Special Report

Cooperative Efforts to Secure Fissile Material in the NIS

EMILY EWELL DAUGHTRY & FRED L. WEHLING[1]

Emily Ewell Daughtry is a consultant to the Center for Nonproliferation Studies (CNS) at the Monterey Institute of International Studies, where she has worked in various capacities since 1994. From 1998-99, she was Co-Director of CNS's Newly Independent States (NIS) Representative Office in Almaty, Kazakhstan. Dr. Fred L. Wehling is Senior Research Associate with CNS's NIS Nonproliferation Project. Before coming to CNS in 1998, Wehling was a consultant at RAND, the Coordinator of Policy Research for the University of California's Institute on Global Conflict and Cooperation, and a researcher at the Cooperative Monitoring Center at Sandia National Laboratories.

THE MATERIAL SECURITY PROBLEM AND THE COOPERATIVE RESPONSE

The threat posed by inadequately protected fissile material in Russia and the other newly independent states (NIS) of the former Soviet Union is well-known: poorly safeguarded fissile material is vulnerable to theft and diversion, and, if diverted, could end up in the nuclear weapon of a rogue nation or terrorist organization. This chilling scenario has been so widely discussed that poorly protected Russian nuclear material is probably the nonproliferation challenge best known to the general public in the United States, the NIS, and the international community at large. But while the problem is fairly easy to understand, it has proved to be anything but simple to solve.

The US Department of Energy (DOE) estimates that there are approximately 650 tons of weapons-usable fissile material in the countries of the former Soviet Union, not including the material in nuclear warheads.[2] This material is scattered throughout military and civilian facilities, including nuclear fuel production facilities; nuclear weapon research, design, and production facilities; non-weapons research facilities; and educational and industrial facilities. The majority of these institutes and factories are located within the territory of the Russian Federation, but a key handful of them are located in other NIS countries, including Belarus, Kazakhstan, Latvia, Ukraine, and Uzbekistan.

The DOE has been at the forefront of cooperative efforts to improve the security and accounting of nuclear materials in the NIS. US assistance in this sphere was initiated as part of the Cooperative Threat Reduction (CTR) Program, which formally began in 1992. This CTR-funded effort was known initially as the DOE Government-to-Government Program. In 1994, DOE launched a separate, parallel program, known as the Lab-to-Lab Program, which used a slightly different philosophy to meet essentially the same objective: improve the protection, control, and accounting of nuclear material in the NIS. In 1996, DOE assumed funding responsibility for future activities in this area through its own budget authority, and in February 1997, DOE consolidated its Government-to-Government and Lab-to-Lab programs into the Materials Protection, Control, and Accounting (MPC&A) Program.[3] In spring 1999, responsibility for the non-Russian NIS was transferred out of the MPC&A Program into DOE's Office of International Safeguards, leaving the MPC&A program to concentrate exclusively on Russia.[4] A few months later, in November 1999, the MPC&A program lost its status as a Task Force and became the responsibility of a newly created Office of International Materials Protection and Emergency Cooperation.[5] At the present time, DOE either has conducted work or has agreements in place to conduct work at approximately 40 facilities in Russia, and at 13 NIS facilities outside Russia.[6] Other projects that fall under the auspices of the MPC&A Program include assistance with the development of a legal and regulatory framework in the nuclear sphere and support for critical training and education in the MPC&A sphere.

Most MPC&A work did not begin in earnest until 1994 or 1995. After a slow start, the MPC&A Program entered a phase in which emphasis was put on "rapid upgrades" consisting of quick installation of modern equipment, such as radiation and metal detectors. But after the August 1998 financial collapse in Russia, there was increasing realization that the quick-fix approach alone would not have a lasting effect on nuclear material security, and needed to be supplemented by efforts to institutionalize and maintain improvements. Thus, in 1999, the MPC&A Program office announced a number of new initiatives, including the Site Operations and Sustainability Program and the Material Conversion and Consolidation Program.[7] The goal of the Site Operations and Sustainability (SOS) Program is to make sure that the new MPC&A systems are sustainable over the long term; the Material Conversion and Consolidation Program is designed to reduce the number of sites, buildings, and NIS states where weapons-usable material is located.[8]

It has been over five years since DOE began to implement projects to modernize MPC&A at sites in Russia and the other NIS. Overall, the MPC&A Program has made and continues to make a significant contribution to the security of nuclear materials in the NIS.[9] The success of the program at individual facilities, however, is uneven. At some facilities, the program has been extremely successful, and the remaining challenge is to sustain those successes over the long term. At other facilities, including some of those where assistance officially has been completed, the program was markedly less successful. At most sites, however, a lot of work remains to be done, and it is critical that the MPC&A Program not lose momentum. By evaluating the shortcomings and the successes of the MPC&A program over the past few years at specific types of facilities throughout Russia and the other NIS, we try to identify why it has been successful at some facilities and not at others. We then use these observations to make recommendations for ways that DOE can make its program more effective as it moves into its next phase of operation.

We have divided the NIS up into the following three categories: (1) Belarus, Georgia, Latvia, and Uzbekistan–countries where DOE has helped upgrade MPC&A at one facility only; (2) Kazakhstan and Ukraine–countries where DOE has conducted upgrades at three or more facilities; and (3) Russia, the location of the vast majority of fissile material in the NIS. We have presented the non-Russian NIS in more detail, as the situation at these facilities is generally less well known.

BELARUS, GEORGIA, LATVIA, UZBEKISTAN

In general, DOE MPC&A projects have been quite successful in Belarus, Georgia, and Uzbekistan. (Although we did not discuss the program with Latvian officials, the similarity of the situation in Latvia to the situation in the other three countries makes it possible to speculate that the program was probably quite successful in Latvia as well.) In interviews, officials from facilities in these countries have affirmed that the measures taken by the DOE MPC&A Program satisfactorily address the risk of diversion of their nuclear materials.[10] These facilities have not had any major difficulties sustaining the MPC&A upgrades now in place. NIS officials point to excellent cooperative relationships based on mutual trust and respect between their facilities and the US teams as the primary reason for such success,[11] and explained that a working group comprising US and NIS team members made all decisions regarding MPC&A upgrades after discussion and consensus. Three factors may have contributed to the ability of US and NIS teams to forge such productive relationships in these countries:

- All four facilities in question were previously nuclear research institutes under the Soviet Academy of Sciences,[12] which means that none of them were particularly sensitive facilities. Consequently, there were no problems with access on the NIS side.

- The governments of all four countries actively supported the projects, and gave their full cooperation. It is worth noting that DOE assistance to these four countries was coordinated with a number of other countries (including Japan, Sweden, and the United Kingdom) through the International Atomic Energy Agency (IAEA) technical assistance program. Thus, there was in effect an international mandate for the work.
- Lastly, the facilities were relatively small and the tasks were relatively straightforward.

It is interesting to note that in at least three of these four countries, the contacts made on the MPC&A projects led to other US joint projects, completely unrelated to MPC&A. These additional projects have also contributed to nonproliferation by helping to prevent brain drain, and have been funded under such US nonproliferation programs as the International Science and Technology Center (ISTC), the Science and Technology Center-Ukraine (STCU), the Initiatives for Proliferation Prevention (IPP), and others.[13]

While these facilities appear to be in good shape now, they would almost certainly benefit from the sustainability activities planned by the DOE MPC&A program. However, these countries have been transferred out of this program and into the Office of International Safeguards, and at least one DOE official has noted that they may not automatically be considered for inclusion in such new initiatives as the SOS Program.[14] Another official has said specifically that the non-Russian NIS will not be included in the SOS Program, but will be part of a separate sustainability program.[15] Clearly, the Sosny Center for Science and Technology in Belarus, with its 370 kilograms (kg) of weapons-usable material, is as much in need of sustainability measures as the Moscow Engineering and Physics Institute, which only has kilogram quantities of weapons-usable materials.[16] It is not clear why non-Russian facilities should be denied the benefit of the thought and effort that has gone into the development of the SOS Program, or why energy and resources should be put into developing a separate sustainability program for them.

