others. Although the disposal of weapons-useable materials also faces enormous challenges, there is at least an enormous effort taking place to mitigate the problem.

IAEA

The IAEA was established in 1957 with a statute that mandated safeguards to assure the non-diversion of weapons-useable materials to military purposes. This was reinforced by the adoption of the Treaty on the Nonproliferation of Nuclear Weapons (NPT), which attempted to include all nation-states to ensure harmonized application of safeguards to prevent further proliferation of nuclear weapons. Normative security of radioactive sources exists, but it varies in each nation-state through non-legally binding, loosely implemented recommendations provided by IAEA Technical Documents (Tec-Docs)/Information Circulars (INFCIRCs) and other cooperation, such as international consultations on best practices and physical protection upgrades. Of course, those states that voluntarily implement IAEA suggestions and attempt to responsibly manage their sources with changes to their laws and regulatory systems do make legally binding commitments, but these too are voluntary and the IAEA does not have a mandate to enforce or oversee their implementation. Most recent IAEA numbers reflect that 95 out of the total 150 IAEA member states have declared a commitment to implementing the IAEA "Code on the Safety and Security of Radioactive Sources" (Code), of which only 53 stated they would harmonize their management of sources with the Code's guidelines.[10]

The 2004 Code and the supplementary 2005 "Guidance on the Import and Export of Radioactive Sources" (Guidelines) that followed were approved by the IAEA Board of Governors and General Conference and were meant to create a voluntary framework for source management and to harmonize related import/export controls. In 2006, a mechanism was established to provide information exchanges, share lessons learned, and to evaluate implementation of the Code. As the IAEA does have a mandate to ensure the peaceful uses of nuclear energy and sources are a direct by-product of nuclear energy, there should be increased funding and political will towards IAEA enforcement and oversight of the above-mentioned commitments. Although the Code does provide language suggesting regulatory authority for the repatriation and safe and secure storage/management of sources, it does not require that member states develop or outline end-of-life disposition strategies for sources. This leaves the sustainable long-term management of sources an open question.

Effect of the NPT

The NPT is a deftly negotiated settlement between Nuclear Weapon States (NWS) and Non-Nuclear Weapon States (NNWS). The NPT is meant to prevent the proliferation of nuclear weapon-related technologies and has been signed and ratified by nearly every country in the world. Despite the honourable intentions and necessity of the NPT as a crucial pillar in the nonproliferation regime, it also has had the unintended effect, through Article IV, of creating an obligation on NWS to share peaceful technology (sources with varying activity levels) worldwide. Article IV of the NPT requires "the fullest possible exchange of equipment, materials and

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[10] Steven McIntosh, International Atomic Energy Agency, *Technical Meeting on Implementation of the Code on the Safety and Security of Radioactive Sources with Regards to Long Term Strategies for the Management of Sealed Sources*, Vienna, International Centre, 2009.

scientific and technological information for the peaceful uses of nuclear energy…with due consideration for the needs of the developing areas of the world." The above commitment, combined with Atoms for Peace and the IAEA Statute, has led to the almost unrestricted global distribution of sources. As nearly all source manufacturers/distributors are official NWS under the NPT or states with existing advanced nuclear technologies, limits of supply might also threaten one of the NPT's core compromises (full exchange of peaceful nuclear technologies) made by NWS to NNWS and further erode the already contentious relationship.

Article VI of the NPT promotes complete disarmament of nuclear weapons, and many other treaties, agreements, governments and non-profit organizations dedicate enormous resources to reducing the amount of weapons-useable materials worldwide.

For sources, there is no legally binding equivalent to the NPT, nor to each signatory state's obligations under the NPT. The NPT has been criticized by some for its loopholes, but at least it exists as a foundation that has been built upon for decades. The Code and its Guidelines are positive steps towards a framework for safe and secure management of cradle-to-grave source lifecycles. The drawback is that because the Code is meant to only provide guidelines, it lacks the legal weight and enforcement mechanisms that a treaty provides. As a legally binding agreement may impose unrealistic goals on many IAEA member states, guidelines may be the most desirable approach. However, as the chairman's report of the 2009 Technical Meeting on Implementation of the Code suggested, harmonization of many aspects of the guidance among not only the member states, but all entities involved in source management, should be a priority.[11] Therefore, either multilateral or IAEA involvement in Code implementation should be a priority.

The problems in enforcement of the NPT through IAEA-mandated safeguard agreements, export control, and other international/national regimes and initiatives pale in comparison with the problems associated with voluntary implementation, reporting, and oversight of sources solely through each nation-state's regulatory framework and the Code. The scope of the problem – unquantifiable amounts of sources in nearly every country worldwide – is indicative of the necessity for a more comprehensive international effort to manage the situation.

