Viewpoint

Sustainability: A Vital Component of Nuclear Material Security in Russia

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A LONG-TERM SOLUTION TO A LONG-TERM PROBLEM

Since the collapse of the Soviet Union in 1991, the uncertain security of nuclear material in Russia and the other newly independent states (NIS) has been a matter of urgent international concern. In response to the perceived danger of nuclear leakage, the United States has sought to assist the NIS in enhancing their nuclear safeguards. Since 1996, the principal means for accomplishing this task has been the Department of Energy's (DOE's) Material Protection, Control, and Accounting (MPC&A) Program.[2] This program of cooperation with the Russian Ministry of Atomic Energy (Minatom) and other Russian and NIS organizations has resulted in a number of significant accomplishments, including progress in safeguarding plutonium and highly enriched uranium.

The MPC&A program has emphasized the provision of technology-based MPC&A systems, which have been installed at a number locations in Russia and the NIS. Of the approximately 650 tons of weapons-usable fissile material (not including material in nuclear warheads) in the countries of the former Soviet Union, 50 tons have been placed under upgraded security and over one ton has been consolidated from smaller facilities for storage at more secure sites.[3] Recently, US assistance has also been directed at cultivating a cadre of Russian specialists who are equipped to install and operate modern MPC&A systems with an eye to their long-term effectiveness. These accomplishments, often achieved under very difficult conditions and without adequate high-level political support, are laudable.

Nevertheless, the foundation for nonproliferation safeguards in Russia and other post-Soviet states remains at best a very rudimentary one. It has major gaps in its coverage, is uneven in its application, and in some crucial respects relies upon inappropriate building blocks for its strength. At several sites, the foundation has even begun to crumble, notwithstanding DOE commissioning ceremonies that sometimes have conveyed the impression that the construction task is complete or at least that the integrity of the structure is sound.[4]

Although there is enormous room for improvement in many dimensions of Russian MPC&A (and especially with respect to material accountancy), the greatest structural weaknesses of the system are the absence of a deeply ingrained safeguards culture and the lack of an incentive structure to encourage the ongoing maintenance of prudent MPC&A practices. As a result, the progress made to date could be reversed unless greater effort is devoted to ensuring the sustainability of nuclear material security in Russia and the other NIS. In order to have a reasonable prospect of success in correcting the current deficiencies, DOE must first clearly recognize the extent of the problem and then initiate a series of steps to: (1) identify specific impediments to safeguards sustainability; (2) develop a program of action to overcome those obstacles; and (3) commit the necessary resources to implement the new program.

With this in mind, this viewpoint describes the impediments to sustainable nuclear material safeguards in Russia and suggests both general strategies and specific measures to overcome these obstacles. The analysis and recommendations offered are informed by official documents and other publications, visits by the authors to numerous Russian nuclear facilities, and a large number of interviews with US and Russian government officials, scientists, technicians, and other experts. As most of these interviews were conducted under conditions of confidentiality, no specific attribution of information to individuals is made.

IMPEDIMENTS TO SAFEGUARDS SUSTAINABILITY

Unique Russian political, economic, and historical circumstances, significant variation in MPC&A priorities among Western and Asian societies, and a relatively recent evolution in the US approach to safeguards caution against an ethnocentric view of safeguards problems.[5] Nevertheless, there are good reasons to be especially concerned about the prospects for safeguards sustainability in Russia. These concerns relate to issues of high politics, institutional and cultural impediments, and infrastructure and resource constraints.

At the level of high politics, one must be concerned about the potential impact on MPC&A of both the general deterioration of US-Russian relations and the erosion specifically of traditional US-Soviet/Russian cooperation for nuclear nonproliferation. Fortunately, these negative trends have not to date had a major direct effect on MPC&A activities. They could, however, spill over in the future, especially if the significant differences that exist in the priorities attached to nonproliferation by the US and Russian political leadership are not narrowed. These differences, to a large extent, are a function of the limited recognition in Russia of the relevance of nonproliferation to the country's immediate economic and political situation.