In addition, specific characteristics of the Sosny Center and Latvia's Nuclear Research Center make them excellent candidates for a highly enriched uranium (HEU) buy-up program, possibly under DOE's new Material Conversion and Consolidation program.[17] Neither facility appears to be using its nuclear material in current projects or experiments; thus they may prefer transferring the material to absorbing the costs of maintaining security on the material over the long term. In addition, Russia's Ministry of Atomic Energy recently expressed its support for a program that would transfer fissile material from the non-Russian NIS (as well as other foreign countries with Russian material) to Russia.[18] Given the close political relationship between Belarus and Russia, it may be relatively easy to work out an arrangement whereby Russia would agree to accept the Belarusian material at one of its nuclear facilities. Lastly, scientists and technicians at these facilities could benefit from attending some of the on-going training and educational programs that DOE is supporting in Moscow and Kyiv.

Belarus[19]

Weapons-usable fissile material is located at only one facility in Belarus: the Institute of Energy Problems (IEP) at the Sosny Science and Technology Center. Of the 1.9 tons of nuclear material at this facility, approximately 40 kg is weapons-grade HEU (over 90-percent enriched), and approximately 330 kg is weapons-usable (over 20-percent enriched).[20] MPC&A upgrades were completed in fall 1996, and since that time, the Belarusians have had ample opportunity to work with the physical protection system on an on-going basis. They continue to be satisfied with the effectiveness of the system, and feel that it adequately addresses the major proliferation concerns and protects against both outsider and insider threats. Thus far, they have not had any problems maintaining the physical protection equipment. The only mild criticism of the program offered by the Belarusians was that they would have preferred to purchase physical protection equipment made in the NIS. In the opinion of Sosny officials, NIS equipment would have been cheaper and more reliable, would have simplified future development of the MPC&A system, and would have made it easier to buy spare parts for the equipment when the existing warranties expire. While the economic situation in Belarus has not affected the functioning of the MPC&A system to date, officials also noted that due to the on-going process of integration between Russia and Belarus, continued economic decline in Russia could eventually affect the situation at Sosny.

The United States currently has a policy of limited engagement with Belarus due to its government's human rights record. Thus, any DOE efforts to sustain MPC&A measures at this site must be reviewed and approved ahead of time by the State Department.[21] Despite these constraints, the United States should make a particular effort to include the Sosny Center in sustainability activities given the large quantity of weapons-usable fissile material at this site.

Georgia

Prior to 1998, fissile material was located at two locations in Georgia: the Georgian Institute of Physics in Tbilisi and the Vekua Institute of Physics and Technology in Sukhumi (Abkhazia) on the Black Sea coast.[22] There were a few years in the early and mid-1990s when the 10 kg of 90-percent HEU at the Institute of Physics, which until 1990 operated an eight-megawatt (MW) research reactor, was totally unprotected and the risk of theft was high. When a civil war broke out in Tbilisi, scientists and lab technicians took turns guarding the reactor with sticks and garden rakes.[23] In August 1995, the Institute sold approximately half its fresh fuel to its counterpart in Uzbekistan, the Uzbek Institute of Nuclear Physics.[24] In 1996, DOE spent approximately six months installing MPC&A upgrades to protect the remaining fuel. However, the measures were temporary. In April 1998, after spending just one and a half months on the ground doing everything from a site survey to packaging the material for transport, the United States removed the last 4.3 kg of fresh fuel and 800 grams of spent fuel from Georgia for secure storage in Scotland. US, Georgian, and British officials agree that the project to remove the fuel, Operation Auburn Endeavor, was a great success.[25]

The second Georgian facility is the Vekua Institute of Physics and Technology in Sukhumi, which conducted research for the Soviet military-industrial complex. A small amount of 90-percent enriched HEU, possibly two kg, was located at the Vekua Institute.[26] Scientists and officials from the Sukhumi Institute were forced to flee to Tbilisi in 1993 when Abkhazian rebels took over the city. Scientists made frantic last-minute attempts to secure the HEU fuel and other radioactive materials before they abandoned the Institute.[27] Since 1993, Georgian scientists and officials have been unable to visit the site, and thus have been unable to do a physical inventory. Officials of the breakaway Abkhazian republic have also refused to acknowledge Georgia's right to allow the IAEA to inspect the facility, despite Georgia's comprehensive safeguards agreement with the IAEA.[28] Russian officials apparently gained access to the site in late 1997, and found nothing. The material had disappeared and its whereabouts are unknown.[29]

Latvia

In March 1996, the Nuclear Research Center at Salaspils, which is under the auspices of the Latvian Academy of Sciences, became the first facility in the NIS where DOE-funded MPC&A upgrade projects were completed. In June 1998, the Salaspils reactor was shut down and decommissioned. According to press reports, the decision to shut down the reactor was based on a lack of government finances and safety concerns. The reactor core contained a maximum of four kg of 90-percent HEU fuel when operational.[30] It is unclear how much fresh nuclear fuel is still stored on-site. However, the director of the facility was quoted in the Latvian press in January 1996 as saying that there is enough nuclear material at Salaspils to make five nuclear bombs.[31]

Uzbekistan

Fissile material is located at two locations in Uzbekistan: the Institute of Nuclear Physics (INPh) in the village of Ulugbek, just outside Tashkent; and the Photon Radioelectrical Technical Plant in the city of Tashkent. DOE completed the majority of physical protection upgrades at the Institute of Nuclear Physics in October 1996;[32] it has not provided any assistance to the Photon Plant.

The INPh operates a VVR nuclear research reactor. The reactor was previously fueled by 90-percent enriched HEU fuel, but the INPh is in the process of converting the core to operate on 36-percent enriched fuel. According to Dr. Bekhzad Yuldashev, the director of the facility, officials at INPh decided to switch to a lower-enriched fuel in order to conform to current tendencies within the international community. After a few years, the INPh plans to reduce the fuel enrichment level further to 20 percent. INPh has received no outside funding for the conversion project.[33]

Physical protection upgrades at INPh were completed in 1996, and facility officials report no real problems sustaining the upgrades. When asked what would happen when the warranty on the new foreign-made equipment runs out in fall 1999, Yuldashev appeared to anticipate continued US assistance, noting confidently that Sandia National Laboratory and DOE have promised to take care of any problems as they arise.[34]

The Photon Radioelectrical Technical Plant, which has a small, pulsed reactor fueled by HEU, previously fell under the auspices of the Soviet Ministry of Electronic Production, which produced microcircuits for submarines.[35] Officials at the Institute of Nuclear Physics have no information about the level of MPC&A at Photon, but they do not believe that any fresh fuel is stored on-site.[36] DOE officials visited this site when they first began work in Uzbekistan, but determined that the material did not pose a proliferation risk and therefore did not warrant MPC&A upgrades. However, DOE officials have noted that they may revisit this site in the future to confirm that their original findings are still valid.[37]

KAZAKHSTAN AND UKRAINE

Overall, the success of DOE assistance in Kazakhstan and Ukraine is more varied than in the NIS countries already described. The facilities themselves are more diverse; they include research institutes of various levels of sensitivity, production facilities, nuclear power plants, and a former naval training facility. Some of the DOE's notable successes in these countries include the upgraded MPC&A system at the Institute of Nuclear Research in Kyiv and the removal of 600 kg of HEU from the Ulba Metallurgical Plant in Kazakhstan in 1994. At other facilities, such as the Mangystau Atomic Energy Combine in Kazakhstan and the Sevastopol Institute of Nuclear Energy and Industry, major proliferation concerns remain, raising questions about DOE's claim that it has completed all MPC&A upgrades outside of Russia. Kazakhstani and Ukrainian government officials are generally positive about DOE assistance, but officials from facilities themselves are not always as quick to praise the program. All facilities would benefit from sustainability activities planned by the DOE MPC&A program. As was the case with the NIS countries above, the transfer of these countries out of the MPC&A program and into the Office of International Safeguards makes it unlikely that they will take part in new DOE initiatives such as the SOS Program. Of the seven facilities in these two countries, the quantity, level of enrichment, and other characteristics of the fissile material at the Kharkiv Institute of Physics and Technology probably make it the best initial candidate for an HEU buy-up program, perhaps under the auspices of the Material Conversion and Consolidation Program.

