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The Risk of Theft:

Protecting Fissile Materials in the Former Soviet Union

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BY THE TIME IT COLLAPSED IN 1991, THE SOVIET UNION had produced the world's largest stockpile of plutonium and highly enriched uranium (HEU). These materials remain in many forms—in nuclear weapons and components from dismantled weapons; metal and oxide reactor fuel elements, including both fresh and spent fuels; bulk oxides or other forms for processing; metal "buttons"; and a wide variety of scraps and waste. Fissile materials are located in hundreds of buildings and facilities at dozens of sites spread throughout the territory of the former Soviet Union, but principally in Russia.[1] Most of the mate-

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Access to fissile materials at Soviet institutes was controlled by simple "wax-and-wire" seals that could be easily spoofed.

rials (and all of the nuclear weapons) are under the control of the Russian Ministry of Atomic Energy (Minatom) or the Ministry of Defense.

While nuclear weapons are generally considered to be better protected and accounted for than nuclear materials in other forms, nuclear weapons may be vulnerable during transport and at some storage sites. In addition, many of Russia's fissile material production sites and other locations lack the material protection, control, and accountancy (MPC&A) systems needed to detect or prevent theft.

The U.S. government has led international efforts to bolster security and accounting systems at nuclear facilities in the former Soviet Union. Although the U.S. program has made substantial progress in the five years since its inception, the task is far from complete. In many cases, Russian MPC&A systems remain well below U.S. or international standards, even though upgrades have been installed. In addition, Russian officials have been slow to allow many facilities at the nuclear weapons labs, fissile material production sites, and weapons assembly/disassembly sites to participate directly in the MPC&A program. Unless greater attention is given to improving the security of Russian plutonium and HEU, especially at these sensitive sites, it seems likely that hundreds of tonnes of Russian plutonium and HEU will remain poorly protected well into the next decade.

Fissile Material Insecurity

Systems that protected fissile materials during the Soviet era are not adequate to the challenges of the post-Soviet age.[2] In the Soviet era, the government and the Communist Party exercised tight control over the nuclear complex and the people who worked there. Vast production complexes that produced fissile materials (Chelyabinsk-65, known as "Mayak," Krasnoyarsk-26, Krasnoyarsk-45, Tomsk-7, and Sverdlovsk-44), the nuclear weapons laboratories (Arzamas-16 and Chelyabinsk-70), and the nuclear weapons assembly/disassembly sites (including Penza-19, Sverdlovsk-45, and Zlatoust-36) were located in "closed cities." Movement in and out of these communities was highly restricted. Even civil nuclear facilities, many of which are located in or near Moscow or other population centers, were highly compartmentalized.

If the Soviets paid considerable attention to preventing "outsiders from getting in," they paid less attention to the threat of "insiders getting out." Soviet nuclear scientists and others who worked at these facilities constituted an elite, privileged segment of Soviet society. They and their dependents enjoyed a higher standard of living than average Soviet citizens. There was little incentive for a Soviet scientist to steal fissile materials, even on the unlikely chance that he could have found a buyer.

Because the Soviets seldom worried about scientists or other insiders removing fissile materials without permission, the technical control and accountancy systems needed to deter or detect theft were never adequately developed. Inventory records at facilities handling fissile materials were used mainly for planning purposes and were often incomplete. Little attention was paid to inventory balances when fissile materials were transported from one site to another, or when they were moved from one building or facility to another at the same site. The materials in the process and waste streams were not carefully measured, and measurements were often not recorded. When not in use, weapon-usable fissile materials were commonly stored in vaults or lockers. Access to these materials was often controlled by no more than easily spoofed wax-and-wire seals or other primitive control devices.

The lack of national regulatory or accounting systems in the former Soviet republics is striking. The post-Soviet states, including Russia, often did not know that facilities contained fissile materials—making it difficult for them to accurately declare their stocks. An International Atomic Energy Agency (IAEA) official said that, shortly after the Soviet collapse, IAEA officials visiting several non-Russian facilities were asked to help measure the fissile material stocks at these sites, since the facilities lacked reliable records and were unable to take measurements themselves. In some cases, the IAEA found stocks in excess of a significant quantity (8 kilograms of plutonium or about 25 kilograms of weapon-grade uranium). Even today, U.S. Energy Department officials and Russian scientists are concerned that many Russian facilities still lack accurate records about their stocks.