Institutional issues in Russia create additional impediments. Foremost among these are the inadequacy of regulation and oversight, including essential national standards, and the absence of a long-term strategy for implementation and sustainability of MPC&A. A dearth of experience with and understanding of international nuclear safeguards on the part of facility management often creates resistance to the introduction of strengthened MPC&A practices. They are viewed as an unnecessary financial drain on already depleted resources, as well as a disruption of standard operating procedures. Pervasive secrecy and opacity—reluctance to report all materials, hoarding, lack of transparency on MPC&A budgets and investments, and very limited lateral communication among facilities on MPC&A issues—also undermine sustainability. Other institutional impediments include poor material accounting practices (reliance on manual and book inventories, acceptance of unverified book values, and limited performance of material balances) and the diminished prestige of the nuclear industry, which limits the recruitment and retention of bright, young specialists.

Resource constraints at the national, ministerial, and facility levels in Russia also hamper sustainability. Funding for MPC&A operations, maintenance, and oversight is limited by persistently poor economic conditions. Russia also suffers from a shortage of human resources for MPC&A, and the cadre of adequately trained safeguards specialists is disquietingly small. Inadequate physical, financial, and industrial infrastructure to support MPC&A at Russia's many sites with fissile material creates further impediments. Problems also arise from the sheer number and widespread distribution of facilities with direct-use material, a significant number of which are controlled by ministries other than Minatom and the Ministry of Defense and possess very limited MPC&A resources.

A final set of impediments within Russia pertains to cultural issues. A penchant for secrecy and inadequate attention to insider threats are the most serious prob-

lems of this kind.[6] Other cultural impediments include a deference to authority (allowing senior facility management to circumvent safeguards procedures) and an assumption of shared patriotism that fosters disbelief that Russian nuclear workers might actually divert nuclear material. Differences between Russian and US conceptions of safeguards also contribute to mistrust of US objectives. The absence to date of a sensational case involving nuclear diversion, with observable negative consequences for Russia and its citizens, reinforces the predisposition on the part of most decisionmakers in Moscow to dismiss the urgency of the threat and the need for corrective action.[7] Absent a spectacular incident, therefore, there will be little pressure for remedial action from above, and it will be necessary to build advocates for a new safeguards culture from below—both within the nuclear bureaucracy and in society-at-large.

Impediments to sustainability result from US as well as Russian shortcomings. The absence of a US strategic plan for MPC&A unconstrained by funding—outlining what would be needed for a comprehensive solution to the material security problem—is the greatest problem, though positive steps toward developing such a plan have recently been taken.[8] A narrow definition of MPC&A training, emphasizing technology to the neglect of broader nonproliferation and safeguards issues, is another major obstacle to progress. Insufficient appreciation of Russian concerns over reciprocity and equality (vitally important for the maintenance of a partnership relationship), inadequate use of Russian expertise in the development of guidelines and priorities, and frequent changes of US government and national laboratory personnel (which inhibits institutional memory) also contribute to the problem. Further institutional impediments to safeguards sustainability include inadequate coordination between the MPC&A program and other programs of nonproliferation assistance to Russia and the NIS, the exclusion of facilities in the non-Russian NIS from the Site Operations and Sustainability Program, and personnel constraints at DOE headquarters. The establishment of the DOE's Office of International Materials Protection and Emergency Cooperation in November 1999 indicates that DOE has recognized a number of these issues and is making a serious effort to address them. The problem of MPC&A sustainability in the non-Russian successor states, however, has yet to be addressed adequately.

PROGRAM OF ACTION FOR SUSTAINABILITY

A three-pronged, integrated approach is necessary in order to make meaningful progress in safeguards sustainability. The first program component should focus on simplifying the problem of sustainability by reducing the amount of direct-use material in need of safeguards and by consolidating it at fewer sites. The second program component should seek to modify MPC&A practices through the introduction of an integrated set of positive and negative incentives tailored to the contemporary Russian economic scene. The third dimension of the program should be directed at building a safeguards culture by strengthening MPC&A norms and nonproliferation values.