Kazakhstan

Weapons-usable fissile material currently is located at three sites in Kazakhstan: the Mangystau Atomic Energy Combine in the Caspian Sea port city of Aktau; the National Nuclear Center's (NNC) Institute of Atomic Energy in Kurchatov City at the former Semipalatinsk Test Site; and a branch of the NNC's Institute of Atomic Energy in Alatau, just outside the former capital of Almaty.[38] Although there was weapons-grade HEU at the Ulba Metallurgical Plant prior to 1994, there is no longer any weapons-usable fissile material at Ulba.[39]

Kazakhstani officials have expressed the opinion that while foreign assistance has helped improve the security of nuclear materials in Kazakhstan, a great deal of work remains to be done. In general, Kazakhstani officials are concerned about their ability to maintain and obtain spare parts for newly installed MPC&A equipment, and have also remarked that facility specialists need more training on nonproliferation issues.[40] Some Kazakhstani facility personnel have complained about foreign-manufactured equipment, noting that it is more expensive to maintain and not as well made as equipment manufactured in the NIS.[41] Paradoxically, some US personnel have criticized the Kazakhstanis for insisting on the installation of expensive, state-of-the-art MPC&A equipment when systems with lower-cost equipment that could be more easily supported by Kazakhstan's technical infrastructure would have been more appropriate.[42] This contradiction suggests that there may have been some misunderstandings between the US and Kazakhstani teams, and illustrates the difficulty of maintaining clear lines of communication on the many issues involved in upgrading and sustaining MPC&A systems.

The BN-350 fast breeder reactor at the Mangystau Atomic Energy Combine, which was permanently shut down in April 1999, remains the most vulnerable nuclear site in Kazakhstan due to its geographic location on the Caspian Sea coast and the amount of plutonium in the spent fuel stored on-site. MPC&A upgrades financed by Japan and the United States have been in place since late 1998, and some additional US-funded physical protection work is scheduled to continue through 2001.[43] In 1997, the United States and Kazakhstan signed an agreement on cooperative efforts to address long-term storage of the spent fuel.[44] A DOE-funded project to transport the spent fuel from Aktau to the more remote and therefore more secure Semipalatinsk Test Site (STS) was launched,[45] and secure railcars for this purpose were developed. According to one schedule, the transfer of spent fuel was due to be completed in the 2004-5 timeframe.[46] However, the spent fuel has not yet been transported to the STS, and there are now some doubts on both the Kazakhstani and the US sides as to the need to move the fuel after all. In December 1999, DOE announced that a joint US-Kazakhstani expert group would begin to study options for long-term storage of this fuel in early 2000.[47] Thus, over 2,000 spent fuel rods plus breeder blankets remain in storage at the BN-350 facility. It is worth noting, however, that hot (highly irradiated) and cool (less irradiated) spent fuel assemblies have been placed together in six packs and welded into steel canisters, making the cool spent fuel considerably less vulnerable to diversion. A number of DOE officials have stated that they are confident that the material at Aktau is secure and well protected.[48]

This conclusion may be premature. On a visit to Aktau in early 1999, CNS staff were shown some of the physical protection equipment, consisting of three specially calibrated metal detectors and an x-ray machine for bags, at the main entrance to the facility. However, the machines were not turned on. Aktau officials explained that it was not necessary to keep the machines on as the reactor was not in operation and there were very few people on-site.[49] DOE officials have pointed out that this equipment was provided by Japan, not the United States, and have explained that DOE's upgrades at the reactor building itself are reliable.[50] However, the attitude of the Aktau officials demonstrates the need for continued development of a safeguards culture at Kazakhstani facilities.

The NNC's Institute of Atomic Energy operates four nuclear research reactors at two locations. One of these reactors, the VVR-K located in Alatau, was restarted in 1998 after a nine-year shutdown for safety upgrades and seismic retrofitting.[51] The reactor operates on 36-percent enriched HEU fuel. US MPC&A assistance has led to significant safeguards and security upgrades at Alatau, where as late as 1996 there were literally no visible signs of physical protection.[52] The IVG-1M and RA research reactors at the Baykal-1 complex, located in the desolate steppe on the STS, operate on HEU fuel enriched to 90 percent. With the exception of material still in the reactor cores and 600 grams of fresh HEU fuel in storage, all fresh fuel at Baykal-1 was returned to Russia by 1997. Kilogram quantities of fresh fuel are stored onsite at the IGR reactor as well.[53] Physical protection upgrades at these reactors have enhanced material security, but some US experts report that some installed systems have not become fully operational due to lack of funding and trained operators.[54] Kazakhstani officials have made a number of suggestions for additional projects to enhance physical protection at these sites. According to Kazakhstani specialists, additional necessary MPC&A upgrades include: modernization of alarm and communications systems, installation of an uninterrupted power source for MPC&A equipment, and installation of portal monitors to detect radioactive materials.[55]

Ukraine[56]

Weapons-usable fissile material is located at three facilities in Ukraine: The Institute of Nuclear Research (INR) in Kyiv; the National Science Center (NSC) Kharkiv Institute of Physics and Technology (KhIPT); and the Sevastopol Institute of Nuclear Energy and Industry (SINEI). DOE did work to improve the security of the fissile materials at these three sites between 1994 and 1999, and in January 1999 ostensibly completed MPC&A upgrades in Ukraine.

According to Ukrainian nuclear specialists, DOE assistance has significantly reduced the risk of diversion and theft of fissile material from Ukrainian facilities. In addition, many of the key personnel at the three nuclear research sites now have a better understanding of the risks of nuclear proliferation, and of their role in securing nuclear materials. However, the results of DOE's assistance have been uneven. MPC&A upgrades were most successful at the Institute of Nuclear Research and least effective at the SINEI. Months after a DOE ceremony to commission a new physical protection system, scientists at SINEI expressed the belief that the nuclear materials at their institute are not adequately protected from insider diversion. And while nuclear materials at the (KhIPT) are better secured and accounted for than they were five years ago, KhIPT officials doubt their ability to sustain the upgrades over the long term. Ukrainian officials are particularly concerned about what will happen when the current warranties on MPC&A equipment run out. It is critical that DOE include all three Ukrainian institutes in its planned SOS Program, and that special attention be paid to the needs and concerns of SINEI and KhIPT.

The INR, located in the Ukrainian capital of Kyiv, is a civilian scientific research institute and was not involved in the Soviet nuclear weapons program. The institute operates a 10-MW nuclear research reactor that uses 90-percent and 36-percent enriched HEU fuel assemblies. Officials at INR expressed great satisfaction with their experience with the DOE MPC&A program and are confident that the nuclear material at their institute is secure against both insider and outsider threats. An upgraded physical protection system was formally commissioned in October 1997. In addition, DOE has provided funds to establish the George Kuzmycz Training Center for Material Protection, Control, and Accounting of Nuclear Materials at INR, analogous to the Russian Methodological and Training Center in Obninsk. Thus far, courses at this center have focused on the technical aspects of MPC&A only.

The KhIPT is located in the industrial city of Kharkiv in northeastern Ukraine. Although much of the research conducted at KhIPT during the Soviet period was in the civilian sector, some of it directly contributed to Soviet nuclear weapons programs.[57] A number of important experimental facilities are located at KhIPT, including the largest linear accelerator in the former Soviet Union. There is up to 75 kg of 90-percent enriched HEU in bulk and item form at KhIPT, making this one of the most proliferation-sensitive sites in the former Soviet Union outside Russia.[58] A key aspect of DOE assistance here involved repackaging the HEU into containers that provided for easier material accountability.

Despite the fact that significant MPC&A improvements were made at this site, KhIPT officials are unsatisfied with many aspects of their joint work with DOE. It appears that the Ukrainian and US team members at KhIPT had a difficult time establishing an effective working relationship based on mutual trust. Disagreements over equipment and methodology often took a long time to resolve, which slowed down the pace of work considerably. DOE officials have expressed frustration with the level of cooperation on the Ukrainian side, and have questioned the commitment of some KhIPT officials to "the stated common goal of protecting the nuclear material."[59] For their part, officials at KhIPT were dissatisfied with some of the decisions to use US-made equipment and are pessimistic about their ability to maintain and operate it after warranties expire at the end of 1999. Those responsible for physical protection at KhIPT compared the situation to being "left on the open ocean in a small boat without oars, and no possibility of making it to shore on our own."