Threats from the inside and the outside. With the collapse of the Soviet Union, the insider threat became a reality. Today, the government neither exercises the pervasive control over its citizens that it once did, nor does it have the resources to keep its nuclear complex afloat during a painful economic transition. A sharp reduction in government orders and subsidies has left many facilities idle or under-utilized. The Soviet-era perks for nuclear complex personnel are gone, and living standards have fallen dramatically. Salaries that were once higher than average are now paid months late, if paid at all. As of September 1998, the Russian government reportedly owed more than $400 million in unpaid wages to nuclear workers in the defense sector.[3]

In September 1998, thousands of nuclear workers went on strike.

These problems affect even the most prestigious Russian nuclear and defense facilities.[4] In October 1996, Chelyabinsk-70 director Vladimir Nechai committed suicide over the inability to solve the financial crisis facing the lab and its thousands of workers and dependents. In September 1998, thousands of workers at Arzamas-16, Chelyabinsk-70, and Mayak (where 30 tonnes of separated civil plutonium are stored) joined a nation-wide strike to protest wages that were months late.

If the extreme political and economic crises were to cause the political disintegration of the Russian Federation, one result would be newly independent territories with nuclear weapons or fissile materials. Earlier this summer, retired Gen. Alexander Lebed, now the governor of Krasnoyarsk, suggested as much. Since Moscow could no longer afford to pay its bills, he wrote, the Siberian territory of Krasnoyarsk should take over the strategic nuclear missile unit that is based there. In an open letter to then–Prime Minister Sergey Kiriyenko, Lebed suggested that "in exchange for the status of a nuclear territory, we will, if you like, feed the unit."[5]

Incomplete accounting records from the Soviet period make it almost impossible to determine if fissile materials could already have been illicitly removed.

Minatom has begun to take steps to close down and convert some defense sites. In February 1998, Minatom head Viktor Mikhailov announced that weapons work would be reduced by the year 2000, with the closure of three weapons production enterprises. But the prospects for converting labs and production sites to successful commercial endeavors are uncertain. It is difficult for the military complex sites, which have little experience in producing or marketing commercial goods, to diversify their activities. Russia's persistent and worsening economic crisis, its complex and arbitrary tax systems, and the high level of corruption make Westerners wary about investing in any significant way. Even a recently announced U.S. commitment to spend $15 million to convert the closed cities may not attract much industry participation, especially in the short term. Civil sites face similar obstacles.

Meanwhile, the outsider threat to fissile material security has grown. Organized crime and corruption have penetrated many

Russian institutions, including the military and the nuclear complex. The Chechen war and continuing unrest in Russia's Caucasus region have fostered ethnic-based criminal organizations, which Russians often call terrorists.

Many walls, fences, storage sites, and other Soviet-era physical protection systems designed to protect against the outsider threat were not maintained following the Soviet collapse. The security forces that guard nuclear sites today are considered less reliable than their Soviet predecessors. The current forces are often made up of poorly paid and undertrained conscripts. These forces can lack both the incentive and the manpower to respond to a concerted attack by outsiders seeking to gain access by force. During the civil war in Georgia, one civil research reactor facility that contained several kilograms of weapon-grade HEU was simply abandoned by security forces. In September 1998, a guard at Russia's Mayak facility went on a shooting spree in a guard house, killing two other guards before escaping with an assault rifle and ammunition.[6]

Threats posed by other governments seeking to exploit the poor security and accounting of Russia's nuclear materials are poorly appreciated. Iraq has a long history of exploiting weaknesses in national and international control systems.[7] Iraq's experience in setting up procurement networks in Europe before the Gulf War, and its ability to obtain Russian-origin missile components via middlemen in the mid-1990s, pose a real threat to inadequate security measures.[8]

Have nuclear weapons or fissile materials been stolen from Russian facilities? While many of the known incidents of nuclear trafficking appear to be scams involving radioactive sources, it is possible that incidents involving fissile materials have gone undetected. Despite current efforts to determine fissile material inventories undertaken as part of the MPC&A program, incomplete accounting records from the Soviet period make it almost impossible to determine if fissile materials could already have been illicitly removed.

