NATIONAL RESEARCH COUNCIL
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PROTECTION, CONTROL, AND ACCOUNTING OF NUCLEAR MATERIALS

INTERNATIONAL CHALLENGES AND NATIONAL PROGRAMS

WORKSHOP SUMMARY

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Workshop Summary

Christopher Eldridge, Rapporteur

Development, Security, and Cooperation
Policy and Global Affairs

NATIONAL RESEARCH COUNCIL
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Preface and Acknowledgments

The protection, control, and accounting of nuclear materials at civilian nuclear facilities are matters of great importance from several perspectives. Nuclear materials must be kept secure so that they are not removed from a facility illegally. If such materials are stolen or sold on the black market, they could potentially be used in a weapon by terrorists or other non-state actors. Further, nuclear materials should be handled safely so that they do not endanger the health of facility workers or local residents. It is also important to manage the use of nuclear materials as efficiently as possible to minimize their impact on the natural environment.

The scientists, engineers, and managers who oversee nuclear materials protection, control, and accounting (MPC&A) at civilian nuclear facilities have primary responsibility for ensuring that these materials are safe and secure. Such MPC&A practitioners around the world face many common challenges. To help them respond to these challenges, the National Academies and the Russian Academy of Sciences (RAS) convened an international workshop on MPC&A practice at the headquarters of the International Atomic Energy Agency (IAEA) in September 2003. The pages that follow summarize the presentations and discussions of the workshop. Both the workshop and the report were made possible through the generous support of the Nuclear Threat Initiative.

The statement of task for this project was as follows:

> The U.S. National Academies and the Russian Academy of Sciences will convene a workshop for sharing best practices in nuclear materials protection, control, and accounting (MPC&A), including the status and application of

> remote monitoring technologies, personnel issues, and both national and international safeguards worldwide. The goals of the workshop will be to identify areas in which the United States and Russia can promote best practices in MPC&A globally and expand U.S.-Russian cooperation on nuclear nonproliferation. The papers presented in the workshop and the outcomes of workshop discussions will form the basis of a workshop report.

As the committee members began planning the event, they realized that the goal of compiling a list of best practices was too lofty for the two-day workshop envisioned by those who originated the project. Therefore, the workshop did not attempt to provide a comprehensive assessment of MPC&A practice. Instead, the committee narrowed the focus of the project, endeavoring to lay the groundwork for further assessments by inviting MPC&A experts from the United States and Russia, as the two leading nuclear weapons states, and from a broadly-defined geographical region: central, south, and east Asia. This provided workshop participants with a range of perspectives on MPC&A, demonstrating the importance of sharing ideas about MPC&A practice and underscoring the point that different governments and cultures approach MPC&A in different ways. Further, the committee believed it important to examine a number of key policy issues in the course of the workshop, again as part of setting the stage for future efforts. As a result, a range of technical and political issues were explored during the workshop.

The workshop presentations and discussions revolved around a central argument that the urgent threats of nuclear terrorism and proliferation continue to outpace society's responses to them. Individual presentations ranged over a variety of broad and specific topics, but they all addressed at least one of the following questions: What is the nature of the threats humanity faces from nuclear terrorism and proliferation? What has been done to address those threats? What should be done in the future to mitigate them? Over the course of the two days, it became clear that events such as this workshop, designed to facilitate sharing the benefits of research and experience among experts, can help to narrow the gap between threat and response.

As the report of an international workshop, this document represents the culmination of a great deal of effort by many people. The National Academies' Committee on Best Practices for Nuclear Material Protection, Control, and Accounting, chaired by Professor John P. Holdren of Harvard University, and the RAS' Committee on U.S.-Russian Cooperation on Nuclear Nonproliferation, chaired by Academician Nikolai P. Laverov of the RAS, had general responsibility for overseeing the workshop planning process. At the request of the committee chairs, members of the two committees formed a small working group that took primary responsibility for planning and holding the workshop. The American co-chair of that group was Professor William C. Potter of the Center for Nonproliferation Studies, Monterey Institute of International Studies. The author is particularly grateful to Prof. Potter, whose patient, energetic, and creative leadership was fundamental to the workshop's success. Dr. Siegfried Hecker of Los Alamos National Laboratories supplied crucial help in planning the event as the other member of the American committee to participate in the working group. The Russian co-chair, Academician Nikolai N. Ponomarev-Stepnoi of the Russian Scientific Center "Kurchatov Institute" was also instrumental in planning the workshop. His colleague Academician Ashot A. Sarkisov served with skill and charm as the Russian co-chair during the event itself.

Several individuals who were not committee members were also extremely helpful in planning the workshop and producing this report. Mark Mullen of Los Alamos National Laboratories was especially helpful during the process of generating the workshop agenda and as a participant in the workshop discussions. Dr. Tariq Rauf, Ms. Elena Bergo, and their colleagues on the staff of the IAEA generously and effectively hosted the meeting at the IAEA headquarters in Vienna. The author also wishes to express his deep appreciation to his colleagues at the National Academies, Ms. Rita Guenther, Dr. Jo Husbands, and Dr. Micah Lowenthal, for their participation in the project and their extremely helpful editorial comments.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the process.

I wish to thank the following individuals for their review of this report: James Goodby, Massachusetts Institute of Technology; Nikolai Khlebnikov, IAEA; Richard Meserve, Carnegie Institution of Washington; Dmitry Nikonov, University of Georgia; Gennady Pshakin, Institute of Physics and Power Engineering; and Carlton Stoiber, Consultant.

Although the reviewers listed above have provided many constructive comments and suggestions, they did not see the final draft of the report before its release. Responsibility for the final content of this report rests entirely with the author and the institution.

Christopher Eldridge

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Introduction

The use and storage of nuclear materials at hundreds of facilities around the world in support of nuclear medicine, nuclear energy, nuclear weapons programs, and other activities presents what has become an oft-repeated litany of security threats. Individuals or groups with destructive intentions can attack or sabotage a nuclear facility, potentially causing the release of radioactivity, or they can attempt to steal nuclear materials for use in a nuclear weapon or a radiological dispersal device. And ready stockpiles of nuclear materials—particularly if the materials are of weapons grade—make it easier for a state to decide to build or expand a nuclear arsenal, or for an individual or government to divert those materials from legitimate to illegitimate uses or to sell them on the black market to others who desire their own nuclear weapons.

The scientists, engineers, and security experts responsible for nuclear materials protection, control, and accounting (MPC&A) play a vital role in mitigating these threats. As they work to meet the threats posed by the presence and use of nuclear materials with effective responses, MPC&A experts seek to achieve a delicate balance between twin imperatives. A national MPC&A system must be viable within its unique political, economic, legal, and cultural context if it is to be effective. At the same time, national MPC&A systems must work in concert with those of other states with nuclear programs to present a united front against the potential for sabotage, theft, and proliferation.

It is clear that a globally impregnable MPC&A system is an ideal that will never be fully realized, and that those responsible for designing, installing, and managing nuclear security systems must balance the expenditure required to pay for security systems and personnel against the risk of attack or theft. There are many who argue, however, that we are very far from achieving a reasonable level of security against threats posed by poorly secured nuclear materials, and that much more can and should be done to achieve universally high MPC&A standards. For that reason, the National Academies and the Russian Academy of Sciences jointly convened a workshop on September 24 and 25, 2003, on MPC&A practice. The workshop, held at the headquarters of the International Atomic Energy Agency (IAEA) in Vienna, Austria, provided an international forum for MPC&A professionals and other experts to exchange ideas and information with one another and with IAEA staff members. The goal was to expand the body of knowledge upon which attendees draw as they strive to make their own MPC&A systems as effective as possible.