The SINEI, which is under the auspices of the Ukrainian State Committee for Nuclear Power Utilization (Energoatom), is located in the city of Sevastopol on the Black Sea coast. During the Soviet-era, it was known as the Sevastopol Naval Academy, and was a training facility for nuclear submarine operators. SINEI has a 200-kilowatt (KW) research reactor, as well as two sub-critical assemblies. The research reactor and one of the sub-critical assemblies are fueled by HEU enriched up to 36 percent.[60] DOE began working at SINEI in 1995 and an upgraded physical protection system was formally commissioned in January 1999. Although both US and Ukrainian officials agree that the nuclear material is now better protected than it was previously, serious deficiencies in the MPC&A system may remain. DOE officials have stated that all engineering and technological upgrades to the security system have been completed.[61] However, Sevastopol scientists have specifically noted that because a portal monitor to detect radioactive material has not been installed, the institute is not adequately protected from the "insider threat." They specifically noted that delays in salaries could provoke workers to steal nuclear materials. DOE officials noted that until the Ukrainians complete some key administrative tasks, the newly installed security systems will not protect the nuclear material at Sevastopol as effectively as possible.[62]

Both the US and Ukrainian sides have acknowledged the problems that were involved with upgrading security at this site. Communication with SINEI was difficult due to poor-quality phone lines, and a misunderstanding at Ukrainian Customs caused US-made MPC&A equipment for SINEI to be impounded for 19 months.[63] SINEI scientists complained that some of the equipment provided was not compatible with the local infrastructure. For example, SINEI scientists noted that physical protection equipment imported from the United States was designed for 60-Hz AC current, but the Ukrainian frequency is 50 Hz. DOE officials countered that this equipment may have been provided by Japan, as they were not aware of any problems with equipment they provided.[64] Operating instructions for some of the equipment were provided in English only—an oversight that has occurred at many sites throughout Russia and the NIS.

It is clear that maintaining a close working relationship and high level of trust between the teams from the two countries is one of the keys to maximum effectiveness of the projects to improve MPC&A. This appears to be one of the reasons that the MPC&A program was so successful at INR, and less so at KhIPT and SINEI. Several factors may have enabled the two sides to build a more productive relationship at INR than at the other institutes. The MPC&A projects began first at the INR when the program was new. Both sides probably exhibited more caution and more enthusiasm than later on, and this may have facilitated the gradual development of a good cooperative relationship. In addition, the INR is and always has been a civilian research institute attached to the Academy of Sciences. Scientists from such an organization are less likely to be inherently suspicious of Americans than scientists at an institute such as KhIPT, which was firmly ensconced within the military-industrial complex, or the Sevastopol Institute, which was part of the Ministry of Defense itself.

RUSSIA

In Russia, the MPC&A program has succeeded in enhancing the security of a significant amount of fissile material. According to DOE estimates, the program has placed approximately 50 tons of fissile material under upgraded security and consolidated one ton from smaller, vulnerable sites to more secure facilities.[65] It has failed, however, to build the institutional partnerships that will be necessary for protecting this material on a long-term basis. In addition, the majority of Russian fissile material is not yet protected by MPC&A systems that have been upgraded under DOE programs. Much work remains to be done, and the threat of theft or diversion from many sites remains quite serious. Given the large number of facilities in Russia, and given that the situation at many sites has been described quite well in a number of other studies, we will not attempt to describe specific upgrades at each individual facility.[66] Instead, we have divided the Russian facilities into three broad categories: weapons research laboratories and serial dismantlement facilities; civilian research facilities; and fissile material production facilities.

Weapons Research Laboratories and Serial Production Facilities

Cooperative programs have significantly improved the security of some nuclear material at Russia's two nuclear weapons laboratories, the All-Russian Scientific Research Institute of Experimental Physics (VNIIEF) in Sarov and the All-Russian Scientific Research Institute of Technical Physics (VNIITF) in Snezhinsk. However, according to one estimate, the majority of fissile material at both facilities is located in areas where security has yet to be upgraded.[67] Other serious safeguards and security concerns at these facilities include physical inventory capabilities and guard forces. Moreover, the cooperative partnerships developed at these facilities during the early years of US-Russian lab-to-lab cooperation have become strained, and progress on MPC&A upgrades has slowed as the relationship between DOE and the Russian Ministry of Atomic Energy (Minatom) has deteriorated. On a more positive note, however, VNIIEF and VNIITF have become centers of excellence in MPC&A procedures and technology, and are developing expertise that should be made available to other Russian facilities.[68] Both laboratories are capable of manufacturing high-quality MPC&A equipment for their own use and for other facilities and, if adequate resources are provided, of operating and maintaining advanced physical security systems.[69]

Much of the weapons laboratories' success in upgrading MPC&A stems from their early and enthusiastic participation in DOE's Lab-to-Lab Program, which formed cooperative relationships essential to the success of security upgrades. Unfortunately, rapid turnover in US personnel assigned to these sites has made it difficult to sustain the cooperative momentum of the program's early days. Working relationships often have to be rebuilt from scratch when new personnel are assigned, adding months to the time required to complete necessary upgrades. Additionally, political developments and questions of access to sensitive facilities have recently slowed progress. Some Russians have expressed the view that US requirements for greater access to sensitive areas are suspicious, as they often come late in the upgrade process, giving them the appearance of attempted espionage.[70] Although US assistance for existing projects will continue, no new projects will be initiated until access issues are resolved.[71] A joint US-Russian task force on access to sensitive facilities was appointed in early October 1999, offering some hope for progress on these critical questions.[72]

In 1998, DOE-funded MPC&A upgrades were scheduled to begin at the very sensitive serial production facilities (where nuclear weapons are assembled and dismantled).[73] Some portal monitors and other equipment upgrades have been sent to these facilities, but US experts have not been given access to any of these sites, and no work will proceed until access issues are resolved.[74]

Civilian Research Facilities

By the end of 1999, the MPC&A program had completed safeguards and security upgrades at 11 small research facilities and finished upgrades for significant portions of three larger research facilities.[75] Some of these upgrades, such as those at the Scientific Production Association Luch (NPO Luch), have been extremely successful and have made major improvements in both physical security and in the development of a safeguards culture. Nevertheless, serious safeguards and security deficiencies remain to be addressed at many facilities, and the sustainability of security upgrades remains a major concern. To give one example, physical protection equipment at the Joint Institute of Nuclear Research (JINR) in Dubna was not being operated properly more than eight months after MPC&A upgrades had been officially completed (though this specific problem may have been subsequently corrected).[76] DOE is attempting to address some of these problems through its SOS Program.[77]

Two other research facilities have been singled out for a pilot project under the Material Conversion and Consolidation Program. HEU from the NPO Luch in Podolsk and the Scientific Research Institute for Instruments in Lytkarino will be blended down from 90 percent to 17 to 19.5 percent at Luch. By September 1999, all the HEU from one of the buildings at Lytkarino was transferred to Luch, and Luch completed the downblending of the first 100 kg of HEU. Also in September 1999, DOE and Minatom signed a letter of intent to expand the program to convert at least one ton of HEU in fiscal year (FY) 2000, and a possible additional eight to 10 tons in the years to follow.[78] In addition, the Reduced Enrichment Research and Test Reactor (RERTR) Program has made serious efforts toward converting HEU-fueled research reactors to operate on lower enriched fuel. As of December 1999, however, technical and bureaucratic problems had prevented the actual conversion of any reactor cores.[79]

Two major training and educational programs have been launched at Russian research facilities with DOE assistance. One is the establishment of the Russian Methodological Training Center (RMTC) for Nuclear Material Control and Accountability at the Institute of Physics and Power Engineering in Obninsk. The RMTC was created in 1994 to act as the central Russian training facility for MPC&A specialists from Minatom and Gosatomnadzor. It is funded jointly by Minatom, the DOE, and the Joint Research Centre of the European Commission. As of late 1998, over 1,000 NIS specialists had gone through training at the RMTC.[80] Another unique educational program, the equivalent of a master's degree in "Nuclear Materials Safe Management, Protection, Control and Accounting," was initiated at the Moscow Engineering and Physics Institute in 1997. The program covers the technical aspects of MPC&A and the political aspects of nonproliferation, and provides intensive English language training. This program fills a critical need, and is doing important work to train the next generation of MPC&A specialists in Russia.

