2010년도 KINU KOREA-U.S. 민간전략대화 및 국제적 공동연구

KINU-USKI JOINT RESEARCH PROJECT

Nuclear Security 2012

: Challenges of Proliferation and Implication for the Korean Peninsula

edited by Jung-Ho Bae and Jae H. Ku

Korea Institute for National Unification

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Printed December 2010
Published December 2010

Published by Korea Institute for National Unification(KINU)
Publisher President, Korea Institute for National Unification
Editor Center for International Relations Studies, KINU

Registration number No.2-2361(April 23, 1997)
Address 275, 4.19(Sailgu)-Gil, Gangbuk-gu, Seoul, Korea(zip code 142-728)

Telephone (82-2) 900-4300; (82-2) 901-2527
Fax (82-2) 901-2543
Homepage http://www.kinu.or.kr
Design · Print Yeawon Creative House Co., Ltd.(82-2) 745-8090

ISBN 978-89-8479-572-3 93340
Price ₩15,000(US$15.00)

All KINU publications are available for purchase at all major bookstore in Korea.
Also available at Government Printing Office Sales Center
Store (82-2) 734-6818; Office (82-2) 394-0337

Nuclear Security 2012

: Challenges of Proliferation and Implication for the Korean Peninsula

Ⅶ. Nuclear Weapons and Non-State Actors: Issues for Concern

Sharon K. Weiner
(American University School of International Service)

Traditionally, concerns about proliferation have focused on the nuclear ambitions of states. The Non-Proliferation Treaty(NPT), for example, is aimed at limiting the horizontal spread of nuclear weapons between states and also at discouraging vertical proliferation - that is, convincing states that already possess nuclear weapons to limit their arsenals and eventually agree to disarm. Increasingly, however, attention has turned to non-state actors, most specifically terrorist groups. For example, the 2010 U.S. National Security Strategy explains that the greatest threat facing the United States is "… the danger posed by the pursuit of nuclear weapons by violent extremists and their proliferation to additional states."[1]

Concern that non-state actors will seek nuclear weapons has led to a focus on security for nuclear weapons, as well as the materials and expertise necessary to make them. To date, more resources have been devoted to securing weapons-usable materials, largely due to the wider variety of places where they can be found, the relatively less stringent security of those materials compared to nuclear weapons, and the fact that weapons expertise is not useful in the absence of such materials. Most recently, in 2010, U.S. President Barack Obama convened a Nuclear Security Summit in Washington D.C. with the purpose of creating international momentum toward the goal of securing all vulnerable nuclear material within four years.

This chapter assesses the ability of non-state actors to acquire nuclear weapons. It begins by looking at their motivations and the

1– U.S. Government, *National Security Strategy* (May 2010), p. 4.

extent to which these translate into proliferation concerns that are similar to, or distinct from, traditional state-focused nonproliferation efforts. Next is a discussion of the locations and quantities of nuclear weapons, weapons-usable materials, and expertise that are available, and the relative vulnerabilities of each to theft or mis-direction. The final section makes the case that by focusing on states, traditional nonproliferation efforts have utilized tools and mechanisms that are in some ways less well-suited for detecting proliferation by non-state actors. Therefore, the future nonproliferation agenda should include efforts aimed an increasing our certainty that meaningful instances of proliferation by non-state actors are discovered.

1. Proliferation and the Motives of Non−State Actors

States and non-state actors probably want nuclear weapons for different reasons. Historically, states have sought not nuclear weapons, but a nuclear weapons program. This is because the ability to master weapons development, production, and deployment is important for states that seek the robust nuclear arsenal necessary for deterring enemies, but also for states that pursue nuclear weapons in order to be seen as modern and technologically advanced.[2] Non-state actors, on the other

[2] For the classic discussion of why states seek nuclear weapons, see Scott D. Sagan, “Why do States Build Nuclear Weapons?: Three Models in Search of a Bomb,” *International Security*, Vol. 21, No. 3 (Winter 1996−1997), pp. 54−86. For the presumed requirements of deterrence, see Scott D. Sagan and Kenneth N. Waltz, *The Spread of Nuclear Weapons: A Debate Renewed* (New York: W.W. Norton, 2003), pp. 17−29.

hand, are presumed to want a nuclear weapon because it gives them a more powerful ability to punish states with which they disagree, compel those states to make certain policy changes, or to seek vengeance.[3] Therefore, such actors are less interested in the ability to build and maintain an arsenal, and more concerned with quickly developing one or a few usable weapons.

Most states eventually develop more sophisticated nuclear warheads that can be precisely targeted and are smaller in size, so they can be delivered with bombers and medium- or long-range missiles. Some discriminate between weapons aimed at population centers, and those intended to destroy their opponent's nuclear weapons or infrastructure. Terrorists, on the other hand, are interested in killing or terrorizing people. Both can be done with a cruder and less sophisticated nuclear weapon.