Workshop Background

As part of their responses to the terrorist attacks in the United States in September 2001, the National Academies and the Russian Academy of Sciences (RAS) formed parallel committees on U.S.-Russian Cooperation on Nuclear Nonproliferation in early 2002, informally creating a joint committee. With funding from the Nuclear Threat Initiative and the MacArthur Foundation, the joint committee has developed and pursued a number of collaborative projects. The workshop described in this report was one of them. This joint activity was cochaired by Academician Nikolai P. Laverov of the RAS and Professor John P. Holdren of Harvard University, and its membership was evenly divided between Americans and Russians. For the purpose of planning the workshop, the committee formed a working group whose members were Professor William C. Potter of the Monterey Institute of International Studies, Dr. Siegfried Hecker of Los Alamos National Laboratory, and Academician Nikolai N. Ponomarev-Stepnoi of the Kurchatov Institute. Mark Mullen of Los Alamos National Laboratory, who served as an unpaid consultant to the committee, substantially assisted the group in facilitating the workshop and identifying its key themes.

One of the many advantages of holding the workshop at the International Atomic Energy Agency (IAEA) headquarters was that it facilitated the participation of several experts from the IAEA staff, senior representatives of the agency, and three ambassadors from IAEA Member States. The workshop had a strong international character, as non-IAEA participants came from India, Japan, Kazakhstan, Russia, Sweden, and the United States. A representative of Pakistan attended as an observer. The quality and utility of the workshop discussions were significantly enhanced by the wide range of perspectives and expertise that this group of participants contributed. The list of participants may be found in Appendix A and the agenda may be found in Appendix B.

The presentations and discussions fell roughly into five topical categories. Following a brief overview of the substantive context in which the workshop took place, each of the topics below is addressed in turn:

- overviews of the international nuclear nonproliferation context
- international political efforts to address the dangers of nuclear weapons and materials
- the legal and regulatory context for MPC&A
- issues of "safeguards culture"
- the IAEA's nonproliferation and MPC&A programs
- domestic MPC&A programs

During the final session of the workshop, Mark Mullen offered concluding remarks. His comments are described in the final section of the report.

Workshop Context

The workshop discussions took place not only at the physical site of the International Atomic Energy Agency (IAEA) headquarters, but also within the broader context of the agency's roles of facilitating the safe and peaceful use of nuclear energy, supporting the international nuclear nonproliferation regime, and improving nuclear materials management and security in member states. The fundamental challenge of nuclear nonproliferation is embodied in a basic tension that exists among those responsibilities: the equipment, facilities, materials, and expertise required to build and operate a nuclear power plant may also form the basis of a nuclear weapons program.

The dilemma posed by centrifuge technology is an example of this tension. Centrifuges are used to enrich natural uranium so that it can be used in a civilian nuclear reactor to generate heat and electricity, precisely the peaceful nuclear energy that the IAEA works to promote. Given enough time and a sufficient number of centrifuges of appropriate design, however, the same centrifuge technology can be used to further enrich the uranium, to the point where it is considered highly enriched uranium (HEU).[1] Because uranium centrifuges can be used to produce HEU of the grade required for nuclear explosives, centrifuge technology can pose a serious proliferation threat. Similarly, a plant for separating pluto-

[1]Highly enriched uranium is defined by the International Atomic Energy Agency as uranium containing 20 percent or more of the isotope ^{235}U.

nium from other by-products of nuclear power generation may provide plutonium for nuclear reactor fuel, for building nuclear weapons, or both.[2]

The nuclear nonproliferation regime developed out of international efforts to manage these tensions. The regime, which is built upon the foundation of the Treaty on the Non-Proliferation of Nuclear Weapons (also known as the Nuclear Non-Proliferation Treaty, or NPT), comprises an evolving complex of treaties, export control agreements, and other formal and informal arrangements. The NPT, which entered into force in 1970, endeavored to halt and reverse the proliferation of nuclear weapons while ensuring access to nuclear energy for all member states. It attempted to accomplish this by restricting possession of nuclear weapons to states that had tested nuclear weapons prior to 1967. These "nuclear-weapon States" (China, France, Russia, the United Kingdom, and the United States)[3] promised to work toward eliminating their nuclear arsenals and to not share nuclear weapons technology with "non-nuclear weapon States." At the same time, the nuclear-weapon States (NWS) promised to share the benefits of peaceful nuclear technology with non-nuclear weapon States (NNWS). In exchange, the NNWS, which comprised the balance of the treaty signatories, pledged not to obtain or develop nuclear weapons, and to accept the application of international safeguards to their nuclear programs to verify their compliance with the treaty.[4]

The International Atomic Energy Agency was established in 1957 to promote the peaceful use of nuclear energy and to ensure as far as possible that any nuclear energy programs with which it was associated were managed safely and used only for peaceful purposes. The activities of the agency are governed by its member states, and the decisions of the member states are implemented by the agency's secretariat, which is based in Vienna. After the NPT entered into force, the IAEA was assigned the responsibility of applying the safeguards required by

[2]The nuclear materials (usually uranium and plutonium) that are used in a nuclear reactor to produce heat through nuclear fission are considered nuclear fuel. Prior to irradiation in the nuclear reactor, the fuel is considered "fresh fuel." After irradiation, the fuel is considered "spent fuel." Irradiation of the most common types of nuclear fuel converts some uranium into plutonium. Chapters 7 and 14 of David Bodansky, *Nuclear Energy: Principles, Practices, and Prospects* (Woodbury, N.Y.: American Institute of Physics, 1996) provide excellent background on the nuclear fuel cycle and its consequences for nuclear proliferation.

[3]The United Kingdom, United States, and Russian Federation are the depositary states for the NPT. China and France acceded to the treaty as nuclear-weapon States in 1992. See Joseph Cirincione et al., *Deadly Arsenals: Tracking Weapons of Mass Destruction* (Washington: Carnegie Endowment for International Peace, 2002), pp. 25-26.

[4]See the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), available at http://www.iaea.org/Publications/Documents/Infcircs/Others/infcirc140.pdf as of April 20, 2005. In the context of the international nuclear nonproliferation regime, "safeguards" are measures taken by the IAEA to verify the accuracy and completeness of a state's claims about the activities and scale of its nuclear complex, including its nuclear material inventories. Domestic safeguards are measures taken by a state to prevent theft or unauthorized use of weapons or weapons usable material.

the treaty.[5] Since that time, the number of NPT signatories has climbed to 189 and the IAEA has gained considerable experience in verifying member states' compliance with their safeguards obligations under the treaty.