Fissile Material Production Facilities

The large volume of fissile material at these facilities makes increased safeguards and security an especially urgent priority. Unfortunately, the management at many production facilities has not given sufficient priority to MPC&A upgrades or taken adequate precautions against insider threats.[81] US experts have not been given required access to HEU production lines at most facilities, making it impossible to evaluate the adequacy of safeguards and security at targets of extremely high value to thieves and terrorists. (Confidential sources report that in some cases, while facility management has been willing to grant access to US site teams, the Federal Security Service (FSB) has prohibited it.) These deficiencies are especially worrisome at facilities, like the Elektrostal Machine Building Plant, that produce low enriched uranium (LEU) fuel or other products for export, as ongoing international contacts and shipping activities could easily create cover for sales or diversion to proliferators.

One reason for the low priority given to MPC&A may be that production facilities do not perceive a financial interest in MPC&A, regarding material security as a net drain on their resources. The possibility that legal export operations could provide cover for illegal exports is also widely ignored. A related problem is that facilities downblending HEU for sale to the United States through the "Megatons to Megawatts" program have been slow to implement transparency measures designed to verify the weapons origin of the downblended uranium. Because LEU fuel exports are a major source of revenue for the entire Minatom complex, the United States and other buyers should require improved MPC&A as a condition in export sales contracts.[82]

Despite some initial difficulties, recent progress in construction of the Mayak Fissile Material Storage Facility (FMSF), which when completed will provide secure storage for 50 metric tons (MT) of plutonium from approximately 6,250 dismantled Russian nuclear weapons, offers a strong positive example of US-Russian material security cooperation.[83] However, as the FMSF is an entirely new facility being built from the ground up through the CTR Program (administered by the US Department of Defense, not DOE), rather than the MPC&A Program, it is not immediately clear how lessons learned and precedents established at the FMSF could be applied directly to DOE-Minatom cooperation to upgrade security at operational Russian facilities.

In September 1997, the United States and Russia agreed to convert the cores of the plutonium production reactors at Seversk (Tomsk-7) and Zheleznogorsk (Krasnoyarsk-26) so that they will no longer produce weapons-grade plutonium.[84] The conversion project has been delayed, however, and as a result these facilities will produce an additional three to 4.5 tons of weapons-grade plutonium by 2003. While some US experts believe it is technically possible to convert the reactor cores, others note that there are significant technical hurdles that must be overcome before the conversion issue can be solved. To further complicate matters, the Russian Federal Inspectorate for Nuclear and Radiation Safety (GAN) opposes the continued operation of these reactors beyond their designed service life for safety reasons, and thus opposes conversion altogether.[85] It is unclear, therefore, whether core conversion can proceed as specified in US-Russian agreements.

Despite the very different nature of these three categories of facilities, it is possible to draw some general conclusions across all three categories.[86]

- The complicated and at times contentious DOE-Minatom relationship, often characterized by suspicion and frustration, is affecting implementation of MPC&A projects in Russia. Here the legacy of the Cold War adversarial relationship between the United States and the Soviet Union is most visible. The October 2, 1999, DOE-Minatom agreement on cooperation in the MPC&A sphere is an important milestone, and may help facilitate the DOE-Minatom relationship.[87]
- US policy and program requirements are not always congruent with Russian priorities. For example, while the United States is primarily concerned with protecting weapons-usable nuclear material, Russian sites must integrate the protection of weapons-usable material into their overall MPC&A planning and operations.
- Russians have criticized both Minatom and DOE for not having an adequate strategic plan for MPC&A.
- Many Russian specialists in this field believe that Russia could solve its MPC&A problems without US assistance, but that it would take much longer. Some US experts, however, are skeptical of this assessment.
- Russian scientists and facility officials have emphasized repeatedly that the rapid turnover within the US teams is negatively affecting their ability to implement MPC&A projects. The Russians claim that US team members barely have time to understand the situation at a specific facility before they are removed from the teams. This can lead to significant delays in project implementation.
- Changing US program priorities and the linkage of funding of on-going projects to enhanced access also give the impression of arbitrary, one-sided decisionmaking. US officials have noted that what may seem arbitrary to the Russians is actually driven by the DOE budgetary process. But the bigger obstacle may be that US and Russian teams simply do not see eye-to-eye on some issues, such as the need for perimeter defense.
- The Russians view the development of radio communications systems for guards at some Minatom facilities as a concrete positive development. Under old Soviet regulations, radio communications equipment at Minatom facilities was strictly forbidden.[88]
- However, Ministry on Internal Affairs (MVD) guard forces are a serious weakness at a large number of Russian facilities. Guards at many sites are underpaid or unpaid, untrained, and have little or no idea of what they are guarding and why they should guard it. Cooperative programs are just beginning to address these deficiencies.
- The level of communication between the United States and Russia in general has been criticized–both on the level of the Russian facilities and US labs, and on the level of DOE and Minatom. The level of communications within the Minatom complex and within the DOE/lab complex has also been criticized.
- Material accountancy and physical inventory sys-

tems are seriously inadequate at most Russian facilities. One Russian expert estimates that a complete physical inventory of all nuclear material in Russia, utilizing current Russian capabilities, would take over 100 years.[89] However, there is positive news in this area: the material accountancy system developed by the Kurchatov Institute was recently certified, and can now be deployed at other Russian sites. The Kurchatov Institute apparently already has a contract to install an MC&A system at Krasnoyarsk-26.

• At many Russian facilities, deference to authority often allows high-level officials and visitors to bypass critical access control systems. This is one of many factors that point to the need to continue to actively promote the development of a nonproliferation and safeguards culture through nonproliferation training.

• Leadership and personal contacts can make a critical difference. Individual MPC&A projects are more likely to succeed if clear leadership and strong personal contacts between US and Russian team members are established.

RECOMMENDATIONS FOR THE DOE MPC&A PROGRAM

The successes and shortcomings of the MPC&A program outlined above suggest the following recommendations for continued and expanded cooperative efforts to improve material security in the NIS.[90]

1. **Funding for MPC&A programs should continue to be provided for at least 10 years.** A great deal of progress has been made in the past five years, and it is critical that DOE's MPC&A efforts not lose momentum.

2. **Prioritize program objectives through joint US–Russian Strategic Planning.** Issues that need to be addressed include US access to sensitive Russian sites in need of MPC&A upgrades, complete physical inventories of fissile material at Russian sites, the use of NIS-manufactured or imported equipment, and "sunset" planning for the eventual end of US financial assistance. DOE's Russian Strategy Group should be reactivated, or another joint US-Russian high-level group formed, to develop an overall strategic plan for sustainable material protection.

3. **Expand material consolidation programs.** Consolidation of fissile material at fewer sites is critical to the long-term protection of the material. In addition to consolidating material within Russia, DOE should consider consolidating material from the non-Russian NIS to Russia as part of an HEU buy-up program. The Sosny Science and Technology Center in Belarus and the Kharkiv Physics and Technology Institute are prime candidates for an HEU buy-up program, as these sites have large amounts of weapons-usable and weapons-grade HEU. While some non-Russian countries may initially be reluctant to part with their HEU, the right combination of financial incentives and careful diplomacy would be likely to encourage their interest in a buy-up program.