Simplify and Consolidate

One practical, cost-effective means to improve safeguards sustainability is to simplify the problem by consolidating direct-use material in fewer buildings, sites, and states. This requires a coordinated program, which simultaneously increases intra-site consolidation and expands inter-site consolidation.[9] Highest priority should be given to consolidating small, vulnerable stockpiles of highly enriched uranium (HEU) in Russia, and to those larger stocks of HEU at sites that are especially vulnerable due to their location, guard force deficiencies, or other safeguards problems. High priority should also be given to purchasing small but proliferation-significant stocks of HEU in Belarus, Kazakhstan, and Ukraine. In some instances both within and outside of Russia, it may also be desirable to support conversion of reactors to run on low-enriched uranium (LEU) instead of HEU fuel. The recent conversion of the research reactor in Ulugbek, Uzbekistan, to use fuel with a much lower enrichment level may be a case worth closer examination.[10]

The new and repeated expression of interest by Russia in cooperating in a "buy-up" of Soviet-origin uranium outside of Russia should immediately be seized upon by the United States as a low-cost, high-return nonproliferation strategy. Failure by the United States to grasp this nonproliferation opportunity, which is now more attainable than at any time since 1995, would give new meaning to the expression "penny wise, pound foolish." The cost-effectiveness of this approach is especially pronounced if one calculates the investment needed to sus-

tain what are at best marginally adequate safeguards at these facilities over a 10-to-20 year period.

Regrettably, tremendous interagency battles preceded the successful removal of HEU from Ust-Kamenogorsk, Kazakhstan, in 1994 ("Project Sapphire") and from Mtskheta, Georgia ("Project Auburn Endeavor") in 1998. In light of the inevitable repeat of this interagency bloodletting over any further HEU purchases, it would be advisable to remove as much of the remaining non-Russian HEU as possible in a single, coordinated initiative to avoid confusing NIS organizations and to minimize interagency disagreements in the US.[11] Ideally, this project would be a collaborative US-Russian or international-Russian activity: the United States or a third party financing the purchases, Russia providing the reactor conversion designs where applicable, and Russia and/or the Untied States accepting portions of the HEU. As new targets of opportunity for consolidation in Russia or elsewhere in the NIS may give rise to parallel DOE-sponsored consolidation projects, administered by different organizations within DOE, care must be taken in coordinating these projects in order to avoid confusing potential participants.

Changing Behavior

Translating MPC&A norms and standards into actual material control practices will require a mutually reinforcing set of positive inducements and negative sanctions consistently applied to all responsible organizations and individuals. Put simply, everyone involved in MPC&A planning, implementation, and oversight must know what they should do, receive rewards for doing it correctly, and expect penalties for doing it poorly or not at all. While some elements of this incentive structure currently exist in the NIS, the application of these incentives at the national, regional, and facility levels ranges from intermittent to nonexistent.

The institutionalization of the required incentive structure may be divided into five interdependent components: political framework, institutional reform, indigenization, regulation and oversight, and funding. A framework of agreements establishing the political and legal basis for continued US-NIS cooperation in MPC&A is essential. Similarly, institutional reform within DOE and NIS organizations with responsibilities for fissile material control is needed to create robust organizational structures with the responsibility and capacity to provide incentives for sustainable MPC&A. Incentives will also be required to build the capacity to manufacture, install, operate, and maintain MPC&A equipment within the NIS. Regulation and oversight will be required to ensure appropriate application of and response to these incentives. Finally, while the need for adequate funding for MPC&A is well understood, funds specifically earmarked for sustainability activities should be increased. A wide variety of actions could be taken to create the necessary incentive structure, but implementation of the behavior-changing measures discussed in the following paragraphs should be given the highest priority.

At the outset, it must be stressed that MPC&A sustainability cannot be achieved without greater commitment to nuclear security and nonproliferation at the highest levels of political leadership, in both the United States and Russia. Nuclear material security must be elevated to the top of the US-Russian nonproliferation agenda. The new working agreement between DOE and Minatom, signed in October 1999, which re-establishes the legal basis for MPC&A cooperation and provides a framework for developing joint plans of action, is an important step in the right direction.[12] The most stringent practicable MPC&A for material in bulk form should be required for any continuation or expansion of agreements to purchase Russian HEU from dismantled weapons. Such agreements should be explicitly linked to MPC&A upgrades at facilities involved in dismantlement and downblending.[13] In the longer term, Russian legislative attention to MPC&A should be encouraged, and options for bilateral or international monitoring of excess fissile material should be explored and implemented.