Safeguards agreements between the agency and individual member states provide the legal and functional basis for IAEA verification activities. The intrusiveness of agency verification activities depends on which safeguards standard the state has accepted and enacted. In 1997, the IAEA began urging member states to adopt what is known as the "Additional Protocol" to their existing safeguards agreements. States adopting this protocol agree to provide an enormous volume of information as well as unprecedented levels of site access to agency inspectors. The goal of this approach is to move beyond facility-by-facility assessments to achieve what the IAEA terms "integrated safeguards," whereby the agency develops a complete picture of a state's nuclear program on a national basis.[6]

The agency's activities may be divided into three categories. The Department of Safeguards verifies compliance with the NPT through inspections, visits, monitoring, and evaluation. The Department of Nuclear Safety and Security provides advice to member states that request assistance in protecting, operating, and managing their nuclear energy facilities, and protecting and accounting for their nuclear materials. Finally, the Department of Technical Cooperation, the Department of Nuclear Energy, and the Department of Nuclear Sciences and Applications share the responsibilities of facilitating international technical cooperation on nuclear energy and other applications of nuclear science.[7]

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[5]David Fischer, "IAEA Vision & Reality," *IAEA Bulletin* 45 (December 2003): 12-15.

[6]International Atomic Energy Agency, "The Safeguards System of the International Atomic Energy Agency," undated document (approximately 2002), pp. 1-5, available at http://www.iaea.org/OurWork/SV/Safeguards/safeg_system.pdf, accessed April 20, 2005.

[7]Information about the activities of each IAEA department may be found at http://www.iaea.org/OurWork/index.html, accessed April 20, 2005.

Overviews of the International Nuclear Nonproliferation Context

The presentations discussed here offered different perspectives on the overall context in which nuclear nonproliferation efforts take place. In one of the first papers given at the workshop, **Charles Curtis** of the Nuclear Threat Initiative set the tone by highlighting the gap between the threats of nuclear terrorism and proliferation and the response to those threats. He pointed out that the international community has made important progress in securing nuclear materials, but a significant amount of work remains to be done. Before September 11, 2001, many who recognized that nuclear materials were inadequately secured hoped that no individual or group that might obtain the necessary materials for a nuclear explosive would actually be hateful enough to use such a weapon in an attack on civilians. The events of September 11 shattered that hope. In his view, the failure of the international community to come together and overcome the challenges of controlling nuclear materials in the months after the terrorist attacks of September 2001 was even more alarming than the attacks themselves. The people attending the workshop, Curtis asserted, understood that unsecured weapons and materials anywhere are a threat to everyone, everywhere; and that efforts to prevent nuclear terrorism in the time that had passed since September 2001 had not come close to matching the threat. What is required is cooperative action on a global scale to secure nuclear materials.

Curtis noted that he did not want to deny that progress had been made; it had. A substantial amount of money had been pledged to the International Atomic Energy Agency's (IAEA) National Security Fund, and the IAEA Board had recently agreed to increase the agency's safeguards budget. The G8 Global Partnership against the Spread of Weapons and Materials of Mass Destruction and the amendment then under consideration to the Convention on the Physical Protection of Nuclear Materials[1] also constituted progress.[2]

Despite these positive developments, however, Curtis argued that it is important to acknowledge several painful truths in order to see the danger clearly. First, given the broad distribution of knowledge and technical expertise related to nuclear materials and weapons, it is possible for a well-funded sub-national group to build a nuclear explosive if they obtain a sufficient quantity of enriched uranium, or possibly plutonium, of the appropriate isotopic composition. Second, plutonium produced in civilian nuclear energy programs and highly enriched uranium at research reactor facilities is at risk.[3] Third, physical security for nuclear materials around the world is inadequate. Fourth, existing safeguards that are intended to prevent the diversion of nuclear materials from civilian to military use are inadequate, particularly with regard to fuel cycle facilities. Fifth, three states that are not NPT members—India, Pakistan, and Israel—have nuclear weapons and materials, and these capacities should be safely secured and controlled. Finally, it must be acknowledged that a solution to the problem of North Korea's nuclear weapons program has not been found.[4]

Curtis argued that the top priority in efforts to counter nuclear terrorism threats should be to secure nuclear weapons and materials at their sources. To help accomplish this goal, the United States and Russia, as well as other states with nuclear energy capabilities, should actively share their expertise and the benefits of their experience—share "best practices"—with each other. In particular, the United States and Russia should organize a joint team of scientific, technical, and military experts to compile a list of best practices that will be shared with any other state that has nuclear weapons or weapon-usable fissile

[1]The Convention on the Physical Protection of Nuclear Materials (CPPNM) is the only legally binding agreement on physical protection of nuclear material. It requires signatories to ensure adequate physical protection for nuclear material during transport and in other circumstances. For more information, see http://www.iaea.org/Publications/Documents/Conventions/cppn.html, accessed June 26, 2005.

[2]Rapporteur's note: the April 2004 adoption of UN Security Council Resolution 1540 is another relevant example. The resolution, which is mandatory for all UN Member States, requires that acts involving weapons of mass destruction—including malevolent acts involving nuclear materials and proliferation—be treated as criminal acts by the state in which the acts take place.

[3]Research reactors are nuclear reactors whose primary function is to support nuclear, medical, or other research rather than to produce energy. Research reactors tend to have a much smaller thermal output than power reactors, but they sometimes use very highly enriched uranium fuel. Many research reactors and their fresh and spent fuel are located at research institutes and university laboratories where they may not receive the level of security that is afforded other highly enriched uranium.

[4]Nonproliferation experts were unsure about the status of North Korea's nuclear weapons program at the time this workshop was held in September 2003, and remain so today. During the time since the workshop took place, North Korea's claim that it has a few nuclear weapons has gained more credence but has not been conclusively established.

materials. A consensus should be reached among NPT Member States that best practices for nuclear security can be shared without violating Article I of the treaty.

Citing the situation in Iran, Curtis pointed to the establishment of international fuel cycle centers as a potential solution.[5] These facilities, managed by the IAEA or another international agency, would provide fresh nuclear fuel for commercial energy production to non-nuclear weapon States (NNWS), taking the used or "spent" fuel back after it has been irradiated in a nuclear reactor. By effectively removing control over the full nuclear fuel cycle from NNWS, this approach would reduce proliferation risks and increase the international community's confidence that the materials were secure. In Curtis's view, however, the NNWS would be unlikely to support such a plan. As a compromise, Curtis proposed that NNWS wishing to produce commercial nuclear fuel be required to adopt the Additional Protocol and yield "sovereign-like" control over their fuel cycle facilities to the IAEA, treating the facilities as they might treat a foreign embassy on their soil. Curtis concluded his presentation by pointing out that the only hope of preventing a nuclear attack by a sub-national group is if government leaders act with the same urgency and cooperation before the attack as they would in the aftermath of such an attack.

Leonard Spector of the Monterey Institute for International Studies provided an overview of the international status of nuclear nonproliferation efforts, using the evolving concept of the term "safeguards" as a lens through which to focus his argument. He began by pointing out that we no longer believe that our protective measures should be confined to enriched uranium and plutonium. Instead, the range of materials covered by protective measures has broadened in response to the threat from radiological dispersal devices.[6] Further, the array of possible actions taken in the name of safeguards has grown to include export

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[5]The nuclear fuel cycle is the several-step process through which nuclear material is used to fuel nuclear reactors. In what is termed the "front end" of the most common nuclear fuel cycles, uranium is mined from the earth, milled, converted to uranium hexafluoride, enriched to an appropriate ^{235}U content, and fabricated into fresh fuel. It is then irradiated in the reactor. In the "back end" of the fuel cycle, the spent fuel is kept in interim storage for a time then either reprocessed to remove the plutonium or moved into permanent storage. See Bodansky, *Nuclear Energy*, chapter 7 for more information on the nuclear fuel cycle.