Most nuclear weapons typically contain either highly enriched uranium(HEU), plutonium, or both.[4] These materials do not occur naturally and are very difficult to make. In nature, uranium contains 0.7% uranium-235, but tends to be mostly U-238, an isotope that cannot support the chain reaction needed for a nuclear explosion. The International Atomic Energy Agency(IAEA) treats HEU that has been

3– For a discussion of the motivations of terrorists, see Charles D. Ferguson and William C. Potter, *The Four Faces of Nuclear Terrorism* (Monterey, CA: Center for Nonproliferation Studies, Monterey Institute of International Studies, 2004), pp. 14－45.

4– Many states have gone on to develop thermonuclear weapons but such weapons require a considerable leap in technological sophistication that would beyond non-state actors.

enriched to 20% as “direct use material,” that is, material that can be used to make a feasible nuclear weapon. In practice the nuclear weapons states have used HEU that is 90% U-235 because this allows them to make small warheads that can be delivered using missiles and bombers.

According to the IAEA, it takes approximately 8kg of plutonium and 25kg of HEU to make the simple, first generation implosion- type weapon of interest to states.[5] However, terrorists are more likely to be able to build a simpler gun-type design, like the one used at Hiroshima, which contained 60kg of HEU. As a result, international attention has focused mostly on securing vulnerable HEU around the world because building a weapon from plutonium would require greater expertise, and such a weapon may be less reliable without extensive research, development and testing, and provides little extra benefit to terrorists.

Another concern is that terrorists might seek to use a radiological device; that is, a conventional explosive that is used to disperse radioactive material over an area. Such “dirty bombs” are not nuclear weapons because they do not undergo a chain reaction. If terrorists seek to build a radiological device, then they can make use of nuclear materials that are widely available, for example, in industrial and medical uses.[6] Although dirty bombs can cause panic and fear, and

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5– International Atomic Energy Agency, *International Atomic Energy Agency Safeguards Glossary, 2001 edition,* International Nuclear Verification Series, No. 3 (2002), p. 19.

6– For various scenarios involving radiological devices, and the resulting consequences, see testimony of Henry Kelly, President, Federation of American Scientists, to the Senate the dispersed radioactive material can result in long-term health concerns and environmental contamination, the casualties that result are primarily due to the conventional explosion. Because dirty bombs do not come close to equaling the destructive power of nuclear weapons, the rest of this chapter focuses on terrorist access to nuclear weapons, weapons-usable material, and the expertise with which to use it.

2. Stealing a Bomb

Obviously the quickest path to nuclear possession is to steal a nuclear weapon. The nine states that have developed nuclear weapons[7] are estimated to collectively have available for use about 5,400 strategic nuclear weapons and 2,550 tactical ones.[8] Most of these are in the United States and Russia, which together also have over 7,000 additional warheads in storage. These weapons would take between a few days and a few weeks to be readied for use. The nuclear weapons that are operationally available are believed to be stored at 111 sites, most of them in the nuclear weapons states.[9] The United States, however, also stores warheads in six other

Committee on Foreign Relations (6 March, 2002). Available on-line at <http://www.fas.org/ssp/docs/030602-kellytestimony.htm>.

7– These states are the United States, Russia, United Kingdom, France, China, Israel, India, Pakistan and North Korea.

8– Federation of American Scientists, "Status of World Nuclear Forces," updated 26 May, 2010. <www.fas.org/programs/ssp/nukes/nuclearweapons/nukestatus.html>.

9– International Panel on Fissile Materials, *Global Fissile Material Report 2009* (Princeton, N. J.: Program on Science and Global Security, Princeton University, 2009), p. 11.

locations in Europe.[10]

It is generally assumed, however, that the theft of a strategic nuclear weapon is unlikely. Such weapons are highly guarded and their movements are closely tracked, although problems have occurred.[11] Strategic nuclear weapons are also very heavy; they can weigh several hundred kilograms each and would be difficult to steal. Periodically, concerns surface about the theft of tactical as opposed to strategic nuclear weapons. Because tactical nuclear weapons are intended for use on the battlefield, they are smaller, more mobile, and may be stored in a wider variety of locations and subject to less stringent command and control arrangements. Many of the concerns about the theft of tactical nuclear weapons date from the 1990s when Russia was either unwilling or unable to provide an inventory of these weapons. These concerns were reinforced by periodic and unsubstantiated claims of a missing "suitcase bomb."[12]

Most concern, however, has focused on Russian nuclear warheads destined for dismantlement, but which need to be moved or are placed

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10– For the specific locations see. International Panel on Fissile Materials, *Global Fissile Material Report 2009,* pp. 132－138.

11– For example, in 2007 a U.S. Air Force bomber moving cruise missiles between military bases was inadvertently loaded with some nuclear-armed missiles. The bomber flew its mission, unloaded the missiles, and they sat unattended for some 10 hours before the warheads were discovered. See Josh White, "In Error, B-52 Flew Over U.S. with Nuclear-Armed Missiles," *The Washington Post* (6 September, 2007).