Urgently needed institutional reforms include the strengthening of MPC&A offices at all nuclear facilities in Russia and establishment of these organizations at facilities where they do not yet exist. Very high priority should also be given to creating an MPC&A troubleshooting and coordination office in Moscow and the establishment of a formal mechanism for coordinating *all* site-specific and national-level training activities. The current practice of excluding some nuclear facilities (e.g., the Kurchatov Institute) from the site-specific sustainability program and strategic plan is illogical and should be altered. While DOE has recently prepared a Site Operations and Sustainability implementation plan, including a section on MPC&A culture, a master strategic plan for sustainability, including con-

solidation, national programs, and site-specific activities, also should be developed. Such a plan should facilitate the prioritization of sustainability objectives. A formal mechanism to coordinate national-level training programs with site-level sustainability activities is also needed. Moreover, the design and evaluation process for site MPC&A operations currently underway for Russian facilities should be applied to non-Russian facilities as well. A complete physical inventory of all the nuclear material in Russian facilities—a goal incorporated into recent Minatom regulations and draft legislation—should remain as a long-term objective. However, as most Russian facilities still lack the equipment and resources required to perform a comprehensive physical inventory, near-term material accounting objectives should be modified to emphasize item accounting, tamper-indication devices (TIDs), and other urgent, low-technology solutions.

Indigenization will require not only expansion of Russia's ability to manufacture and maintain upgraded MPC&A systems, but also development of human resources through on-the-job training and practical experience. One high priority for indigenization is the use of peer review by Russian experts, with initial funding support from the United States. Russian specialists from institutions with well-developed MPC&A capabilities should replace American team members involved in MPC&A assistance at other facilities wherever feasible. Recent contracts with the All-Russian Scientific Research Institute of Technical Physics (VNIITF) in Snezhinsk to manage MPC&A upgrades at Minatom facilities in Siberia offer positive precedents that should be emulated.[14] Reliance on Russian cadres for peer review teams and training at regional centers should also be increased, and other options for using Russian personnel from facilities with better MPC&A performance (such as Luch) should be explored.

With regard to indigenization of operations and maintenance of installed systems, documentation in Russian for all equipment should be provided; this is still lacking at many sites. In the longer term, DOE should work with Russian suppliers to increase capacity for indigenous production and maintenance of reliable and warranteed MPC&A systems. While key components for these systems may have to be imported in the short term, Russian firms providing security for banks and industrial facilities may have the capacity to install and service equipment, and possibly to manufacture replacement parts, if not entire systems.

Regulatory reform in Russia will be challenging to implement in the short and medium terms, but is absolutely required for long-term sustainability. DOE should maintain its support for Gosatomnadzor (GAN), Russia's nuclear regulatory agency, as GAN is responsible for verifying safeguards at civilian nuclear facilities. Minatom's internal regulatory capacity also should be strengthened, and consideration should be given to subsidizing Minatom-led inspection teams.

Extension of emergency sustainability measures, support for initial operations and maintenance of installed MPC&A systems, and expanded funding for training through the Operations and Sustainability program should receive highest priority for funding. Additionally, overall budgetary support for the MPC&A program should be maintained for at least 10 years, and a modest expansion of the program by at least $20 million annually should be sought, with the greater part of the increase going toward sustainability measures.

Several other activities designed to change MPC&A behavior in the NIS that will be more complicated to implement also deserve high priority. These include improving the legal framework for US assistance to sustainability activities (especially by guaranteeing US MPC&A assistance complete exemption from taxation[15]); conducting realistic, integrated performance-testing of installed MPC&A systems; and earmarking new revenue streams for sustainability (possibly including funds from Russian reprocessing of spent fuel from European reactors, storage of spent fuel from non-Russian sites, and the sale of additional Russian ex-weapons HEU to the United States).[16]