4. **Expand the budget for sustainability activities.** Sustainability is the key to maintaining effective MPC&A at nuclear sites in the former Soviet Union. DOE has proposed an ambitious SOS Program to address this issue, but it must be adequately funded in order to be successful. This program was funded at $11 million in FY 2000; at a minimum the annual budget for this program should be doubled.[91]

5. **Include the non-Russian NIS in sustainability activities.** There is as much need to sustain MPC&A improvements in the non-Russian NIS as there is in Russia. DOE has plans to address some of the important, but relatively simple sustainability issues by extending warranties on MPC&A equipment in these countries.[92] However, measures to address less tangible aspects of sustainability, such as development of an effective safeguards culture, must also be addressed. The non-Russian NIS would benefit from comprehensive sustainability measures, such as those envisioned in the SOS Program.

6. **Expand Russia's capacity to enforce MPC&A regulations.** Regulatory reform in Russia will be challenging to implement, but is absolutely required for long-term sustainability. To this end, DOE should be careful not to de-emphasize its support for Gosatomnadzor. Minatom's internal regulatory capacity also should be strengthened, and consideration should be given to subsidizing Minatom-led inspection teams.[93]

7. **Link export opportunities for Russian fissile material production facilities to adequate implementation of MPC&A systems.** Fissile material production facilities may be more likely to take their MPC&A responsibilities seriously if poor implementation of MPC&A leads to denial of export licenses or refusal to purchase nuclear fuel or other products from these facilities.

8. **Focus on education as the means for development of a nonproliferation culture in Russia and in the non-Russian NIS.** The establishment of MPC&A training centers in Obninsk and Kiev, as well as educational programs such as the one at MEPhI are extremely positive developments, and DOE should continue to actively support them.

- **Sponsor the participation of specialists from the non-Russian NIS in training courses at the RMTC in Obninsk or the Kuzmycz Center in Kyiv at least once a year.** To date, Russian and Ukrainian specialists have been the primary beneficiaries of these programs. It may make sense to send Uzbek scientists and technicians to Kyiv, given the established relationship between Uzbekistan and Ukraine in the nonproliferation sphere. (Uzbekistan chose to join the Ukrainian Science and Technology Center as opposed to the Moscow-based International Science and Technology Center.)
- **Sponsor the participation of one non-Russian NIS specialist per year in the MEPhI master's degree program in MPC&A.**
- **Sponsor the development of courses at the Kuzmycz Center on the political aspects of nonproliferation**. The PIR Center in Moscow, a Russian non-governmental organization (NGO), has been instrumental in organizing courses for the MEPhI MPC&A Program on the political aspects of nonproliferation, using indigenous nonproliferation expertise. The Research Center on Nonproliferation Problems in Kyiv, a new Ukrainian NGO directed and staffed by some of Ukraine's top nonproliferation specialists, might be able to organize similar courses at the Kuzmycz Center in Kyiv.

9. **Foster the development of strong cooperative relationships between US and NIS teams based on mutual trust and respect.** Such relationships appear to be one of the key factors in the successful outcome of MPC&A projects. There are a number of ways this could be done:

- **Reduce personnel turnover on US teams.** Rapid turnover prevents US personnel from fully understanding the situation at Russian facilities, and does not give them time to develop meaningful relationships with their Russian counterparts. US cooperation with the Russian Navy and the Kurchatov Institute to upgrade the security of fresh fuel for naval propulsion reactors has benefited greatly from the long-term assignment of a small, consistent team of US experts.[94]
- **Brief Russian and NIS site management on the US budget process for MPC&A projects to reduce suspicions of arbitrary or politically motivated funding decisions.**
- **Provide cultural sensitivity training to US team members, especially to those who have never spent any time in the former Soviet Union.** A lack of cultural sensitivity can hinder the development of strong relationships. DOE may also want to consider mandatory basic Russian-language training for key managers and team leaders.
- **Take into account the specific nature of a particular facility when applying lessons learned to strategies for the future.** Facilities that were not an integral part of the nuclear weapons complex may be much more receptive to cooperation with the US than facilities that were.
- **Provide more opportunities for informal communication and information-sharing between Russian and NIS facilities and DOE and US lab personnel.** An MPC&A newsletter, such as the one proposed by officials at the RMTC in Obninsk, and websites with technical and policy information in Russian, including translations of papers presented at the annual meetings of the Institute of Nuclear Materials Management, are excellent examples of ways to promote increased communication.[95] The professional conferences planned under the SOS Program are also important steps toward this goal.
- **Promote scientific exchanges and joint projects outside the MPC&A Program through existing ISTC, STCU, and IPP programs.** These projects provide institutes with a relatively stable source of outside income so that they can spend more of the limited resources they receive from their respective governments on MPC&A maintenance. Joint projects also make scientists feel that the United States is actually interested and concerned about the future of their institutes, and does not regard them simply as the repository of a certain number of kilograms of HEU.

To sum up, although the security of fissile material in the NIS has often been treated as a technical problem, it is actually a "people problem." Nuclear custodians in the NIS must be provided with adequate organization, motivation, training, equipment, and resources to perform their primary mission of safeguarding nuclear material on a sustainable basis. The DOE MPC&A program must therefore pay as much attention to building and maintaining cooperative relationships as it has given to installing MPC&A equipment and systems in order to sustain a successful partnership for nuclear material security.

[1] The authors would like to thank John M. Boyd, Oleg Bukharin, Matthew Bunn, Todd Perry, Philip Robinson, and Yurii Volodin for their comments and suggestions on this article.

[2] Rose Gottemoeller, "The Importance of Sustainability in Securing Nuclear Material in the FSU," paper given at the American Nuclear Society Global '99 Conference, Jackson Hole, Wyoming, August 29-September 3, 1999, <http://www.doe.gov/nn/mpca/pubs>.

[3] Monterey Institute of International Studies and Carnegie Endowment for International Peace, *Nuclear Successor States of the Soviet Union: Status Report on Nuclear Weapons, Fissile Material, and Export Controls,* No. 5, March 1998, p. 42.

[4] Kenneth B. Sheely and Mary Alice Hayward, "New Strategic Directions in the MPC&A Program," paper presented to the 40th Annual Meeting of the Institute of Nuclear Material Management, July 25-29, 1999, Phoenix, AZ, <http://www.dp.doe.gov/nn/mpca/pubs>.

[5] DOE official, correspondence with author, December 1999.

[6] Carrie Smarto et al., "MPC&A Site Operations and Sustainability: A Policy Overview," paper presented to the 40th Annual Meeting of the Institute of Nuclear Material Management, <http://www.dp.doe.gov/nn/mpca/pubs>; and US Department of Energy, "MPC&A Program Strategic Plan," January 1998.

[7] Sheely and Hayward, "New Strategic Directions in the MPC&A Program."

[8] Gottemoeller, "The Importance of Sustainability in Securing Nuclear Material in the FSU."

[9] Noteworthy evaluations of the cooperative programs for fissile material security include John M. Shields and William C. Potter, eds., *Dismantling the Cold War: U.S. and NIS Perspectives on the Nunn-Lugar Cooperative Threat Reduction Program* (Cambridge, MA: MIT Press, 1997); William C. Potter, "Outlook for the Adoption of a Safeguards Culture in the Former Soviet Union," *Journal of Nuclear Materials Management* 26 (Winter 1998), pp. 22-34; James Doyle and Stephen Mladineo, "Assessing the Development of a Modern Safeguards Culture in the NIS," *The Nonproliferation Review* 5 (Winter 1998), pp. 91-100; US General Accounting Office, *Nuclear Nonproliferation: Concerns with DOE's Efforts to Reduce the Risks Posed by Russia's Unemployed Weapons Scientists,* GAO/RCED-99-54, Washington, DC, February 1999; US Congressional Budget Office, *Cooperative Approaches to Halt Russian Nuclear Proliferation and Improve the Openness of Nuclear Disarmament,* May 1999; National Research Council, *Proliferation Concerns: Assessing US Efforts to Help Contain Nuclear and Other Dangerous Materials and Technologies in the Former Soviet Union* (Washington, DC: National Academy Press, 1999); Matthew Bunn, "The Next Wave: Urgently Needed New Steps to Control Warheads and Fissile Material," Carnegie/Harvard Joint Working Paper, September 1999; and Todd Perry, "From Triage to Long-Term Care: A US NGO View on the Future of the MPC&A Program," paper presented at the 40th Annual Meeting of the Institute for Nuclear Materials Management.