12– It is unlikely that the USSR ever constructed a bomb that would fit into a suitcase and much of the concern over this issue has been attributed to the political ambitious of Russian General Alexander Lebed. See David Smigielski, "A Review of the Suitcase Nuclear Bomb Controversy," *Policy Update* (Russian-American Nuclear Security Advisory Council, September 2003).

temporarily in storage as they wait to be destroyed. Russia has an estimated 3,000 warheads that are awaiting dismantlement, which will need to be moved from storage sites to dismantlement facilities.[13] Since the early 1990s, as part of its Cooperative Threat Reduction(CTR) program, the United States has helped Russia increase the security of weapons, and weapons materials, that are in transit to storage or dismantlement facilities by providing secure railcars, containers, and protection materials (such as Kevlar blankets to shield the weapons from small arms fire). Despite this, the movement of warheads and materials remains a concern because the routes frequently involve long distances, often also transport commercial goods and passengers, and involve the temporary storage of warheads, often in significantly less secure buildings, as they wait to be transferred to different routes or between trains and trucks.

Another focus has been the estimated 48 places where warheads are currently believed to be stored in Russia.[14] In total, there are an estimated 110－130 places where warheads could be stored if necessary.[15] Although the U.S. and Russia have cooperated to provide security improvements at many of these sites, as of 2008, upgrades had not been completed at approximately one-quarter of these facilities.[16]

Most of the weapon-focused security upgrades in Russia have been

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13– Federation of American Scientists, “Status of World Nuclear Forces,” <www.fas.org/programs/ssp/nukes/nuclearweapons/nukestatus.html>

14– International Panel on Fissile Materials, *Global Fissile Material Report 2009*, p. 11.

15– Matthew Bunn, *Securing the Bomb 2008* (Cambridge, MA: The Harvard Project on Managing the Atom, November 2008), p. 94.

16– *Ibid.*

aimed at physical security - that is, improving the fences around facilities, and training and equipping guards to patrol them. Another key element has been developing a means of identifying each weapon individually - for example, with a unique bar code - and installing portal monitors and other equipment to track its movement.

Since 2001, however, Pakistan has eclipsed Russia as the focus on concern about warhead theft. Here security worries have also included theft by insiders or unauthorized launch.

Pakistan is believed to have 70－90 nuclear weapons that are stored at a possible eight sites.[17] Although this arrangement is intended to give Pakistan time to assemble and ready its weapons for use in the event of war with neighboring India, in practice the dispersal of these weapons has raised U.S. concerns that it makes the weapons vulnerable to unauthorized access. Pakistan has instituted new and more robust command and control arrangements for its nuclear forces, including electronic "keys," called permissive action links, that allow the weapon to be launched only by those with the appropriate code.[18] There is also a personnel reliability program designed to weed out those with fundamentalist sympathies or who might otherwise seek to take control of the weapons for their own purposes. Critics, however, contend that there is no way to judge independently whether Pakistan's security systems work because there is no system of public oversight

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17– International Panel on Fissile Materials, *Global Fissile Material Report 2009*, p. 9; p. 11.

18– For details, see Kenneth N. Loungo and Naeem Salik, "Building Confidence in Pakistan's Nuclear Security," *Arms Control Today* (December 2007).

and accountability.[19] While admitting that the United States has limited knowledge about weapon and warhead security in Pakistan, the U.S. Chairman of the Joint Chiefs of Staff, Admiral Mike Mullen, has argued that he is "comfortable" that security in Pakistan is sufficient to prevent terrorists from gaining access to nuclear weapons.[20]

3. Weapons Materials

Although the theft of a weapon is cause for concern, much more emphasis has been placed on the security of HEU and plutonium. Non-state actors are not likely to be able to produce these materials themselves. HEU requires a uranium enrichment facility, a large and complex undertaking which, in the past, has proven difficult even for states. Plutonium requires building a nuclear reactor and re-processing the spent fuel, both of which are complex and hazardous tasks that are clearly out of reach for non-state actors. Therefore, the theft of these materials is considered the only practical alternative. As John Kerry explained succinctly in the 2004 U.S. presidential campaign: "Remember, no material, no bomb, no nuclear terrorism."[21]

19– See Pervez Hoodbhoy, "Letters to the Editor: 'Trust Us' Is Not Enough in Pakistan," *Arms Control Today* (March 2008).

20– "Adm. Mullen: Pakistan Nuclear Nukes Secure But … ," *CBS World News* (4 May, 2009).

21– Jodi Wilgoren, "Kerry Promises Speedier Efforts to Secure Nuclear Arms," *The New York Times* (2 June, 2004).