Safeguards Culture

Arguably the most difficult and important component of MPC&A sustainability is the transformation of the attitudes or "mind-sets" of nuclear workers, guards, and administrators. The history of US material safeguards shows that this has been a difficult challenge in the United States.[17] The task of building a safeguards culture in Russia will be at least as difficult.[18] Although much of this workforce has acquired excellent technical skills related to MPC&A, only a small percentage has more than a vague understanding of why safeguards and nonproliferation are vital to Russian and international

security. In order to alter Russian norms and foster the growth of a safeguards culture in Russia, DOE should devote more resources to broadly based nonproliferation education and training, the promotion of information-sharing and lateral contacts among MPC&A specialists, and the engagement of the inchoate civil society (e.g., non-governmental organizations [NGOs] and journalists) in Russia.

The education and training component of an effective safeguards sustainability program should concentrate on two distinct but related approaches: (1) giving a short introduction to the basic elements of nonproliferation and international safeguards to the widest possible audience in the Russian nuclear sector; and (2) giving extended nonproliferation training to a select number of highly motivated individuals who can serve as agents of change within organizations responsible for nuclear material control.

Central to the first approach would be the introduction of an extremely important change in the curriculum at the Russian Methodological Training Center (RMTC) in Obninsk, established in 1995 as a national center for safeguards and security training.[19] This change, which is highly practical, is inexpensive to accomplish, and is sought by some key MPC&A personnel at Obninsk, entails the preparation of a short, two-to-four hour module on international safeguards and nonproliferation. Such a module should be developed as soon as possible and included in *all* RMTC courses for all levels of personnel from facility guards to site managers. Nonproliferation specialists from Russian academic, NGO, and government sectors should be engaged in the preparation of the course module. Relevant nonproliferation instructional materials in Russian are readily available.[20]

A more ambitious program of training in nonproliferation basics could incorporate both interactive software and distance learning via the Internet. A pilot Internet-2 network, based upon the existing MIRnet service, is being developed as a joint project of the US National Science Foundation and the Russian Ministry of Science. When completed, this network will provide a dedicated 6 megabytes per second (Mbps) service connecting Russian scientific networks with US high-performance networks. (Network speed should increase over time, up to 45 Mbps, as telecommunications costs decrease.) Now in its testing phase, this service will provide the bandwidth to enable advanced Internet applications. Real-time remote instrumentation, "collaboratories," and high-quality videoconferencing are a few of the applications that might benefit US-Russian nonproliferation training programs.[21] Internet-2 is now operational at only a few nodes in St. Petersburg and Moscow, but extension of this network to other locations, including the "nuclear cities," could provide a new level of connectivity and engagement with Russian nuclear facilities. As Internet-2 requires high-quality fiber optic cable, installation at a large number of sites in the NIS may be impractical in the near future, especially at those sites at great distances from the existing nodes in Moscow and St. Petersburg. Extension of the network to the RMTC, however, might be cost effective because of its proximity to Moscow and the pedagogical infrastructure that is already in place. Since the Moscow Engineering Physics Institute (MEPhI) has been identified as a planned Internet-2 node in Moscow, DOE may wish to experiment with the new technology at that site and assess its practicality and potential for both national-level and site-specific MPC&A training.

In conjunction with its program of providing basic nonproliferation education to the broadest possible Russian audience, DOE should initiate at the earliest possible date a parallel program of intensive but more extended nonproliferation training that targets a small group of highly motivated individuals who may emerge as agents for change in the safeguards culture within relevant nuclear agencies and organizations. The premise of this approach is that most successful and sustained organizational change, including a reorientation in organizational culture, requires the presence of an individual who believes passionately in the necessity of change and is in a position to persuade top management of this necessity.

In some rare instances DOE may be able to find and support individuals already able and inclined to introduce and manage the implementation of a new safeguards culture. Possible examples are senior personnel at Luch, the Kurchatov Institute, and the Russian Navy. More often than not, however, the prospective advocates for change at Russian nuclear facilities will be younger individuals, less wedded to the traditional organizational culture, who are not yet in the top echelons of management. An important component for the DOE's program of MPC&A sustainability in Russia today, therefore, should be the extended nonproliferation training of a small but select number of MPC&A change-agents for tomorrow. Prime candidates for such training,

which should include three-to-six month nonproliferation fellowships at relevant international and NGOs, are graduate students enrolled in the special MEPhI safeguards curriculum and the Presidential Fellows participating in Minatom's Moscow Institute of Professional Training (MIPK Atomenergo).