[6]A radiological dispersal device (RDD) is not a nuclear explosive, i.e. it does not generate a "nuclear yield" via an explosive chain reaction. The successful detonation of a nuclear explosive, even one that is crude by today's standards, could cause catastrophic destruction and loss of life. An RDD, by contrast, is a weapon that is designed to disperse radioactive material into the environment, and many types of radioactive material might be used. Although RDDs certainly have the capacity to cause damage to public health and local economies, the number of fatalities and the amount of destruction associated with the use of an RDD would be significantly less than would result from the use of a nuclear explosive.

controls, customs checks, border security measures, and interdiction of maritime traffic through the Proliferation Security Initiative.

Spector noted that efforts to control fissile materials now also include critically important programs to eliminate the materials themselves. Under the HEU Purchase Agreement, for example, the Russian Federation takes excess highly enriched uranium (HEU) from dismantled nuclear warheads and “blends it down” to low enriched uranium (LEU) levels suitable for use as fuel in civilian nuclear energy programs. The United States then purchases the LEU, which is shipped to the United States for processing into fresh fuel for nuclear reactors. This nuclear fuel is used to generate approximately 10 percent of the electricity used in the United States.[7] Another example is the joint U.S.-Russian effort to consolidate and eliminate HEU from sites around the former Soviet Union. Spector noted that even as these elimination efforts continue, however, Russia and other countries continue to reprocess their spent fuel to produce plutonium for which there is no valid need, increasing the already-large stockpiles of this dangerous material.

Spector offered some suggestions for addressing the risks associated with nuclear materials. He argued that the international community should “put HEU at the front of the queue” by making the consolidation and securing of highly enriched uranium stocks their top priority because HEU is easier to use in a nuclear weapon than plutonium. He suggested that the government of the United States, and other governments, should also plan much more actively for the use of a radiological dispersal device (RDD), because it seems likely that one eventually will be used. Preparations should include a vigorous public education campaign, so that people know what an RDD is, what it is not, and how to respond if one is used. Authorities should also lay plans for mitigating the consequences of an RDD attack, including planning for wide-area decontamination and for the public health response.

Returning to the expanding definition of safeguards, Spector suggested that the international community should assume more responsibility for determining who is authorized to have access to nuclear weapons and materials. The definition of “unauthorized persons” is also expanding so that, in certain states, elements of the state’s governing apparatus may in fact be “unauthorized.” In states where the leadership or command structure is weak, for example, elements of a national government may gain access to fissile materials without proper authorization from the relevant authorities. He argued, for example, that it is not always clear that the leader of a particular nuclear-armed country is fully in control of the weapons. In such circumstances, typical approaches to materials protection, control, and accounting (MPC&A) may not provide effective security.

In concluding his presentation, Spector proposed that the group consider

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[7]Further information about the HEU Purchase Agreement may be found at http://www.nti.org/e_research/cnwm/reducing/heudeal.asp, accessed April 20, 2005.

putting aside the traditional notion that the maintenance of effective nuclear safeguards is voluntary. He argued that international law could be read to mean that effective safeguards are actually a matter of international obligation, for a number of reasons. First, the NPT requires all NNWS to maintain comprehensive accounting of all relevant nuclear materials. Second, many nuclear facilities, especially those in NNWS, use equipment or materials imported from the nuclear supplier states, most of which require recipients of those items to comply with the physical security standards outlined in the IAEA technical document INFCIRC 225. Third, an argument can be made that the NPT requires all member states to maintain effective accounting and control over relevant nuclear materials, because the NPT prohibits the export of those materials without the application of IAEA safeguards, and states cannot meet that criteria without implementing effective, comprehensive MPC&A measures over both civilian and military programs. Finally, Spector argued that the general principles of customary international law, which require states to manage dangerous activities in a manner that does not cause injury to other nations, may also impose a duty on national governments to effectively protect radioactive materials. Spector acknowledged that such an argument could have broad ramifications, but did not try to explore them in depth. Instead, he asked workshop participants to assist him in thinking through this new approach.

Rose Gottemoeller of the Carnegie Endowment for International Peace suggested that the mechanisms that have been devised for cooperative threat reduction efforts between the United States and former Soviet states might be useful models for addressing other international challenges. Gottemoeller cautioned that what works in one situation will not work automatically in another, and that none of the existing programs is perfect. Nevertheless, in her view, policy makers and program managers should think of collaborations like the MPC&A program that the U.S. Department of Energy manages in Russia not as one-time, situation-specific solutions, but as tools in an ever-growing toolbox of mechanisms useful for addressing certain types of problems. For example, policy makers might look to U.S. experience with Belarus, Kazakhstan, and Ukraine for approaches that might resolve the current crisis with North Korea. Security assurances, energy assistance, and help with the elimination of remaining nuclear materials might go far toward a nuclear-weapon-free solution on the Korean peninsula. In Iraq, "brain drain" programs similar to those established in Russia, such as the International Science and Technology Center and the Nuclear Cities Initiative, might reduce the risk that Iraqi scientists who were no longer needed to support Iraq's weapons programs might sell their expertise outside Iraq. In Iran, cooperation between Russia and Iran on nuclear reactor technology at Bushehr was not really the cause of concern; it was evidence of large-scale fuel cycle activities that were hitherto unknown to the IAEA. Cooperative approaches similar to the MPC&A program might be helpful in that difficult situation. In closing, Gottemoeller underscored her main point, that cooperative threat reduction procedures and techniques can be used to bring countries posing a nuclear proliferation threat toward the "fold." Such approaches, however, should not be considered as replacements for the NPT regime, the international safeguards system, or the Additional Protocol.

Vladimir Shmelev of the Kurchatov Institute argued that the proliferation landscape has changed dramatically over a relatively short period of time. In his view, the nonproliferation regime must leave its Cold War roots behind and adapt in response to evolving threats from non-state actors, RDDs, and clandestine programs to develop nuclear weapons. The safeguards system was initially designed to address the situation as it was when the nonproliferation regime was first created. This required the development of new technologies, and they were relatively effective, in the Cold War context, in preventing international and domestic proliferation. We are now faced with the need to adapt to our new situation. The challenges of adapting to the new circumstances will take many forms. The adoption of the Additional Protocol, for example, will not only increase the burden upon individual states as they work to comply, but also upon those responsible for processing and managing the enormous volume of new data that will result. Shmelev also argued that scientific resources must be focused on conducting systematic investigations of proliferation threats and assessing methods of addressing those threats. He cited a number of technological hurdles that must be overcome, including developing proliferation-resistant nuclear energy technology, assessing options for internationalizing portions of the nuclear fuel cycle, and improving MPC&A mechanisms and inspection techniques. He also underscored the difficulty of maintaining the necessary balance between nonproliferation goals and honoring NPT commitments to share the benefits of nuclear technology. In short, Shmelev argued, adequate safeguards are a prerequisite for an effective nuclear nonproliferation regime.