Highly Enriched Uranium(HEU)

Of the nine nuclear weapons states, all except for Israel, India, and North Korea have produced HEU for their nuclear weapons. Pakistan is the only country still doing so while the rest are considered to have existing stockpiles that are sufficient for their future weapons needs. India currently also produces HEU, but it is believed this is for use in reactors for nuclear submarines, although this material could be diverted to its weapons program in the future if it were to undergo additional enrichment.[22]

According to the International Panel on Fissile Materials, there are an estimated 1,610 metric tons of HEU worldwide, most of which is in the nuclear weapons states.[23] Collectively, the nuclear weapons states have an estimated inventory of over 900 metric tons of HEU, either in or available for use in nuclear weapons.[24] The bulk of this material is in Russia (an estimated 590 metric tons)[25] and the United States (an estimated 250 metric tons). HEU is also used for fuel in naval reactors by Russia, the United States, and the United Kingdom, in addition to India. Russia, the United States and the United Kingdom are estimated to have collective stockpiles totaling approximately 380 metric tons for this purpose.[26] Additionally, Russia and the United

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22– The International Panel on Fissile Materials estimates that India is producing 200－300 kilograms of HEU per year, although this is enriched only to 45%. International Panel on Fissile Materials, *Global Fissile Material Report 2009*, p. 14.

23– *Ibid.*, p. 13.

24– *Ibid.*

25– *Ibid.*

26– *Ibid.*

States have approximately 245 metric tons of HEU that is declared to be in excess of their military needs and is waiting to be down-blended for use as reactor fuel.[27] Part of this process involves the 1993 HEU Purchase Agreement in which the United States agreed over a twenty year period to pay Russia some $12 billion for 500 metric tons of HEU from dismantled Soviet nuclear warheads. Russia down-blends this material which, in turn, is then used to fuel nuclear power plants in the United States.[28]

Besides HEU for military uses, an additional estimated 70 metric tons is associated with fuel for nuclear reactors that are used for research purposes.[29] Of the approximately 135 HEU-fueled research reactors worldwide, the vast majority are in Russia and the United States.[30] The rest are in non-nuclear weapons states and are therefore subject to IAEA safeguards. Since the late 1970s, there has been a global effort to reconfigure these reactors to use low enriched uranium, which is not useful for weapons purposes.[31] Because many of these research reactors are located at civilian facilities - including, for example, universities - they have been a source of particular concern. For example, the research reactor used by the Massachusetts Institute

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27– International Panel on Fissile Materials, *Global Fissile Material Report 2009*, p. 13.

28– For details, see Matthew Bunn, “Reducing Excess Stockpiles: U.S.-Russian HEU Purchase Agreement,” *Nuclear Threat Initiative* (5 March, 2003). <http://www.nti.org/e_research/cnwm/reducing/heudeal.asp?print=true>.

29– International Panel on Fissile Materials, *Global Fissile Material Report 2009*, p. 15.

30– Union of Concerned Scientists, “Preventing Nuclear Terrorism Fact Sheet,” (April 2004).

31– This is the Reduced Enrichment for Research and Test Reactor(RERTR) program begun by the U.S. Department of Energy in 1978.

of Technology(MIT) is located in the heart of Cambridge, and, in the past, has been criticized for placing only limited restrictions on access.[32] Although such reactors typically do not contain enough material to make a nuclear weapon, and sometimes the material available needs additional processing before it can be used in weapons, the concern is that the minimal security measures makes these facilities an attractive target for non-state actors.[33] For example, in 2007 gunmen attacked the Pelindaba nuclear reactor and research center in South Africa, which may have held bomb grade uranium. This facility raised particular concerns because it is considered to be well-guarded.[34]

Plutonium

Plutonium is created in nuclear fuel during irradiation in a nuclear reactor. It has to be chemically separated from the highly radioactive spent nuclear fuel (known as reprocessing) before it can be used for weapons purposes. Today, separated plutonium can be found in the nine nuclear weapons states plus Japan. There are an estimated 500 metric tons of plutonium stockpiled in these states.[35] Of this amount, about one-third is in weapons programs and an additional 92 tons has

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32– For details see "ABC Investigation Finds Gaping Lapses in Security at Nuclear Reactors," *ABC News* (13 October, 2005).

33– William J. Broad, "Research Reactors a Safety Challenge," *The New York Times* (12 April, 2010).

34– Michael Wines, "Break-In at Nuclear Site Baffles South Africa," *The New York Times* (15 November, 2007).

35– International Panel on Fissile Materials, *Global Fissile Material Report 2009*, p. 16.

been declared excess of weapons needs by the United States and Russia and is awaiting to be turned into reactor fuel.[36] The remaining plutonium, almost 250 tons - about half the global total - is in civilian nuclear power programs. This plutonium is intended for use as fuel for advanced reactors.