Particular care should be devoted to strengthening the unique and very promising safeguards educational program at MEPhI and securing appropriate placement of its graduates.[22] Such attention to this program will facilitate the recruitment of the best new students, who are most likely to advance rapidly in the nuclear complex and acquire positions in which they can effect organizational change.

More generally, DOE should support opportunities for nonproliferation internship, study, and research fellowships or sabbaticals for Russian nuclear specialists at US, European, and Japanese universities, research centers, and nuclear organizations, including Euratom. One model of possible relevance is the Japanese nuclear safety on-the-job training program designed to inculcate safety culture norms in Russian nuclear power plant personnel, dozens of whom "intern" at Japanese facilities each year.

Very high priority also should be given to creating and maintaining mechanisms that facilitate routine, lateral communication among Russian MPC&A directors, senior personnel, and specialists. Regular interaction among safeguards specialists from different nuclear facilities, virtually absent at present, is vital for both the development of a sense of community among MPC&A professionals and the timely sharing of information on the best practices and on lessons learned. Among the most practical means to further these objectives would be the launching of an MPC&A newsletter (perhaps under the auspices of one of the Institute for Nuclear Materials Management affiliates in Russia), and the development of official and unofficial websites focusing on MPC&A issues, possibly maintained by one of the new nonproliferation centers at Obninsk, Snezhinsk, or Sarov. Leading MPC&A experts should be encouraged to conduct research (possibly funded by grants from the Nuclear Cities Initiative and the International Science and Technology Center) and to publish their research findings in the new newsletter and online. In addition to promoting information-sharing and contacts among safeguards professionals, the production of MPC&A publications could provide relevant employment for graduates of the MEPhI safeguards program.

The shortcomings of the information infrastructure in the NIS mean that there is no substitute for personal contact to build and sustain a network of skilled and motivated MPC&A personnel. The Russian International Conference on Nuclear MPC&A, sponsored jointly by Minatom, DOE, the American Nuclear Society, and the Institute for Nuclear Materials Management, should become an annual event (the next conference will be held in Obninsk in May 2000). Additionally, meetings for small groups of MPC&A personnel drawn from both Minatom and non-Minatom facilities, possibly patterned on the sustainability seminar organized by the Monterey Institute's Center for Nonproliferation Studies and the PIR Center in Moscow in November 1999, should be convened on a regular basis. Participation of experts from the non-Russian NIS in these meetings should be encouraged in order to learn from their experiences and to foster the development of MPC&A norms in other states that still possess HEU or plutonium.

The creation of a safeguards culture in Russia will be facilitated by the growth of a well-connected community of nonproliferation specialists including, but not limited to, MPC&A workers at nuclear facilities. A potentially significant source for nonproliferation advocacy in Russia is its emerging civil society, which features NGOs with nonproliferation interests, journalists who cover nuclear safety and security issues, and professors and young scholars teaching and researching nonproliferation topics. As these individuals gain seniority, their effectiveness as MPC&A advocates within government and in civil society will increase, as will their ability to mentor younger nonproliferation specialists. DOE should make much greater use of these non-traditional MPC&A cadres in order to create and maintain a critical mass of Russian nonproliferation expertise.

Progress in building a Russian safeguards culture will also be influenced by US readiness to adopt new training and information-acquisition/sharing measures. In particular, there is a pressing need for DOE recruitment of more laboratory and contractor personnel with Russian expertise and, preferably, language skills. DOE headquarters also would be well served to have an in-house expert on the Russian economy, who could provide timely advice about how to adjust MPC&A

incentives to volatile Russian economic circumstances. At a minimum, it would be highly desirable for US MPC&A personnel to receive greater cross-cultural training.