[10] Dr. Bekhzad Yuldashev, Director of the Institute of Nuclear Physics, Ulugbek (Tashkent), Uzbekistan, interview with author, February 1999; Drs. Gogi Kharalidze, Zurab Saralidze, and Shukuri Abramidze, Institute of Physics, Georgian Academy of Sciences, Tbilisi, Georgia, interview with author, April 1999. Alexander Mikhalevich, Director, Institute of Energy Problems, Sosny Science and Technology Center, correspondence with author, August 1999.

[11] One Belarusian official pointed out that despite the difficult political relationship between Belarus and the United States, the Belarusian Sosny Science and Technology Center and the US national laboratories have maintained excellent relations.

[12] Center for Nonproliferation Studies, NIS Nuclear Profiles Database, Sections on Belarus, Georgia, Latvia, and Uzbekistan, Subsection: "Nuclear Fuel Cycle Facilities."

[13] For example, the Institute of Energy Problems in Belarus currently has five cooperative projects, unrelated to MPC&A, with Brookhaven National Laboratory, Lawrence Livermore National Laboratory, the National Laboratory for Renewable Energy, Argonne National Laboratory, and Sandia National Laboratory. A. Mikhalevich, "Evaluation of the Effectiveness of Physical Protection, Control and Accounting of Fissile Materials at the Institute of Energy Problems, National Academy of Sciences of Belarus," unpublished CNS paper, August 1999.

[14] DOE official, discussion with author, December 1999.

[15] DOE official, correspondence with author, December 1999.

[16] Approximate amounts of fissile material are from *Nuclear Successor States of the Soviet Union,* Table 1-E, p. 37, and discussions with Russian scientists, fall 1999.

[17] William Potter has argued in favor of an HEU buy-up program for a number of years. See William C. Potter, "A US NGO Perspective on US-Russian MPC&A Cooperation," paper presented at the 39th Annual Meeting of the Institute for Nuclear Materials Management, Naples, Florida, July 26, 1998.

[18] Valentin Ivanov, Deputy Minister of Atomic Energy, interview by James Clay Moltz, September 1999.

[19] Unless otherwise noted, data from this section is taken from Mikhalevich, "Evaluation of the Effectiveness of Physical Protection, Control and Accounting of Fissile Materials at the Institute of Energy Problems, National Academy of Sciences of Belarus."

[20] *Nuclear Successor States of the Soviet Union,* p. 37.

[21] Phil Robinson, Program Manager NIS/Baltics, International Safeguards Division, US Department of Energy, correspondence with author, December 1999.

[22] Center for Nonproliferation Studies, NIS Nuclear Profiles Database, Section on Georgia, Subsection: "Nuclear Fuel Cycle Facilities."

[23] Georgian nuclear scientists (names withheld by request), discussions with author, April 1999.

[24] Georgian and Uzbek officials (names withheld by request), discussions with author, February 1997 and April 1999.

[25] David Bakradze, "Removal of HEU Fuel from Georgia," unpublished paper given at CNS conference, Proliferation Problems and Nonproliferation Initiatives, Almaty, Kazakhstan, October 1998.

[26] Georgian officials (names withheld by request), discussions with author, June 1997.

[27] Revaz Salukvadze, former Director of Sukhumi Institute of Physics and Technology, interview with author, April 1999.

[28] Georgian Ministry of Foreign Affairs officials (names withheld by request), discussions with author, June 1997 and April 1999.

[29] William Potter, "Highlights of INMM Meeting, Naples, Florida, July 26-27, 1998," unpublished CNS paper, August 1998. This paper drew from interviews with Russian nuclear officials. The situation at the Vekua Institute in Sukhumi has also been confirmed in interviews by William Potter with Russian and Georgian officials in 1997, 1998, and 1999.

[30] Center for Nonproliferation Studies, NIS Nuclear Profiles Database, Section on Latvia, Subsection: "Nuclear Fuel Cycle Facilities."

[31] Iveta Tomsone, "Na Salaspilsskom Reaktore Uluchshayut Systemu Bezopasnosti," *Rigas Balss*, January 3, 1996, p. 5.

[32] "DOE Secures Nuclear Material in Belarus and Uzbekistan, Reduces Risk of Nuclear Proliferation," DOE Press Release, October 1, 1996.

[33] Bekhzad Yuldashev, Director, Institute of Nuclear Physics, interview with author, February 1999.

[34] Ibid.

[35] Center for Nonproliferation Studies, NIS Nuclear Profiles Database, Section on Uzbekistan, Subsection: "Nuclear Fuel Cycle Facilities."

[36] Bekhzad Yuldashev, Director, Institute of Nuclear Physics, interview with author, February 1999.

[37] Phil Robinson, Program Manager NIS/Baltics, International Safeguards Division, US Department of Energy, correspondence with author, December 1999.