Although plutonium is more difficult to use in a nuclear weapon and is thus usually associated with state nuclear programs, non-state actors could use it to produce a bomb with a small yield. In 1997, the U.S. Department of Energy released a finding stating that reactor-grade plutonium could be used to build a bomb "no more sophisticated" than a first generation nuclear weapons but with a yield in the range of a few kilotons.[37]

Problems Securing Materials

Efforts to secure fissile materials around the global have revealed a host of problems and vulnerabilities. Some of these are physical. For example, there has been persistent concern that storage sites lack adequate guns, guards and gates. But other problems stem from a lack of cooperation and coordination between the bureaucracies that are responsible for security within one state. Yet another set of problems is political and stems from the different motivations states have for pursuing fissile material security.

The recognition that access to nuclear materials is key to nuclear

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36– International Panel on Fissile Materials, *Global Fissile Material Report 2009*, p. 16.
37– *Ibid.,* p. 130.

weapons has propelled states to seek political solutions. Thus there has been a long standing effort to agree to an international treaty to ban the production of HEU and plutonium for weapons. The idea for a Fissile Material Cut-Off Treaty(FMCT) was first introduced in 1957 at the United Nations General Assembly. It proved impossible to reach agreement, however, because of the Cold War and U.S. and Russian concerns over the relative size of their nuclear arsenals. In 1993, the UN General Assembly agreed again to begin talks to consider an FMCT. Since then, however, that has been very little progress. The United States, the United Kingdom, Russia, France, China, and North Korea have all stopped the production of fissile materials for weapons. The FMCT seeks to formalize the status quo in these countries and to end continuing production in Israel, India, and Pakistan. These three, predictably, seek to build their fissile material stocks before agreeing to a cut-off.

Even if an FMCT were agreed to, it would not necessarily end production of HEU for naval fuel. It is possible for naval reactors to operate on low enriched uranium, as is done in France and China. The United States, United Kingdom, Russia, and India, however, have shown no interest in moving to this fuel for their naval reactors.

An FMCT would also not necessarily end the reprocessing of spent nuclear fuel in civilian nuclear power programs. China, France, Russia, and the United Kingdom have reprocessing plants as part of their civilian nuclear programs. Japan also has a reprocessing plant but because it is a non-nuclear weapons state under the NPT the plant is subject to IAEA safeguards. An additional concern is South Korea, which has shown interest in developing its own reprocessing capacity. Independent analysts have argued that South Korea's plan is of questionable economic value and, further, that it would create new proliferation concerns because a fully operational reprocessing capacity would generate enough excess plutonium to make about 100 nuclear weapons each year.[38]

Finally, even it an FMCT were reached, it would not reduce current stockpiles of HEU and separated plutonium, which would continue to be at risk. Besides the lack of political will to end the production of fissile materials, there are other proliferation vulnerabilities having to do with the security of storage sites for these fissile materials that remain important. To date, it is the security of fissile material storage that has been the focus of nonproliferation concerns.

The United States, which has been the most open about security problems, has found it very difficult and expensive to secure its fissile materials. After the 9·11 terrorist attacks, the United States increased security measures at most sites and as of 2006 was spending over $1 billion per year on physical security at its nuclear facilities.[39] Despite this, problems have persisted. The three agencies responsible for nuclear security have inconsistent requirements and lack coordination between their efforts.[40] Further, in 2008, the U.S. Department of

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38– See, for example, Frank Von Hippel, "South Korean Reprocessing: An Unnecessary Threat to the Nonproliferation Regime," *Arms Control Today* (March 2010).

39– International Panel on Fissile Materials, *Global Fissile Material Report 2007* (Princeton, N. J.: Program on Science and Global Security, Princeton University, 2007), p. 43.

Energy, which is responsible for security at the nuclear weapons laboratories, reduced the demands of the threat that its facilities are supposed to be able to defend against.[41] Moreover, there are numerous examples of security failures. For example, in a 2008 test of the security system at Livermore National Laboratory in Livermore, California, attackers were able to steal fissile material and assemble an improvised nuclear explosive at the site before they were stoppe d.[42] Further, U.S. non-proliferation policy has tended to downplay such concerns and instead place more focus on stopping terrorists from smuggling weapons materials or a weapon into the country.[43]

Even though the United States has been unable to convincingly secure its own materials, since the early 1990s it has focused on fissile material security in the former Soviet Union and especially Russia. Storage sites here were considered particularly vulnerable because of the collapse of the Soviet Union which left such facilities in countries that would soon be independent but had few or no security protocols of their own. For example, in many places containers of fissile material were "locked" with wax seals that could easily be removed and replaced without detection. Economically, Russia, which inherited the vast majority of the material, did not have the financial

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40– Project on Government Oversight, "U.S. Nuclear Weapons Complex: How the Country Can Profit and Become More Secure by Getting Rid of Its Surplus Weapons-Grade Uranium," (14 September, 2010), p. 8.

41– *Ibid*., p. 8－9.

42– *Ibid*., p. 8, Footnote. 26.