Global Issue

Although weapons-useable materials and sources both have the issue of accumulating growth worldwide, weapons-useable materials are generally stockpiled and accounted for, and tremendous efforts towards their disposition are underway. HEU downblending and Pu reprocessing/ conversion to mixed oxide fuel for re-use in reactors are just a few of the nuclear fuel-related disposition methods already in progress. Separated civilian and military Pu stockpiles primarily reside in NWS,[12] as do 99% of total global stockpiles of HEU.[13] This demonstrates that weapons-

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[11] *Technical Meeting on Implementation of the Code of Conduct on the Safety and Security of Radioactive Sources with Regards to Long Term Strategies for the Management of Sealed Sources*.

[12] Exceptions are Israel, India, Pakistan and North Korea; however, their stockpiles total far less than those declared by the NWS.

useable materials tend to remain in countries with advanced nuclear programs and therefore benefit from established security, accounting, and control mechanisms. Alternative technologies to replace high-risk sources continue to be explored, but most of these are not cost effective or technically feasible.[14]

Although the importance of protection, control, and accountancy of weapons-useable materials is vital, the reasoning behind unanimous support for their nonproliferation should also have been applied to radioactive sources long ago. As a result of the ubiquitous nature and undeterminable number of current and legacy sources distributed, some are likely to be or will be abandoned, lost or stolen, or otherwise fall out of regulatory control. Disused and orphan sources are not only an issue for developing nation-states, but are truly a global phenomenon. For example, in the US alone, there are estimates of 5,000 devices (i.e. teletherapy heads, irradiators) containing 55,000 high-activity sources; tens of thousands of smaller sources are owned by the NRC and state licensees.[15] Worldwide there are likely millions of sources of varying activities and isotopes.

Source distributors rely solely on each nation-state's national regulatory agency, which may or may not exist or have effective enforcement mechanisms, to ensure that the end user will manage and dispose of the source properly. Compounding this issue, attempts to restrict the supply of sources to any nation-state would likely have immediate and long-term deleterious consequences to public health. Therefore, as suggested by Charles Ferguson's Occasional Paper 11, the quickest immediate relief to the issue of the global oversupply of sources would be for the IAEA to continue assisting states in improving their regulatory infrastructure.[16]

The Path Forward

The complementary relationship that exists in a strong commercial interest in supplying sources and the high demand for sources among end users must be addressed to ensure that continued source usage does not lead to an increase in society's vulnerability to an accident or deliberate misuse of an RDD. The international community can depend neither on commercial mechanisms nor the inconsistent implementation of individual nation-state's regulatory systems to control the distribution of sources worldwide. This holds true for weapons-useable materials as well, but less so, as at least national export control systems and supplier groups are designed to prevent the dependence upon commerce alone as a control mechanism.

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13 *Global Fissile Material Report 2008: Third annual report of the International Panel on Fissile Materials*, Program on Science and Global Security, Princeton, New Jersey, Princeton University, 2008, pp. 7-16.

14 Committee on Radiation Source Use and Replacement.

15 Committee on Radiation Source Use and Replacement, National Research Council, National Academy of Sciences, *Radiation Source Use and Replacement*, Washington, DC, The National Academies Press, 2008.

16 Charles D. Ferguson, Tahseen Kazi, and Judith Perera, *Commercial Radioactive Sources: Surveying the Security Risks*, Occasional Paper No. 11, Monterey, California, Center for Nonproliferation Studies, 2003.

The first step in remediating the effects of historical bad habits is to recognize the behaviour itself and assess the consequences. A methodology for the repatriation, disposal, and/or secure storage of all sources that are currently manufactured and distributed worldwide should be a priority. The UN, through its member states, is the proper organization to initiate negotiations for a legally binding agreement that will provide the IAEA the expanded mandate to determine the aspects of the Code that should remain voluntary and those which require oversight in implementation. As the number of sources distributed and continuing to be produced worldwide is in the millions, the initial focus should be on high-activity Category 1-3 sources that appear in Annex I of the Code, which should be the first sources slated for increased IAEA oversight.

Both the recent Chairman's report of the Technical Meeting on Implementation of the Code and the subsequent IAEA General Conference resolution call upon member states to identify and develop secure central storage/disposal facilities, address obstacles to the repatriation of sources to the supplier/state, and improve information sharing between member states. These suggestions by the General Conference are laudable and an excellent preliminary step towards proper source management at the end of their lifecycle.

The preamble of United Nations Security Council Resolution 1540 includes a statement that most states have bound themselves legally to their responsibilities under the Code. However, it does not call on remaining states to do so, and furthermore the resolution focuses on only on nuclear, chemical, and biological materials, completely by-passing radioactive materials. Nonproliferation policy specialists from governmental and non-governmental organizations need to assess the potential consequences of allowing the problem of continually unchecked distribution of sources worldwide. News organizations and policy debates need to begin to incorporate the source threat in their dialogue.

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