International Political Efforts to Address the Dangers of Nuclear Weapons and Materials

This section of the report is derived entirely from a workshop panel entitled "Political Initiatives," during which the ambassadors of the Russian Federation, the United States, and Japan to the international organizations in Vienna spoke to participants regarding the political context in which the international nuclear nonproliferation regime operates. **Ambassador Grigoriy V. Berdennikov** of the Russian Federation was the first to speak, and he drew a picture of firm Russian support for international collaboration on nonproliferation. For example, he cited the Russian government's continuing commitment to the NPT and the Comprehensive Nuclear Test-Ban Treaty (CTBT).[1] He also expressed regret about the withdrawal of the United States from the Anti-Ballistic Missile (ABM) treaty,[2] a

[1]The CTBT seeks to restrict the proliferation of nuclear weapons by banning all nuclear explosive tests around the world. It includes provisions for creating a global network of stations that will monitor seismic and other disturbances for indications of nuclear explosions. The United States signed this treaty when it opened for signature on September 24, 1996, but the U.S. Senate blocked its ratification in 1999. The treaty will not enter into force until 44 designated "nuclear-capable states," including the United States, have ratified it. To date, the current U.S. administration has declined to re-submit the treaty for the Senate's consideration, although the administration is observing the moratorium on critical nuclear weapons testing that was signed into law in 1992. China has also signed the treaty without ratifying it. The remaining nuclear-weapon States under the NPT (the United Kingdom, France, and Russia) have all ratified the CTBT.

[2]Formally entitled the Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Limitation of Anti-Ballistic Missile Systems, and negotiated as part of the Strategic Arms Limitation Talks, this treaty was signed on May 26, 1972. It restricted the ability of both the United States and the Soviet Union (and later the Russian Federation) to build nationwide

step that he felt weakened the nuclear nonproliferation regime. Among other treaties and programs, Berdennikov also mentioned the Draft International Convention for the Suppression of Acts of Nuclear Terrorism, which Russia proposed to the United Nations in 1996. The convention defines nuclear terrorism broadly so that anyone involved in obtaining nuclear materials with the intent that they will be used for terrorism can be arrested for nuclear terrorism. It also stipulates that signatory states must enact national legislation to prosecute and punish such individuals.[3] Berdennikov also underscored the value of international efforts, such as the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), to develop new nuclear energy technologies that include resistance to nuclear proliferation as one of their key features. Referring to U.S. opposition to Russia's assistance of Iran's nuclear energy program,[4] Berdennikov also argued that building proliferation resistance directly into new nuclear technology would reduce the emphasis on nuclear nonproliferation and safeguards while ensuring that the benefits of nuclear energy would remain available to all nations.[5]

Ambassador Kenneth Brill presented the view of the United States on some of the same issues. He argued that the nuclear safeguards regime was in danger of unraveling because of pressures generated by states such as Iran and non-state actors that want to obtain nuclear weapons. He underscored recent U.S. initiatives in support of the nuclear nonproliferation regime, including leading the

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defenses against ballistic missiles, in the belief that the existence of such systems would encourage the expansion of nuclear arsenals. The treaty originally permitted the United States and Soviet Union to build two fixed, ground-based systems with a maximum of 100 missile interceptors each, but a 1974 protocol to the treaty halved the number of missile interceptors allowed per side. The treaty is no longer in force, as the United States withdrew from it on June 13, 2002.

[3]The treaty was adopted by the United Nations General Assembly on April 13, 2005. See "General Assembly Adopts Convention on Nuclear Terrorism," UN press release April 13, 2005, available at http://www.un.org/News/Press/docs/2005/ga10340.doc.htm, accessed April 20, 2005.

[4]Russia has been providing Iran with technical assistance in building a nuclear reactor at Bushehr for some time, and at the time of this workshop, that assistance was a sore point in U.S.-Russian relations, particularly because the IAEA had recently revealed that Iran had been secretly enriching uranium. Although the technical assistance continues, Russian and U.S. positions on Iran have moved closer together since the workshop, as Russia supports the efforts of France, Germany, and the U.K. (the "EU3") to convince Iran to permanently halt its enrichment activities, and because the Russian government obtained Iranian agreement that, once the Bushehr plants are operating, Russia will provide the fuel for them and Iran will return the spent fuel after it has been used. As of April 2005, Iran's enrichment program remains "frozen" pending the outcome of negotiations with the EU3. Background information about Iran's nuclear program is available at http://www.nti.org/e_research/profiles/Iran/index.html, accessed April 20, 2005. For information regarding the February 2005 agreement between the Russian Federation and Iran, see "Russia-Iran Nuclear Deal Signed," BBC News website February 27, 2005, available at http://news.bbc.co.uk/2/hi/middle_east/4301889.stm, accessed April 20, 2005.

[5]Further information on this program is available at http://www.iaea.org/worldatom/Programmes/Nuclear_Energy/NENP/NPTDS/Projects/inpro.html, accessed April 20, 2005.

successful effort to increase funding for the International Atomic Energy Agency (IAEA) and preparing to accept the Additional Protocol for its own nuclear complex.[6] He also emphasized that all countries, nuclear-weapon States and non-nuclear weapon States alike, should fulfill their national and international obligations. For example, in response to Amb. Berdennikov's comments, Amb. Brill noted that while the United States does not support the CTBT, it does support the International Monitoring System that is intended to detect nuclear explosions and thus be the basis for verifying compliance with the CTBT. He also noted that some countries lament the failure to enact the CTBT but do not pay their share of the cost for the monitoring system or share their own monitoring data. Brill also argued that the international community should ensure that the IAEA has the resources it requires to strictly enforce its mandate and seek out creative approaches to keeping nuclear materials out of the hands of terrorists, expecting that nations will act on behalf of their own perceived needs if the international system does not meet those needs.

The final presentation on this panel was given by **Ambassador Yukio Takasu** from Japan. He noted Japan's strong support for the NPT regime and its efforts to universalize the Additional Protocol. In this connection, he reiterated Amb. Brill's assertion that nuclear-weapon States were not the only ones with obligations. He also discussed what he considered disparities in the system of providing funds for the safeguard regime, which he felt relieved developing countries of too much of the burden of responsibility that comes with nuclear energy programs. He closed by expressing support for the United States' Proliferation Security Initiative, which facilitates the boarding of ships suspected of carrying contraband materials related to weapons proliferation.[7]

[6]The U.S. Senate ratified the Additional Protocol for safeguards activities in the United States on March 31, 2004. See http://www.fas.org/nuke/control/usiaea/docs/usiaea4.htm, accessed April 20, 2005.

[7]The Proliferation Security Initiative was announced by the U.S. government in May 2003. The program facilitates cooperation among participating states on interdicting the smuggling of materials and equipment for the production of weapons of mass destruction.

The Legal and Regulatory Context for MPC&A

Two presentations explicitly focused on legal and regulatory issues, but **Leonard Spector's** paper, discussed above, also made a number of points regarding the international legal context for materials protection, control, and accounting (MPC&A). Spector suggested that states might in fact be legally obligated to establish and maintain effective nuclear safeguards under some readings of international law. To meet their responsibilities under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), for example, nuclear-weapon States must maintain an accurate accounting of their nuclear materials. This requires an effective MPC&A system. Similarly, the NPT, by stipulating that all exports of nuclear equipment and materials must be monitored by states, may implicitly mandate the establishment of comprehensive safeguards systems for all nuclear materials and facilities, whether under civil or military control. Spector also wondered whether international norms requiring that states manage dangerous activities in a way that does not damage other states might have some application in this field. In the discussion following Spector's presentation, **Carlton Stoiber** argued that although there is growing international pressure on states to implement effective domestic safeguards, the broad interpretation of international law described by Spector, that effective nuclear safeguards are mandatory rather than voluntary, is neither general state practice nor the understanding of most legal experts at this point.