CONCLUSION

The US government was very slow to appreciate the variety of nuclear custodians in Russia. Even today, DOE has very incomplete information on the number and location of non-Minatom sites possessing direct-use material, and even less information on their organizational structure, culture, decisionmaking processes, and relationship to other nuclear custodians. There is a similar dearth of organizational information about DOE's principal negotiating partner, Minatom. An improved understanding of the major Russian bureaucratic actors with interests in the nuclear sector may be crucial in devising an effective incentive structure for encouraging desired Russian MPC&A practices. DOE also needs to develop options to maintain support for MPC&A activities in Russia under the more adverse conditions associated with increased political differences over arms control, NATO operations in Kosovo, and allegations of Russian use of US banks for money laundering.

The potential impact of domestic and international politics on MPC&A cooperation underscores the fact that political commitment in both Russia and the United States will be essential for sustainable protection of nuclear material. This commitment must be displayed not only through the participation of political leaders at signing and commissioning ceremonies, but also through the continued provision of financial, organizational, and human resources at facilities and at the national level. Safeguards and security are similar to environmental safety in that they require significant resources, appropriate regulation and oversight, adequate education and training, and internalization of motivation and norms. The Chernobyl accident and the gradual discharge of radioactive material into the air, soil, and water of the NIS show how lack of attention to environmental safety at Russian nuclear facilities has had catastrophic results. Lack of commitment to MPC&A sustainability creates the same potential for disaster: special nuclear material may leak out slowly through insider theft, or a significant quantity may be stolen from a single facility by terrorists. Sustained commitment to MPC&A, consolidation of nuclear material, and development of a safeguards culture in Russia and the other NIS will significantly reduce the likelihood of these disasters.

[1] The authors would like to thank Matthew Bunn, Todd Perry, and Adam Stulberg for their useful comments on this article.

[2] For a brief history of the MPC&A program, see Kenneth B. Sheely et al., "A Progress Report on the US Department of Energy Nuclear Material Protection, Control, and Accounting Program," in Office of Arms Control and Nonproliferation, US Department of Energy, *Partnership For Nuclear Security: United States/Former Soviet Union Program of Cooperation on Nuclear Material Protection, Control, and Accounting* (Washington, DC: GPO, 1998), pp. 1-6.

[3] 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>, and Rose Gottemoeller, remarks at CNS-PIR Seminar on Nonproliferation and MPC&A Sustainability, Moscow, Russia, November 11-12, 1999.

[4] These problems are documented in 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), and United States Congressional Budget Office, *Cooperative Approaches to Halt Russian Nuclear Proliferation and Improve the Openness of Nuclear Disarmament*, May 1999.

[5] On this topic see 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); Matthew Bunn, "The Next Wave: Urgently Needed New Steps to Control Warheads and Fissile Material," Carnegie/Harvard Joint Working Paper, September 1999; Fredric Morris et al., "Creating the Regulatory Base for MPC&A in the Russian Federation: Challenges and Strategy," paper presented at the 40th Annual Meeting of the Institute for Nuclear Materials Management, Phoenix, AZ, July 25-29, 1999; 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, Phoenix, AZ, July 25-29, 1999.

[6] There are some positive signs that awareness of insider threats at Russian facilities is developing. See Irina Koupriyanova, "Russian Perspectives on Insider Threats," paper presented at the 40th Annual Meeting of the Institute for Nuclear Materials Management, Phoenix, AZ, July 25-29, 1999.

[7] See Emily Ewell, "NIS Nuclear Smuggling Since 1995: A Lull in Significant Cases?" *The Nonproliferation Review* 5 (Spring-Summer 1998), pp. 119-125.

[8] Minatom has developed a master plan for physical protection, and DOE has drafted a strategic plan for future MPC&A activities. (Oleg Bukharin, researcher, Center for Energy and Environmental Studies [CEES], Princeton University, correspondence with authors, January 4, 2000). Graham Allison and Matthew Bunn offer suggestions for a comprehensive MPC&A strategic plan in "What More Could Be Done to Secure Nuclear Warheads and Fissile Materials With More Resources?" (draft), CSIS Global Nuclear Materials Management Task Force 1: Funding Nuclear Security, June 16, 1999. See also US Department of Energy, "MPC&A Program Strategic Plan," January 1998; US Department of State**, "**Expanded Threat Reduction Initiative," unpublished proposal, March 1999; and Carrie Smarto et al., "MPC&A Site Operations and Sustainability: A Policy Overview," paper presented at 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>.