43– For a summary of U.S. nonproliferation policy, see Jonathan Medalia, "Nuclear Terrorism: A Brief Review of Threats and Responses," *CRS Report for Congress* (22 September, 2004).

resources to maintain perimeter security around these facilities and, in many cases, pay for salaries or equipment for guards.[44]

Under the Material Protection, Control, and Accounting(MPC&A) program, the United States funded accounting and tracking systems for Russian fissile material as well as building and perimeter security upgrades. According to U.S. estimates, there were some 215－245 buildings in the former Soviet Union that stored fissile material.[45] As of October 2009, upgrades at 210 storage sites had been completed.[46] The United States and Russia also built a state-of-the-art storage facility in the Russian city of Mayak that could hold some 25,000 containers of fissile material from nuclear weapons.

Progress on these security measures was, however, much slower and more problematic than expected and the U.S.-Russian experience offers lessons for other such non-proliferation efforts.[47] First, it is important to be realistic about timelines. For a variety of different reasons, progress on fissile material security was slow, despite the consistent belief that such efforts were both necessary and urgent. For

44– For a good summary of the main problems and challenges see Matthew Bunn, *The Next Wave: Urgently Needed New Steps to Control Warheads and Fissile Material* (Washington D.C.: Carnegie Endowment for International Peace; Cambridge, MA: The Harvard Project on Managing the Atom, April 2000).

45– Matthew Bunn, *Securing the Bomb 2007* (Cambridge, MA: The Harvard Project on Managing the Atom, September 2007), pp. 64－66.

46– Matthew Bunn, *Securing the Bomb 2010* (Cambridge, MA: The Harvard Project on Managing the Atom, April 2010), p. 33.

47– For a summary of key lessons from the Cooperative Threat Reduction program overall, see Sharon K. Weiner, "The Evolution of Cooperative Threat Reduction: Progress, Problems, and Issues for the Future," *The Nonproliferation Review*, Vol. 16, No. 2 (July 2009), pp. 211－235.

example, most Russian fissile material storage sites was supposed to have had security upgrades after about ten years, but work will end up taking closer to twenty before it is completed. The Mayak facility also suffered from considerable delays.

Second, these delays, plus disagreements and genuine misunderstandings, frequently contributed to cost overruns. Mayak, for example, was originally supposed to cost the United States $275 million but ended up at around $421 million.[48]

Third, cooperation on material security often raised concerns about revealing the details of a state's nuclear weapons. Numerous disagreements and delays resulted when Russia refused to grant the United States access to facilities where upgrades were planned or had already taken place. The United States, in turn, felt it was entitled to such access to verify that money had been spent as previously agreed. For similar accountability reasons, the United States wanted assurances that the material stored at Mayak was indeed from nuclear weapons. Russia refused out of concern that allowing the U.S. to sample these materials would have revealed details about Russian warhead design.

Fourth, at times cooperation on specific security upgrades got caught up in larger political disagreements. For example, Russia slowed cooperation because it disagreed with U.S. policy and military actions towards Bosnia in the mid-1990s. The United States frequently

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48– Nuclear Threat Initiative, "Securing Nuclear Materials and Warheads, Mayak Fissile Material Storage Facility," (24 October, 2010), <http://www.nti.org/e_research/cnwm/securing /mayak.asp>.

tried to use nuclear security spending to pressure Russia in a variety of policy issues including Russian technical cooperation with Iran, the sale of military equipment to India, and even domestic human rights laws. In other words, the vulnerability of Russian sites to theft was often a function of broader issues about politics, understanding, communication, and respect.

In addition to Russia and the former Soviet Union, U.S. efforts have focused on Pakistan. Here material security efforts have suffered because of a lack of trust between that country and the United States. The United States worries about the seizure of material by Al Qaeda, other extremists groups, or the Pakistan military. Pakistan, which shares these concerns, also has fears that the United States might, in a crisis, seek to take its weapons or key materials. As a result, Pakistan has denied outsiders access to its nuclear facilities and even U.S.-Pakistani security efforts tend to be kept secret.

Additional problems securing fissile materials arise from concerns about sustainability and a state's "security culture." Sometimes states do not assign the same degree of importance to nuclear security matters because of differing priorities or differences of opinion about the threat or when and how it will be realized. The ability of a state to sustain security upgrades after external funding has ceased is referred to sustainability. For example, at some fissile material storage sites in Russia, budgets have been insufficient to sustain U.S.-funded upgrades. Facilities cannot afford replacement parts or, in places, the electricity needed for alarms to function. Another concern is that states do not take security seriously. For example, the "security culture" raises concerns when guards have not had the training to operate necessary equipment or do not take new security protocols seriously.[49] Therefore, preventing proliferation requires not just security upgrades, but the sustained commitment to make sure a state is able to use and operate them properly.

4. Expertise

Having fissile material is not enough to make a nuclear weapon. A non-state actor will need some expertise to identify how much fissile material, of what kind, and in what form is appropriate for a weapon. Special expertise is also necessary to understand how to process this material and prepare it for use in a nuclear explosive. Finally, to make a weapon also involves decisions about how to assemble the explosive such that it will detonate when intended and have the desire effect.