Stoiber began his presentation by outlining four issues that have an important bearing on the legal and regulatory framework for MPC&A. The first issue is the importance of regulatory independence in promoting safeguards. There is often a tension between independent regulatory bodies and other government agencies regarding jurisdiction for protecting national security. The degree of oversight that the regulatory agency has in establishing standards and procedures, in monitoring compliance with those procedures, and in independent inventory verification is very important. The distribution of oversight authority among government agencies is also among the questions that must be addressed.

Second, Stoiber argued that complacency can be a critical factor in degrading effective safeguards. Complacency in following safeguards procedures is a more difficult problem, he argued, than is complacency in obeying safety rules. This is because the consequences of ignoring safety procedures are much clearer and can be directly linked to a specific action (or failure to act), while events resulting from complacency about safeguards are much more insidious and difficult to identify or measure. Nevertheless, regulatory agencies can and should address complacency about safeguards through inspections to verify compliance with procedures and enforcement measures to penalize infractions.

The third issue that Stoiber raised was that, in order for safeguards to be sustained effectively over time, resources and political support must be adequate, predictable, and enduring. This is because effective safeguards require repeated expenditures for expensive equipment and maintenance and a well-trained and motivated workforce of adequate size. All of these requirements can be reflected in regulations. Regulations alone, however, are not enough. Stoiber noted that effective regulatory oversight requires an adequate legal and organizational framework, sufficient resources, and political support.

Finally, Stoiber discussed the balance between the need to protect sensitive information against the need for transparency and openness in the U.S. regulatory system for domestic nuclear safeguards. Before September 2001, the U.S. Nuclear Regulatory Commission (NRC) had developed a highly transparent approach to information about domestic nuclear safeguards. After the terrorist attacks, however, the National Security Council directed the NRC to restrict the dissemination of information of potential value to terrorists. Since that time, the commission has developed a process that weighs the costs and benefits of releasing information and tries to lean toward transparency whenever possible. Stoiber also provided a list of U.S. statutes and executive orders relevant to public disclosure of sensitive information related to nuclear energy, materials, and weapons. "Classified Information" includes both "National Security Information" governed by Executive Order 12598 as amended by Executive Order 13292, and "Restricted Data" as defined by the Atomic Energy Act, section 142. "Safeguards Information" is governed by the Atomic Energy Act, section 147. "Critical Infrastructure Information" is defined by the Homeland Security Act of 2002, Subtitle B: Critical Infrastructure Information Act of 2002, sections 212-214.

Yuri G. Volodin, of the Russian Federal Inspectorate for Nuclear and Radiation Safety (Gosatomnadzor, or GAN),[1] described his agency's activities in

[1]This agency was renamed during the reorganization of the Russian government that took place in 2004. It is now the Federal Service for Environmental, Technological, and Nuclear Oversight.

establishing and strengthening Russia's nuclear regulatory framework. He listed four elements of nuclear infrastructure oversight: regulatory documents, licensing, inspections, and sanctions. The areas of nuclear activity requiring regulation, in his view, are facility design and construction, facility operation, decommissioning of outmoded facilities, inspections, and the prevention of terrorism. Volodin laid out a hierarchy of legal and regulatory documents that are under development in Russia, emphasizing that the process of identifying and filling gaps in Russia's regulatory structure is evolutionary and ongoing. The hierarchy is as follows:

1. Laws
2. Normative acts, resolutions, and orders of the president and government
3. Federal norms and rules regarding the use of atomic energy
4. Documents produced by regulatory authorities
5. Regulatory documents produced by nuclear agencies and facilities

Major documents regulating MPC&A activity in Russia include the Federal Law on the Use of Atomic Energy (1995), the Federal Law on Radiation Safety (1995), the Federal Law on Protection against Terrorism (1998), the Main Rules of Accounting and Control of Nuclear Materials (2001), and the Provisions for Oversight of the State System of Nuclear Material Accounting and Control (2003). Additionally, there are legal provisions for preventing nuclear terrorism and mitigating the consequences of a nuclear terrorism event; rules on the physical protection of nuclear materials, nuclear installations, and storage sites for nuclear materials; rules for the safe and secure transport of nuclear materials; and rules for physical protection of radiation sources, radioactive substances, radioactive wastes, and storage areas for those materials. Volodin explained that a number of regulatory documents were being developed to supplement existing rules and regulations.

Volodin next explained some of the limitations and obligations stemming from the application of physical security procedures to nuclear facilities. These include restrictions of the rights of persons who work at or visit nuclear sites, checks to ensure that trusted persons are reliable and do not have physical problems relevant to security issues, and the responsibility of individuals and institutions to uphold Russian law governing the use of atomic energy. The objectives of physical security at nuclear facilities include preventing unauthorized access to nuclear sites, nuclear materials, or radioactive sources; detecting and preventing attempted acts of terrorism and sabotage; detecting theft of nuclear materials or radioactive sources; and applying physical protection to the transport of nuclear materials and at all stages of the design, construction, use, and decommissioning of nuclear facilities.

Volodin reviewed a number of measures that the Russian Federation had recently taken to improve physical security at nuclear installations. These included providing an armed capability to defend against air targets, establishing protected areas around nuclear sites within 3 to 5 kilometers of the site, restricting access to those protected areas, strengthening the capabilities of protective forces, developing a federal program to upgrade physical protection, accelerating planned physical upgrades and the development of related regulatory documents (such as a national Design Basis Threat assessment), and accelerating the development of the state system for early detection and prevention of nuclear terrorism. He concluded that the international community should develop statistical tools for jointly analyzing and assessing the threats of attacks against nuclear facilities.

Safeguards Culture

In recent years, experts on nuclear nonproliferation have been giving increasing attention to understanding the role of human beings in effective materials protection, control, and accounting (MPC&A). Issues such as the priority that government officials assign to MPC&A, mechanisms for fostering institutional memories that retain the benefits of retiring workers' experience, and encouraging workers to take the threats of nuclear proliferation seriously in their work are examples. These studies explore the ways in which decision makers at multiple tiers of a political or organizational structure understand the threats of nuclear proliferation, and how they express that understanding through their daily decisions. Experts who study the role of culture in the management of nuclear materials have developed definitions of several types of culture, including safety culture, security culture, and safeguards culture:

- **Safety Culture**: This term refers primarily to the safe operation of civilian nuclear power plants. The concept began receiving significant attention after workers' lack of attention to safety protocols led to the Chernobyl nuclear power plant accident of 1986. According to the International Atomic Energy Agency (IAEA), a robust nuclear safety culture is defined as "that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance."[1]

[1]Ian Barraclough and Annick Carnino, "Safety Culture: Keys for Sustaining Progress," *IAEA Bulletin* 40 (June 1998): 27-30, available at http://www.iaea.org/Publications/Magazines/Bulletin/Bull402/safetyculture.pdf, accessed April 20, 2005.