[38] Center for Nonproliferation Studies, NIS Nuclear Profiles Database, Section on Kazakhstan, Subsection: "Research, Power and Waste."
[39] Center for Nonproliferation Studies, NIS Nuclear Profiles Database, Section on Kazakhstan, Subsection: "Fissile Material Production."
[40] Kazakhstani nuclear officials (names withheld by request), discussions with CNS staff, spring and fall 1999.
[41] Kazakhstani nuclear officials (names withheld by request), discussions with CNS staff, fall 1999.
[42] US physical protection specialist (name withheld by request), interview with author, March 1999.
[43] Center for Nonproliferation Studies, NIS Representative Office, Weekly Report, "Aktau: January 29 – 30, 1999," February 5, 1999.
[44] Center for Nonproliferation Studies, Nuclear Profiles Database, Section on Kazakhstan, Subsection: "Research, Power and Waste."
[45] Sergey Borisov, "Nuclear Wastes Will Remain in Kazakhstan: America Aided the Republic in This Respect," *Obshchaya gazeta,* no. 21, 28 May-3 June 1998, p. 5, in "Problem of Radioactive Waste Disposal Eyed," FBIS-TEN-98-167.
[46] K.K. Tokayev and V. S. Shkolnik, "Deyatel'nost' Respubliki Kazakhstan v Oblasti Nerasprostraneniya I Konversii," paper given at the Second International Conference on Nuclear Nonproliferation Issues, Kurchatov City, Kazakhstan, September 1998.
[47] Kazakhstani nonproliferation specialists (names withheld by request), correspondence with author, November 1999; DOE, Press Release, 12/21/99, "US, Kazakhstan Agree to Decommission, Secure Kazakhstani Nuclear Reactor Near Iranian Border."
[48] DOE officials, discussions with author, December 1999.
[49] Center for Nonproliferation Studies, NIS Representative Office, Weekly Report, "Aktau: January 29 – 30, 1999," February 5, 1999.
[50] Phil Robinson, Program Manager NIS/Baltics, International Safeguards Division, US Department of Energy, correspondence with author, December 1999.
[51] "Experimental Reactor Brought up to 'Energy-Producing Level'," *Rossiyskaya Gazeta*, January 17, 1998, p. 1, in FBIS-SOV-98-021, January 21, 1998; and "Agenstvo po atomnoy energii Kazakhsatana razreshilo pusk issledovatelskogo yadernogo reaktora v 30 km ot Moskvy," *Panorama*, December 5, 1997, p. 10.
[52] Visit by author to Alatau branch of the Institute of Atomic Energy, May 1996.
[53] National Nuclear Center of Kazakhstan scientists (names withheld by request), discussions with author, September 1997 and September 1998.
[54] US physical protection specialist (name withheld by request), interview with author, March 1999.
[55] See Kazakhstani Institute of Nonproliferation, "Usileniye fizicheskoy zaschity, kontrolya i ucheta yadernykh materialov na kazakhstanskikh yadernykh ustanovakh," unpublished paper written for CNS, summer 1999.
[56] Unless otherwise noted, data from this section was taken from CNS interviews with and reports from Ukrainian nuclear scientists and officials, winter and spring 1999.
[57] NSC Kharkov Institute of Physics and Technology website, section on history, <http://www.kipt.kharkov.ua/>.
[58] *Nuclear Successor States of the Soviet Union,* p. 61.
[59] Phil Robinson, Program Manager NIS/Baltics, International Safeguards Division, US Department of Energy, correspondence with authors, December 1999.
[60] *Nuclear Successor States of the Soviet Union,* No. 5, March 1998, p. 61.
[61] Phil Robinson, Program Manager NIS/Baltics, International Safeguards Division, US Department of Energy, correspondence with authors, December 1999.
[62] Ibid.
[63] G.A. Sheppard et al., "The US DOE MC&A Assistance Program to Ukraine," <http://www.dp.doe.gov/nn/mpca/pubs/inmm/nibs/nib217.htm#sevastopol>.
[64] Phil Robinson, Program Manager NIS/Baltics, International Safeguards Division, US Department of Energy, correspondence with authors, December 1999.
[65] Gottemoeller, "The Importance of Sustainability in Securing Nuclear Material in the FSU,"
[66] See Center for Nonproliferation Studies, NIS Nuclear Profiles Database, for details on MPC&A upgrades at all facilities involved in cooperative programs.
[67] US nonproliferation specialist (name withheld by request), communication to authors, December 17, 1999.
[68] This is already occurring to some extent, as VNIITF has become a contractor for security upgrades at the Urals Integrated Electrochemical Plant (Sverdlovsk-44). Additionally, as VNIITF officials have said that the RMTC in Obninsk does not meet their needs for training MPC&A specialists (as they need to train about 1,000 people and can only send five to six specialists to Obninsk for training each year), VNIITF is also planning to open a second MPC&A training center, likely to be funded at least partially by the European Union.
[69] VNIITF officials (names withheld by request), discussions with author, January 1999; and DOE and US national laboratory personnel (names withheld by request), interviews with author, February 1999.
[70] Russian facility staff (names withheld by request), discussions with authors, fall 1999.
[71] DOE officials (names withheld by request), discussions with authors, fall 1999.
[72] Rose Gottemoeller, remarks at CNS-PIR Seminar on Nonproliferation and MPC&A Sustainability, Moscow, November 11, 1999.
[73] *Nuclear Successor States of the Soviet Union*. The four serial production/dismantlement facilities are the Avangard Electromechanical Plant (at Arzamas-16), Start Production Association (NPO Start or Penza-19), Elektrokhimpribor (Sverdlovsk-45), and the Instrument Making Plant (Zlatoust-36). Avangard and NPO Start are scheduled for shutdown.
[74] US national laboratory staff (names withheld by request), interviews with author, winter 1999.
[75] The 11 smaller facilities (listed in Smarto, "MPC&A Site Operations and Sustainability") are the Institute of Theoretical and Experimental Physics (ITEP) in Moscow; the Joint Institute of Nuclear Research (JINR) in Dubna; the Karpov Institute of Physical Chemistry, Obninsk; the Research and Development Institute of Power Engineering (RDIPE) in Moscow; the Moscow State Engineering and Physics Institute (MEPhI) in Moscow; the Beloyarsk Nuclear Power Plant (BNPP) in Zarechniy; the Sverdlovsk Branch of the Research and Development Institute of Power Engineering (SF-NIKIET) in Zarechniy; the Tomsk Polytechnic University (TPU) in Tomsk; the St. Petersburg Nuclear Physics Institute (PNPI) in Gatchina; the Khlopin Radium Institute in St. Petersburg; and the Krylov Shipbuilding Institute in St. Petersburg. The larger facilities are the Scientific Production Association Luch (NPO Luch) in Podolsk, the Scientific Research Institute of Atomic Reactors (SRIAR) in Dmitrovgrad, and the Kurchatov Institute in Moscow. See Center for Nonproliferation Studies, NIS Nuclear Profiles Database, for details on upgrades at these facilities.
[76] William C. Potter, "Highlights of Trip to Russia, October 3 – 13, 1998," December 2, 1999, p. 10. Many additional MPC&A deficiencies are described in National Research Council, *Proliferation Concerns.*
[77] This program is described in Smarto et al., "MPC&A Site Operations and Sustainability." In June 1999, DOE sent follow-up teams to a few sites, including JINR, the Moscow Engineering and Physics Institute, and the Karpov Institute of Physical Chemistry under this new program. See US Department of Energy, "Ensuring Sustainable Security Operations In Russia," July/August 1999, <http://www.dp.doe.gov/nn/mpca/frame04.htm>.
[78] US Department of Energy, "Significant Milestones Reached For The MPC&A Program's Material Consolidation And Conversion (MCC) Project," September/October 1999, <http://www.dp.doe.gov/nn/mpca/frame04.htm>.
[79] Oleg Bukharin evaluates the RERTR program in "U.S.-Russian RERTR Cooperation," unpublished CNS study, June 1, 1999.
[80] US Department of Energy, "Grand Opening of RMTC Training Center," November 1998, <http://www.dp.doe.gov/nn/mpca/frame04.htm>.
[81] US DOE management and US MPC&A specialists (names withheld by request), interviews with author, fall 1999.

[82] See Bunn, "The Next Wave: Urgently Needed Next Steps to Control Warheads and Fissile Material"; and US General Accounting Office, *Nuclear Nonproliferation: Status of Transparency Measures for U.S. Purchase of Russian Highly Enriched Uranium*, GAO/RCED-99-194 (Washington: Government Printing Office, September 1999).

[83] Figures from Thomas Kuenning, "Cooperative Threat Reduction Program," briefing given at the 1999 National Convention of the American Association for the Advancement of Slavic Studies, St. Louis, November 21, 1999.

[84] Agreement between the Government of the USA and the Government of the Russian Federation Concerning Cooperation Regarding Plutonium Production Reactors, September 23, 1997.

[85] US officials (names withheld by request), interview with CNS staff, June 1999; US nonproliferation specialist (name withheld by request), correspondence with authors, December 17, 1999; Michael Knapik, "U.S. Urged to Look at Alternatives to Russian Core Conversion Project," *NuclearFuel*, December 27, 1999, pp. 1, 8. For more on the conversion of Russian plutonium production reactors, see Center for Nonproliferation Studies, NIS Nuclear Profiles Database, Section on Russia, Subsection: "Foreign Assistance: Gore-Chernomyrdin Commission."

[86] Unless otherwise noted, these conclusions are based upon discussions with Russian nuclear scientists in a variety of forums throughout 1999.

[87] US Department of Energy, "The Agreement Between The United States and The Russian Federation On Nuclear Materials Protection, Control And Accounting (MPC&A) Is Signed!" September/October 1999, <http://www.dp.doe.gov/nn/mpca/frame04.htm>.

[88] Gennady Pshakin, "MPC&A Upgrades in Russia: Results, Problems and Perspectives," paper presented at CNS international conference on Proliferation Problems and Nonproliferation Initiatives After the South Asian Tests, November 16-17, 1998, Almaty, Kazakhstan.

[89] Russian nuclear scientist (name withheld by request), interview with authors, December 4, 1999.

[90] For more recommendations on improving the MPC&A program, see William C. Potter and Fred L. Wehling, "Sustainable Material Security in Russia: Commitment, Consolidation, and Culture," paper presented at the 1999 National Convention of the American Association for the Advancement of Slavic Studies, St. Louis, November 21, 1999; National Research Council, *Proliferation Concerns;* Bunn, "The Next Wave: Urgently Needed Next Steps to Control Warheads and Fissile Material;" and Perry, "Securing Russian Nuclear Materials."

[91] For further analysis and recommendations on sustainability issues, see Potter and Wehling, "Sustainable Material Security in Russia."

[92] Phil Robinson, Program Manager NIS/Baltics, International Safeguards Division, US Department of Energy, correspondence with author, December 1999.

[93] See Potter and Wehling, "Sustainable Material Security in Russia."

[94] For more on US-Russian cooperation on naval fuel storage see James Clay Moltz, "Russian Nuclear Submarine Dismantlement and the Naval Fuel Cycle," *The Nonproliferation Review* 7 (Spring 2000).

[95] Todd Perry, Union of Concerned Scientists, correspondence with authors, December 1999.