There is some evidence that non-state actors have reached out to weapons experts. It is known that Al Qaeda met with retired Pakistani nuclear experts in Afghanistan before 2001 and the group may also have approached Russian weapons scientists.[50] The Japanese cult "Aum Shinrikyo" is thought to have tried to hire nuclear scientists, especially from the former Soviet Union.[51]

49– Bunn, *Securing the Bomb 2010*, pp. 36－42.

50– David Albright and Holly Higgins, "A Bomb for the Ummah," *Bulletin of the Atomic Scientists*, Vol. 59, No. 2 (March/April 2003).

51– John V. Parachini, David E. Mosher, John Baker, Keith Craine, Michael Chase

The most obvious source of expertise is from scientists who are from nuclear weapons programs. There are only nine such states with active weapons programs today and all can be expected to carefully monitor the activities of their experts. These experts, in turn, can be assumed to see sharing nuclear expertise as unpatriotic and probably treason. Ukraine, Belarus, and Kazakhstan inherited nuclear weapons from the Soviet Union but agreed to give them up under the 1992 Lisbon Protocol. South Africa ended its weapons program and Libya and Iraq each, at one time, had active weapons efforts. These countries thus raise the potential of nuclear experts who no longer have lucrative incomes or strong connections to state programs. There have also been concerns that retired weapons workers may sell their knowledge as a way to supplement their pensions.[52]

The largest source of expertise that is a concern is the former Soviet Union. It built the largest nuclear weapons complex of any state and its collapse led to a period of ten years during which there were concerns about very low salaries, decaying institutions, and the need to re-train and re-employ nuclear scientists, engineers and technicians or they might be tempted to make a living by selling their skills. Although estimates varied, the U.S. government tended to cite 60,000 as the number of experts with skills that raised proliferation

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and Michael Daugherty, *Diversion of Nuclear, Biological and Chemical Weapons Expertise from the Former Soviet Union: Understanding an Evolving Problem* (Santa Monica, CA: RAND, 2005), pp. 25–26.

52– Oleg Bukharin, Russia's Nuclear Complex: *Surviving the End of the Cold War* (Princeton, N. J.: Program on Science and Global Security, Woodrow Wilson School of Public and International Affairs, Princeton University, May 2004), p. 21.

concerns.[53] Russia, which inherited the bulk of these experts, was committed to reducing the overall size of its nuclear weapons complex but had problems implementing successful conversion efforts.

As part of CTR, the United States and other countries funded a host of programs to retrain and re-employ these nuclear weapons experts. In general, these efforts proved very successful at engaging weapons experts in temporary research contracts but much less successful at finding them permanent jobs outside of the weapons complex.[54] Some of these programs have now expanded to work with Iraqi and Libyan scientists. There is also a proposal to implement similar cooperation with North Korea.[55]

It has now been twenty years since the collapse of the Soviet Union and the feared knowledge proliferation has yet to materialize. There have been very few documented cases of former Soviet nuclear weapons experts sharing their skills with other states or non-state actors. Although the United States has raised issues about Russian experts aiding in the construction of Iran's Bushehr nuclear reactor, Russia does not agree that this constitutes pro- liferation. There have been far more confirmed cases of technicians and guards at fissile

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53– Senate Committee on Governmental Affairs, "Global Proliferation of Weapons of Mass Destruction, Part II," 104th Congress 2nd session (13, 20, and 22 March, 1996), p. 53.

54– For a closer look at two of these programs and the difficulties they encountered, see Sharon K. Weiner, "Organizational Interest, Nuclear Weapons Scientists, and Nonproliferation," *Political Science Quarterly*, Vol. 124, No. 4 (Winter 2009－2010), pp. 655－679.

55– Jungmin Kang, "Redirecting North Korea's Nuclear Workers," *Bulletin of the Atomic Scientists*, Vol. 65, No. 1 (January/February 2009), pp. 48－55.

material storage facilities attempting to sell stolen materials or offering outsiders access.[56]

5. Detecting Proliferation

A key element of the success or failure of any nonproliferation scheme is a system for detecting violators. State enforcers of the nonproliferation regime need some degree of certainty that they are detecting significant violations and with enough advance warning to respond. As with motivations for proliferation, it is also the case that our ability to detect nonproliferation by state versus non-state actors is different.

In general, the global nonproliferation regime has tried to detect state cases of proliferation by focusing on the process of acquiring the materials needed for the production of weapons-usable materials. In particular, the NPT requires state signatories to monitor trade in equipment and materials that can be redirected to weapons activities. The production of fuel for nuclear power plants is monitored by the IAEA to make sure states are not engaged in producing weapons-usable material. Non-state actors, because they are interested in a bomb but not a bomb program, are unlikely to try to acquire centrifuge or reprocessing technology. They do not own nuclear power plants.