• **Security Culture**: According to a recent report, nuclear security culture has three elements: "the degree to which all personnel, from senior managers and supervisors down to the most junior operators, are aware of and committed to widely understood security requirements and best practices; the degree to which available and affordable security technology is put to use, kept in good working condition, and improved; and the degree to which security regulations and procedures are implemented and personnel are motivated to accomplish their security-related tasks."[2]

• **Safeguards Culture**: This term encompasses the notion that a robust security culture requires the appropriate national context. One article defines it as a "pervasive, shared belief among political leaders, senior managers, and operating personnel that effective MPC&A is critically important, as manifested in decisions and actions, large and small."[3]

A number of presentations at the workshop touched on issues related to safeguards culture and security culture, but three focused primarily on these themes.

Lars van Dassen of the Swedish Nuclear Power Inspectorate manages international projects that help former Soviet Union states establish effective MPC&A systems. He began his presentation by pointing out that "human factor" issues constitute a significant portion of the challenges to effective MPC&A. Nuclear safeguards activities, for example, entail substantial amounts of time spent searching for errors. Human culture issues are also important for physical security, as demonstrated by incidents of illicit nuclear trafficking. For these and other reasons, van Dassen argued, it is of paramount importance that the nuclear work force is educated about its responsibilities in mitigating the dangers of nuclear proliferation and well trained to carry out those responsibilities effectively.

Several issues must be addressed, however, in the course of creating a well-trained nuclear work force. One is that an effective legal and regulatory structure must be in place. It is difficult, however, for experts in nuclear regulation to manage the establishment of a regulatory structure in another culture. Van Dassen suggested that an incremental approach, relying on local expertise, offers the best chance of success. Another issue is that finding and keeping competent staff can be a significant challenge. Facility managers with little MPC&A experience often find it difficult to determine their own staffing needs. Further, in newly-independent states, security personnel who have gone through intensive training at the expense

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[2]Igor Khripunov, et al., *Nuclear Security Culture: The Case of Russia*. (Athens, Ga.: Center for International Trade and Security, University of Georgia, 2004), p. 9. Available online at http://www.uga.edu/cits/documents/pdf/Security%20Culture%20Report%2020041118.pdf, accessed April 20, 2005.

[3]James Doyle and Stephen Mladineo, "Viewpoint: Assessing the Development of Modern Safeguards Culture in the NIS," *The Nonproliferation Review* 5 (Winter 1998): 91, available at http://cns.miis.edu/pubs/npr/vol05/52/doyle52.pdf, accessed April 20, 2005.

of the nuclear facility or the donor country are often lured away by more lucrative offers from banks or other institutions. A third issue is that nuclear facilities may not have the organizational or technical infrastructure, or the required staff resources, to maintain and operate new equipment effectively in the long run. Finally, even though equipment manufacturers often provide training and education when they install new equipment, the owners of the new equipment may not have enough staff, or the necessary organizational or technical infrastructure, to maintain and operate the equipment effectively and safely throughout its normal lifespan.

Van Dassen closed with a few general observations. Those entrusted with operating, maintaining, and protecting equipment and materials at nuclear facilities must be well-motivated to make responsible decisions. This is less likely with an opaque system in which management believes "the less the guards know, the better." Finally, he pointed out that we must remember that this is not merely technology, but technology run by humans.

Irene Koupriyanova of the Institute of Physics and Power Engineering began her presentation by explaining that the phrase "safety culture" was introduced by the International Nuclear Safety Advisory Group in the late 1980s, when it used the phrase in its summary report about the Chernobyl accident. The phrase "human factor" was also used for the first time in reference to nuclear energy activities in that report. Koupriyanova suggested that the "human factor" in MPC&A refers to a nuclear facility operator's physical ability to react appropriately and quickly in response to problems, and to the cultural background of the operator. She underscored the growing importance of addressing human factor issues as the scale of terrorism attacks increases, and the ramifications of those attacks expand correspondingly, across national borders.

Koupriyanova explained that when many of the current Russian facilities were built in the 1950s, positions of employment in the Soviet nuclear complex were prestigious and very difficult to obtain. Because the screening of prospective employees was so rigorous, those who worked inside the nuclear complex were considered trustworthy, and the equipment and systems were designed to make the job comfortable rather than to protect against insider threats. When the Soviet system crumbled and democracy came to Russia, the level of control over employees within the nuclear complex did not increase to compensate.

Culture, in Koupriyanova's view, is a set of values and moral standards which are fundamental to an individual and to how he or she adheres to performance requirements, procedures, and facility policies. There have been no systematic studies of the cultural component of safeguards to date. Values are standards and principles that govern attitudes and behaviors. All workers in a nuclear facility must share the same values with regard to the proper operation of the facility equipment, especially upholding the basic tenet that safeguards must never be compromised. It is also important to develop preventive measures to stop or slow down workers who are intent on sabotage or nuclear terrorism.

Koupriyanova pointed out that some analysts argue that critical thinking on the part of nuclear facility workers is important for effective MPC&A. She disagreed, arguing that top managers and security analysts should have the authority to think critically, but that workers should do as they are instructed and follow the rules. In her view, the key to effective MPC&A is maintaining strict discipline through coaching and training. If there is not enough control over workers, they will not report on one another, and they will only perform tasks if they agree it should be done. She noted, however, that appropriate MPC&A practice will vary from one country to another, and suggested that the international community should strive to define international standards of permissible nuclear activities, along with mechanisms to implement them, since nuclear accidents have international consequences.

Koupriyanova emphasized that domestic approaches to safeguards culture may vary. Russia, for example, is democratic now but continues to be under pressure from the values and moral standards of Soviet times. Nevertheless, Russian workers must now learn to use new MPC&A equipment safely and effectively, without the old system of control in place.

Koupriyanova concluded with two points: first, it is time to develop an international standard for the acceptable character of safeguards culture in a nuclear facility, and propose a mechanism to regulate it. Second, appropriate safeguards culture should be defined not only for nuclear power plants but for all nuclear facilities.

Commentator **Igor Khripunov** of the University of Georgia (U.S.) offered some guiding principles of security culture. In his view, all staff at nuclear facilities should be able to demonstrate that they recognize their own and their facility's vulnerability to attack or to theft of nuclear materials. Security culture also requires effective local leadership, user-friendly procedures, and workers motivated by a sense of personal performance and responsibility to constantly learn and improve. Additionally, the condition of equipment at nuclear facilities must be very good, and it must be used as it was intended. In Khripunov's view, security culture should be defined as a set of globally-agreed standards, applied via country-specific policies.

In the pursuit of a robust security culture, Khripunov suggested that the community of MPC&A experts try to define the aspects of culture that have relevance for MPC&A by focusing on observable actions. He also advocated the use of "nuclear security models" as a way of delineating specific cultures and understanding their similarities and differences. Types of societies with nuclear culture problems include transitional societies, countries with "opaque" nuclear systems as described by van Dassen, and countries who are just beginning to build their nuclear energy complexes. Khripunov espoused proactive approaches to management that focus on security policy, understand the use of authority, and clearly communicate expectations. Finally, he noted that these efforts should strive for the establishment of a young, rising "nuclear elite" of managers and policy makers.