Several highly publicized seizures of weapon-usable nuclear materials illustrate the trafficking threat.[9] One case involving the seizure of 360 grams of weapon-grade plutonium in the Munich airport in August 1994 was the result of a German government sting. The material was confiscated from passengers who had flown to Munich from Moscow. In December 1994, more than 2.5 kilograms of nearly weapon-grade HEU were seized in Prague; another 20 grams was seized by Czech authorities in mid-1995. Law enforcement investigators believe these caches, together with a smaller amount of HEU seized in mid-1994 in Germany, originated at the formerly closed city of Mayak.[10]

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A Russian scientist holds a full-size mockup of plutonium fuel rods stored at the Joint Institute for Nuclear Research. Hundreds of rods, each containing roughly 175 grams of plutonium, are stored at the facility.

Fortunately, there is no credible evidence that any of Russia's nuclear weapons have been stolen. Media reports that Russia is "missing" nuclear weapons have not been verified.[11] The United States remains confident that Russia's nuclear weapons, particularly its deployed weapons, are secure from theft.[12] This assessment could rapidly change, however. Recent U.S. intelligence assessments concluded that "declining morale and discipline in the military, as well as economic conditions, raise our concerns about the potential for warhead theft."[13] Russian military officials said in 1996 that many nuclear weapons storage facilities are 30 to 40 years old and badly in need of repair or replacement.[14] These facilities are often filled beyond their design capacity with weapons awaiting maintenance or retirement. Trains carrying nuclear weapons between storage and assembly/disassembly sites are also considered vulnerable to armed attack.

Fissile materials that are not contained in weapons are considered to be more vulnerable. Both civil and military processing and fuel-fabrication facilities contain large quantities of material in bulk or waste forms. Soviet-era material accountancy systems tolerated large processing losses, which would have allowed a knowledgeable operator to regularly skim off small quantities of material. Over time, significant quantities might be diverted in this way. In 1992, an employee at the Luch production facility in Podolsk, where more than a tonne of materials are located, removed more than a kilogram of weapon-grade HEU before being caught.

Research facilities, particularly those that operate research reactors, pose their own unique risks. Many of these sites are now idle with their HEU or plutonium fuels in storage. Many of these fuel elements are easily concealable. For example, Moscow's Institute for Theoretical and Experimental Physics (ITEP) once operated a research reactor that used HEU fuel. Although the reactor was shut down long ago, ITEP still has 100 kilograms of weapon-grade HEU in the form of thousands of cylindrical, aluminum-clad fuel elements. Each element, which measures 150 by 50 millimeters, contains 10 to 15 grams of weapon-grade HEU. The Institute for Physics and Power Engineering (IPPE), approximately 70 miles south of Moscow, possesses tonnes of plutonium and HEU fuel elements that are each roughly the size of a U.S. half-dollar.

The collapse of the Soviet Union also left naval propulsion reactor fuel vulnerable to theft. Fresh fuel elements were stored at dozens of poorly protected facilities at naval bases. In November 1993, two men—one an active duty captain in the Russian navy—removed 4.5 kilograms of fresh HEU (non-weapon-grade) from a storage facility at Sevmorput.[15] The thieves simply entered through a hole in a fence and sawed off a padlock on the storage depot door. The transportation of naval HEU from fabrication sites, often by rail, is also considered to be vulnerable.

Other former Soviet republics have fissile materials that may be at risk of theft. Several non-Russian republics, including Belarus, Ukraine, and Uzbekistan, inherited small research reactors that are fueled with HEU. Kazakhstan inherited several tonnes of plutonium contained in lightly irradiated "blanket" material at the Aktau breeder reactor facility, located on Kazakhstan's western

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Scientists at the Joint Institute for Nuclear Research demonstrate the use of material accountancy improvements. These scales, and other equipment, were provided through the Department of Energy's MPC&A program.

border along the Caspian Sea. U.S. and Kazakh authorities were concerned that Iran, which shares a border with the Caspian and has opened up a consulate at Aktau, would try to acquire this plutonium, if given the chance. As a result, the material is to be moved across the country to a more secure facility at the former Soviet nuclear test site at Semipalatinsk.