56– A summary of such incidents can be found in Bunn, *Securing the Bomb 2010*, pp. 4－5; pp. 31－34. and William C. Potter and Elena Sokova, "Illicit Nuclear Trafficking in the NIS: What's New? What's True?" *The Nonproliferation Review*, Vol. 9, No. 2 (Summer 2002), pp. 112－120.

The United States is leading an effort to begin creating an international regime to deal with the problem of proliferation by non-state actors. Negotiations are underway at the United Nations to develop a common definition of terrorism and for member states to adopt laws allowing for the prosecution, extradition, and punishment of terrorists. In 2005, the Convention on the Physical Protection of Nuclear Material was amended to make states legally responsible for protecting their own nuclear facilities and material and to help facilitate quicker cooperation between states when material is stolen or found missing. Under UN Security Council Resolution 1540, member states are responsible for criminalizing proliferation including making it illegal to aid non-state actors in such pursuits.

In contrast to states, non-state actors are more likely to approach traditional criminal and smuggling networks in their attempts to secure nuclear material. Such networks operate on the basis of money exchanged for services. In other words, they will transfer people, drugs, or nuclear materials for a price. Detection of proliferation by state actors focuses on export controls or the sale of centrifuge technology. But proliferation by non-state actors is more likely to be discovered by focusing on transfers of money, the corruption of border and customs officials or local police forces, and monitoring traditional smuggling networks.

To date, the United States has concentrated on getting other countries to improve border security and on scanning containers for HEU as they pass through key transit points and ports on their way to the United States. There are two problems with this detection system.

First, there are simply too many shipping containers carrying too many goods. It is impossible to monitor all goods in and out of a country and attempts to make any monitoring and detecting system more robust create problems because they delay commerce and, as a result, can result in increased prices for goods. A second problem is that the radiation portal monitors used to detect the presence of HEU often produce false alarms. This is because a variety of materials - cat litter, bananas, and brazil nuts are examples[57] - emit harmless radiation that may look like HEU. The opposite problem also exists: some equipment cannot detect HEU reliably, especially when terrorists attempt to conceal it in lead or steel.[58] According to a 2008 study by the U.S. Government Accountability Office, technology is currently limited in its ability to detect HEU and other important nuclear materials, there is a lack of coordination and strategic planning among U.S. agencies whose mission is to prevent smuggling into the United States, and it has proven difficult to effectively implement and then sustain such efforts.[59]

Finally, even when proliferation is discovered, there are problems associated with reporting those cases. The main repository for such information is the Illicit Trafficking Database, maintained by the IAEA.

57– Thomas B. Cochran and Matthew G. McKinzie, "Detecting Nuclear Smuggling," *Scientific American*, Vol. 298, No. 4 (April 2008).

58– Cochran and McKinzie, "Detecting Nuclear Smuggling," provides an example of one set of tests of the reliability of these portal monitors conduced by *ABC News*.

59– U.S. Government Accountability Office, "Nuclear Detection: Preliminary Observations on the Domestic Nuclear Detection Office's Efforts to Develop a Global Nuclear Detection Architecture," GAO-08-999T (16 July, 2008).

This database, however, is dependent on IAEA member states and only reports incidents of the unauthorized transfer of nuclear materials that those state agree to make public. It has no power to investigate suspicions or stories or even to reconcile conflicting information that is submitted by a state. Because such events are embarrassing to states, or may raise questions about their security measures, there is an inherent incentive to underreport such problems or the amount of fissile material that is involved. As a result of inadequate measures, experts estimate that we may only know a small fraction of the illicit nuclear smuggling that takes place.[60]

6. Preventing Proliferation by Non-State Actors

As long as nuclear weapons and fissile materials exist, there is a basis for continuing concern about proliferation by non-state actors. For states, efforts to secure nuclear weapons and materials impinge on fundamental issues of national security and therefore there is a natural reluctance for states to be open. The ability of non-state actors to acquire access to scientists and engineers with the expertise to identify and use fissile materials to make a weapon is likely to also continue to be seen as a problem. The nuclear weapons states seem committed to active weapons programs, plus they also have a cohort of retired weapons experts. These realities are complicated by the increasing globalization of the international economy, which makes it

[60] "Tracking Nuclear Materials Worldwide," *USA Today* (1 June, 2002).

harder to detect the successful acquisition of nuclear material by non-state groups.

It would seem, therefore, that for the foreseeable future there will be a sound basis for concern about proliferation by non-state actors. Physical security measures, as explained above, are not adequate to deal with this problem. In addition, it will require states to muster the political will to reduce the size of arsenals, limit or end the production of fissile material, and agree to prioritize cooperative non-proliferation efforts.

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KINU-USKI JOINT RESEARCH PROJECT

Nuclear Security 2012

: Challenges of Proliferation and Implication for the Korean Peninsula

edited by Jung-Ho Bae and Jae H. Ku

Korea Institute for National Unification

93340
9 788984 795723
ISBN 978-89-8479-572-3