[9] See Thomas Wander and Neil R. Zack, "The MPC&A Material Consolidation and Conversion Project: Exploring the Material Conversion Option," paper presented at the 40th Annual Meeting of the Institute for Nuclear Materials Management, Phoenix, AZ, July 25-29, 1999.

[10] Bekhzad Yuldashev, Director, Institute of Nuclear Physics, interview with CNS staff member, February 1999.

[11] For details of Project Sapphire, see William C. Potter, "Project Sapphire: US-Kazakhstani Cooperation for Nonproliferation," in 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), pp. 345-362. On Project Auburn Endeavor, see Center for Nonproliferation Studies, NIS Nuclear Profiles Database, Section on Georgia, Subsection: "Nuclear Fuel Cycle Facilities: Institute of Physics."

[12] Agreement Between the Government of the United States of America and the Government of the Russian Federation Regarding Cooperation in the Area of Nuclear Material Physical Protection, Control, and Accounting, October 2, 1999.

[13] See Todd Perry, "Securing Russian Nuclear Materials: The Need for an Expanded US Response," *The Nonproliferation Review* 6 (Winter 1999), pp. 84-98, and Matthew Bunn, "The Next Wave: Urgently Needed Next Steps to Control Warheads and Fissile Material."

[14] Progress in MPC&A at Snezhinsk is summarized in Gennady Tsygankov et al., "Progress and Future Plans for MPC&A at Chelyabinsk-70," paper presented at the 40th Annual Meeting of the Institute for Nuclear Materials Management, Phoenix, AZ, July 25-29, 1999.

[15] For more on taxation issues, see "Programma Nanna-Lugara stalkivaetsya s sereznymi yuridicheskimi I nalogovymi problemami, Rossiya poka ne gotova ikh reshat," *Voprosy bezopasnosti*, 51, no. 7, April 1999, and H. Nicole Nelson, "The Impact of the Russian Taxation System on the Material Protection, Control, and Accounting (MPC&A) Program," paper presented at the 40th Annual Meeting of the Institute for Nuclear Materials Management, Phoenix, AZ, July 25-29, 1999.

[16] See Matthew Bunn, "Urgently Needed Next Steps to Control Warheads and Fissile Material."

[17] For differing perspectives on safeguards culture development in the United States, see William J. Desmond et al., "The First 50 Years: A Review of the Department of Energy Domestic Safeguards and Security Program," *Journal of Nuclear Materials Management* 26 (Spring 1998), pp. 17-24; John McPhee, *The Curve of Binding Energy* (New York: Farrar, Strauss, and Giroux, 1974); US Congress, House of Representatives, Committee on Energy and Commerce, Subcommittee on Oversight and Investigations, *Nuclear Weapons Facilities: Adequacy of Safeguards and Security at Department of Energy Nuclear Weapons Production Facilities*, March 6, 1986, Serial #99-143 (Washington, DC: GPO, 1987); and United States General Accounting Office, *Nuclear Security: Safeguards and Security Weaknesses at DOE's Weapons Facilities*, GAO/RCED-92-39, Washington, DC, December 1991.

[18] See Potter, "Outlook for the Adoption of a Safeguards Culture in the Former Soviet Union." Doyle and Mladineo, "Assessing the Development of a Modern Safeguards Culture in the NIS," suggests indicators of safeguards culture development in Russia.

[19] The RMTC is described in US Department of Energy, Russia/NIS Nuclear Materials Security Task Force, *Improving Nuclear Materials Security Through Training: Russian Methodological and Training Center, Obninsk, Russia*, June 1999.

[20] Possible items include a Russian translation of Gary Gardner's *Nuclear Nonproliferation: A Primer*, as well as the journal *Yaderny Kontrol* (*Nuclear Control*) and the periodical *Yadernoye Rasprostraneniye* (*Nuclear Proliferation*).

[21] For more information on MIRnet, see the project's website, <http://www.mirnet.org>.

[22] This program is described in *Moscow State Engineering Physics Institute Master in Nuclear MPC&A*, June 1998.