Reducing the Risks

Several countries and international organizations, notably the European Union, the United States, Sweden, and Japan, have sought to improve MPC&A systems in Russia and in other former Soviet republics. The most comprehensive and well-funded of the programs is led by the U.S. Department of Energy (DOE), which is currently engaged in efforts to improve security and accounting at more than 50 sites in the former Soviet Union. These efforts are focused on facilities where fissile materials in non-weapon forms are located.

Although U.S. efforts to improve security and accounting were initiated in 1993, the MPC&A program did not get under way in earnest until late 1994, when DOE decided to back low-level, technical contacts between U.S. and Russian nuclear labs. The cooperative relationships that developed through this process are often credited for many of the key program successes to date. Many U.S.-Russian arms control initiatives have fizzled or failed to get off the ground in recent years, but the MPC&A program is actually growing. Its budget has grown from $3 million in 1993 to an estimated $150 million in 1999.

The program's purpose is to "reduce the threat of nuclear proliferation and nuclear terrorism by rapidly improving the security of all weapons-usable nuclear materials in forms other than nuclear weapons" in Russia and the other former Soviet republics.[16] Frequently, this involves the installation of a standard package of upgrades. Typical physical protection upgrades include the hardening of doors and windows, new walls and fences equipped with intrusion detection sensors, video surveillance cameras at points of access, a secure central alarm station, and improved computer and communication systems. Material access control upgrades include the installation of fissile material-detecting portal monitors at doors and vehicle entrances, keypad and swipe-card access control systems, and container seals. Material accountancy upgrades include the use of computerized, site-wide accounting systems, procedures for inventorying on-site materials, and the use of bar codes, digital scales, non-destructive assay equipment, and computerized record-keeping to track material inventories and transfers. The program also encourages sites and facilities to consolidate material inventories to the greatest practical extent, to reduce the number of buildings that need protection.

To date, the MPC&A program has gained access to and improved conditions at dozens of sites containing fissile material. By November 1998, site-wide physical protection and material control and accountancy systems had been completed at more than 20 locations. Other recent accomplishments include the installation of system upgrades at buildings containing significant quantities of fissile materials at Chelyabinsk-70, Arzamas-16, and the Russian Northern Fleet. Fissile material inventories at Luch and IPPE continue to be consolidated at on-site central storage facilities. By mid-1999, DOE expects to complete site-wide upgrades at six additional sites, and it will continue to work to improve protection and accountancy systems at key facilities, including the RT-1 reprocessing plant and associated plutonium storage buildings at Mayak. Progress also is expected at Arzamas-16, Chelyabinsk-70, IPPE, and—for the first time—at assembly/disassembly sites. Efforts to improve the security of materials in transport, either by hardening existing rail cars or providing secure trucks, is also anticipated.

Training Russian personnel to use these new systems is a key aspect of the MPC&A program. An MPC&A training center for facility operators has been established at IPPE, and other training sites are planned. The Moscow Engineering and Physics Institute is initiating a graduate course in MPC&A for students who are expected to move into government positions. The first class to take this course matriculated in 1998.

Establishing a national regulatory system that sets and enforces MPC&A standards is an important part of the DOE's plan. However, these efforts have been hampered by the weak authority of Gosatomnadzor, Russia's nuclear regulatory agency, relative to Minatom and the Ministry of Defense.

In addition to the MPC&A program, the United States has contributed to the security of Russian nuclear weapons through the Defense Department's Cooperative Threat Reduction (CTR) program. This effort helped Russia to securely transport nuclear weapons from the non-Russian republics to Russian bases after the Soviet Union collapsed. The CTR program also helped Russia to consolidate its weapons at roughly 50 storage sites, down from more than 100 in 1991, and it has contributed to efforts to improve security at these sites. The Defense Department is also providing funds for the construction of a secure storage facility at Mayak that will hold tens of tonnes of fissile materials extracted from dismantled nuclear weapons. However, it is difficult to assess the success of these efforts, because Russia shares little information about the security conditions at sites where nuclear weapons are stored.

In some instances, the United States has acted directly to move materials out of harm's way. In 1994, in "Operation Sapphire," the United States airlifted approximately 600 kilograms of HEU from Kazakhstan. This was after Iranian officials were reported to have visited the facility where the material was stored. In early 1998, several kilograms of HEU were moved from Georgia to Dounreay in Scotland.

Evaluating the MPC&A Program

Of the two U.S. efforts to improve Russian fissile material security, the MPC&A program is perhaps the more important. It is estimated that more than half of Russia's fissile materials—more than 600 tonnes—are already outside weapons.[17] Compared to the materials contained in weapons, the non-weapon materials are in a variety of forms at a large number of sites. Moreover, the non-weapon stockpile will grow as more weapons are dismantled and additional civil plutonium is produced. In contrast, the materials in weapons are in fewer forms and located at a smaller number of sites.

Viewed this way, the MPC&A program's accomplishments to date are small when compared to the overall task. Without discounting the importance of the program's work so far, the only "completed" sites are small, civil facilities, where relatively small quantities of material are located. Through 1998, DOE has significantly improved the security and accounting of tonnes, or perhaps tens of tonnes, of Russian fissile materials. But if one counts only materials at facilities with complete, site-wide upgrades, the secured amount is far less—perhaps only a few tonnes.

The United States and Russia have not yet agreed on the total number of facilities that need protection. Under its original plans, the Energy Department set a goal of installing security and accounting system upgrades at 80 to 100 facilities at only 30 sites. However, as more information is learned about the military production sites, the number of facilities and buildings taking part in the program could more than double.

The DOE effort has rarely succeeded in bringing MPC&A

practices in Russia to the level of internationally accepted standards. Many sites, facilities, or buildings are ill-suited to retrofitting new technologies. Making "rapid upgrades" means that materials located at some sites are secured where they are located; new, central storage facilities would be better, but they are expensive and time-consuming to construct. As a result, few if any sites and facilities where MPC&A systems have been improved could meet U.S. standards.

DOE personnel have been criticized for how they interact with their Russian counterparts. When the MPC&A program was in its infancy, it was nurtured by contacts at the technical level, which helped to build trust and a cooperative spirit among U.S. and Russian personnel. In turn, Russian personnel, including senior scientists at Russian weapons labs, became advocates of the MPC&A program. Some former U.S. government officials now worry that, as the program has grown, opportunities to build cooperative relationships are being lost and that the level of enthusiasm has diminished among Russian program supporters. According to one account, "The fact that the diplomatic teams spend very little time at a new facility proves to be a challenge for many of the facilities in dealing with the issue of top facility management 'buy in.' "[18]

MPC&A teams must overcome other setbacks, which sometimes are beyond their control. For example, maintaining the upgrades installed at Russia's nuclear sites will require technology providers to make maintenance, training, spare parts, and upgrades available to facility personnel. It is unrealistic to expect U.S. personnel to provide these services indefinitely, but Russian suppliers have been criticized for their lack of attention to these details. Moreover, the main supplier of physical protection technology has a virtual monopoly over goods and services provided to Minatom facilities. This prevents competition among a number of smaller Russian companies for the vast majority of the sites that are taking part in the program.

DOE's plans also assumed that Russia's economic and political conditions, which continue to deteriorate, would remain stable. Privately, many officials are now concerned that Russia's recent economic downturn has made conditions in Russia as bad as they were in 1991 before the MPC&A program was initiated. Severe funding and resource constraints in Russia have led to situations where recently installed MPC&A systems are not operating because guards have not been paid or because the electricity has been shut off. Ironically, the MPC&A program increases in importance as economic conditions deteriorate, even as those conditions make it more difficult to carry out the program.

Over the long term, the main challenge to fissile material security in Russia will be Russia's own lack of commitment and the resources needed to create its own, sustained MPC&A program, including the nurturing of a safeguards culture. Russia must be willing to dedicate the time, energy, and resources needed to improve security conditions for the MPC&A program to have a long-term effect. It took several decades and tens of billions of dollars for the United States to develop its current physical protection and material accountancy systems. The need to maintain and continually improve MPC&A technologies and systems will remain even after the current DOE program ends.

1. Following the Department of Energy's (DOE's) conventions, for the purposes of this chapter a "facility" is a cluster of "buildings" engaged in related activities, which are in turn located within a larger "site."
2. For a comprehensive analysis of how the collapse of the Soviet Union has affected the security of nuclear weapons and fissile materials in Russia, see Graham Allison, Owen Coté, Jr., Richard Falkenrath, and Steven Miller, *Avoiding Nuclear Anarchy: Containing the Threat of Loose Russian Nuclear Weapons and Fissile Material* (Cambridge, Mass.: MIT Press, 1996).
3. Thomas Nilsen, "Nuclear Defense Workers Go on Strike," Russia News and Status, Bellona, September 8, 1994 (on-line version: http://www.bellona.no/e/russia/980909-1.htm)
4. For a summary of conditions at several Russian military production sites as of mid-1997, see "The Nuclear Weapons Complexes: Meeting the Conversion Challenge," Russian American Nuclear Security Advisory Council (RANSAC), September 1997, especially Annex 3. For a more recent assessment by several principal RANSAC members, see Matthew Bunn et al., "Retooling Russia's Nuclear Cities," *Bulletin of the Atomic Scientists*, September/October 1998.

5. "Lebed Raises Spectre of Nuclear Break-up," Reuters, July 24, 1998.
6. Bill Gertz, "Yeltsin Orders Nuke Security Probe," *Washington Times,* October 21, 1998.
7. Khidhir Hamza, "Inside Saddam's Secret Nuclear Program," *Bulletin of the Atomic Scientists,* September/October 1998.
8. For a recent assessment of Iraq's ability to obtain sensitive materials from Russia, see Vladimir Orlov and William Potter, "The Mystery of the Sunken Gyros," *Bulletin of the Atomic Scientists*, November/December 1998.
9. Many of the cases described in this chapter have been widely reported. See, for example, "Chronology of Nuclear Smuggling Incidents," Nonproliferation Center, Central Intelligence Agency, October 13, 1995; William Potter, "Before the Deluge? Assessing the Threat of Nuclear Leakage from the post-Soviet States," *Arms Control Today*, October 1995; and Allison et. al., *Avoiding Nuclear Anarchy*.
10. Mark Hibbs, "Smuggled HEU Seized In Germany, Prague, Came from Mayak Stockpile, Police Say," *Nuclear Fuel*, September 21, 1998.
11. In 1997, General Lebed made widely publicized claims that Russia could not account for about 100 atomic demolition munitions. See Bill Gertz, "Lebed Says Russia May Have Lost 100 Suitcase-sized Atomic Bombs," *Washington Times*, November 6, 1997.
12. Jeff Erlich, "U.S. General Applauds Security of Russia Nukes," *Defense News*, November 11–17, 1997.
13. "Responses to Questions for the Record from the Central Intelligence Agency," *Current and Projected National Security Threats to the United States,* Hearing before the Senate Select Committee on Intelligence, U.S. Senate, 105th Cong., 2nd sess., January 28, 1998, S. Hrg. 105–587; p. 134.
14. Statement of Lt. Gen. Igor Valynkin, First Deputy Head of the 12th Main Directorate, Russian Ministry of Defense, "Stenographic Record of the Parliamentary Hearings on the Topic 'Issues Concerning the Security of Hazardous Nuclear Facilities,'" Committee on Security, Russian State Duma, reprinted in *Yaderny Kontrol Digest No. 5*, Center for Policy Studies in Russia (PIR Center), Moscow, Fall 1997.
15. William Potter, "Before the Deluge?"
16. MPC&A Program Strategic Plan, U.S. Department of Energy, January 1998.
17. David Albright, Frans Berkhout, and William Walker, *Plutonium and Highly Enriched Uranium 1996: World Inventories, Capabilities, and Policies* (Oxford: Stockholm International Peace Research Institute [SIPRI] and Oxford University Press, 1997), pp. 59, 114, and 414 (table 14.11).
18. William Toth, "Implementation of Physical Security Systems Technology Necessitates Changes to Facility Management and Other Network Support Elements in Nuclear Facilities of the Former Soviet Union," IAEA-CN-68/39. Paper presented to the International Conference on the Physical Protection of Nuclear Materials: Experience in Regulation, Implementation, and Operations. (International Atomic Energy Agency; Vienna, November 10–14, 1997).