IAEA Nonproliferation and MPC&A Programs

The International Atomic Energy Agency's (IAEA) central role in bolstering the international nuclear nonproliferation regime was underscored many times during the workshop discussions. Over the course of the workshop, five IAEA staff members addressed the participants about the work of the agency. Deputy Director General **Tomihiro Taniguchi**, Head of the Department of Nuclear Safety and Security, opened the workshop by reviewing the activities of his department. He began by noting that the terrorist attacks of September 2001 have significantly increased international awareness of the threat that, if nuclear or other radioactive materials fall into the wrong hands, they may be used in terrorist attacks. "The effective and timely accountancy and control of nuclear material," he argued, "is at the core of the multitude of measures that are aimed at protecting against nuclear terrorism." In November 2001, the IAEA Board of Governors identified four threats of nuclear terrorism, and asked the agency to increase efforts to mitigate these threats:

1. Theft of a nuclear weapon
2. Acquisition of nuclear material to make a weapon
3. Acquisition of nuclear material for use in a Radiological Dispersal Device (RDD) or other mechanism
4. Sabotage of nuclear facilities

To respond to these threats, Taniguchi suggested that knowledge shared during the workshop about materials protection, control, and accounting (MPC&A) practice should be used to promote cross-fertilization and exploit synergies in the broad context of security, safeguards, and safety. He thought that feedback from the bilateral cooperation between the United States and Russian Federation would be especially useful in this regard.

Taniguchi described the IAEA's plan of activities for protecting against nuclear terrorism, which takes a comprehensive approach to nuclear security in response to the threats of terrorism. The plan builds on, accelerates, and expands a number of ongoing agency activities under a single coordinator in the Department of Nuclear Safety and Security. It also introduces a number of new initiatives intended to improve nuclear security in a comprehensive, coordinated fashion. These include

- physical protection of nuclear material and facilities
- detecting malicious activities involving nuclear and other radioactive materials
- strengthening state systems for nuclear material accountancy and control
- improving the security of radioactive material other than nuclear material
- assessing safety and security vulnerabilities of nuclear facilities
- responding to malicious acts or threats thereof
- supporting adherence to and implementation of international agreements, guidelines and recommendations
- coordinating nuclear security and information management

Taniguchi then discussed the IAEA's efforts to strengthen state systems for nuclear material accountancy and control, the third activity area (listed above) in the agency's "Comprehensive Nuclear Security Approach." He pointed out that the plan underscores the multiple purposes of nuclear material accountancy. Effective accounting is required for states to fulfill their international nuclear nonproliferation obligations. It is also the "first and last step of physical protection," i.e. the protection of known inventories and the detection of theft if protection measures fail.

The agency has begun updating earlier guidelines for State Systems for Accounting and Control (SSAC), with the intention of guiding states in meeting their reporting requirements under safeguards agreements and providing useful information for nuclear facility operators. The guidelines will take into account the multipurpose character of nuclear material accountancy systems as well as safeguards reporting needs, safety and reactor control issues, challenges in the timely detection of thefts, and the need to obtain export and transport licenses.

Other IAEA activities to strengthen SSACs include assessing current nuclear material accounting and control systems and providing assistance to upgrade those systems. The agency is also broadening the range of training that it already provides to states on SSACs to include a new course on nuclear material accounting and control at the facility level. Taniguchi suggested that the discussion at the workshop would be important for helping the agency in its work in several of the activity areas outlined above, particularly in strengthening SSACs. He also pointed out that, in general, the accounting of nuclear materials remains inadequate.

Next, Taniguchi reviewed the status of IAEA activities in support of the agency's nuclear security plan. Since 2001, the agency has conducted many regional and national training courses held in IAEA Member States. Topics included the physical protection of nuclear material, combating illicit trafficking, state systems of accounting and control, methodology for developing a Design Basis Threat analysis, the safety and security of radioactive sources, and responses to incidents related to security or to radiological events.

Taniguchi also described several of the advisory services provided by the agency. The International Nuclear Security Advisory Service performs an initial assessment of the overall security needs of a member state as a basis for further assistance from the agency or from donor states. The International Physical Protection Advisory Services helps member states review, strengthen, and enhance the effectiveness of the physical protection of their nuclear facilities. The International SSAC Advisory Service advises states about how they might strengthen nuclear material accounting and control systems at the national or the facility level. Finally, the Emergency Preparedness Review Service provides opportunities for those responsible for planning emergency responses to communicate their ideas and experiences with each other.

IAEA also contributes to information-sharing and coordination efforts. The agency maintains an Illicit Trafficking Database, which collates information provided by member states on illegal transport and trafficking of nuclear materials. Taniguchi explained that, as national accounting systems improve, the quality and quantity of material in the database will also improve. The agency also participates in the UN Security Council's Counter-Terrorism Committee, which was established in 2001. The IAEA also works with the members of the Interagency Coordination Committee for the Illegal Movement of Radioactive Materials, who include the World Custom Organization, Interpol, the International Civil Aviation Organization, and other agencies. The IAEA also conducts international conferences on nuclear materials security or related topics.

Taniguchi closed by reminding the participants that it is important to acknowledge the broader perspective when trying to improve nuclear security, building upon connections among existing programs. He summarized his presentation by saying that the IAEA is pursuing a comprehensive, multi-faceted approach to mitigating the dangers of nuclear terrorism. But the program is a new one, and considerable work must be done to establish the envisioned international nuclear security framework, which is needed to support both global and national assistance efforts. Both proven and new technologies are required. The agency works to develop the framework and promote new technologies in parallel with its efforts to provide services and assistance that have been requested by the member states. The feedback from this workshop will help IAEA in all of these endeavors.

Kenji Murakami of the Department of Safeguards reviewed the lessons the IAEA has learned about MPC&A practice. He began by discussing national nuclear material control. He argued that an effective state control system is a key to the security of nuclear material. Noting that SSACs are national responsibilities, he suggested that SSACs should cover all aspects of nuclear material control. Murakami then discussed several elements of an integrated approach to nuclear material accounting and control:

Legislation: this includes the core nuclear law; nuclear regulation of accounting, control, physical protection, and exports and imports; nuclear guidelines; and nuclear licensing systems.

SSAC Accountancy: this includes analysis of nuclear material flow and inventory, procedures for recording and reporting inventories and changes, computers and computer programs for state and facility offices, installation and testing of software, and training.

SSAC Technical Systems: this includes evaluating existing measurement systems at the national and facility levels, defining and specifying additional needs, procuring and installing measurement equipment, ensuring quality and certifying systems, and training.

Physical Protection: this includes developing the state concept for a physical protection system, performing technical assessments of physical protection systems at facilities, designing and upgrading physical protection systems at facilities, supplying and installing systems, and training.

Export and Import Control: elements of this include enacting and enforcing legislation and regulations, developing a framework for controlling exports and imports, generating licensing and enforcement procedures for that system, obtaining equipment to support export and import controls, and training.

Next, Murakami discussed the process of developing SSACs in the Newly Independent States (NIS). First, he explained the rationale for developing SSACs in the Newly Independent States. A new accounting and control system must be established to replace the one used by the Soviet Union. The NIS have major nuclear facilities and activities, in which it is necessary to implement IAEA safeguards. The infrastructure that is necessary for effective accounting and control is limited or nonexistent; legislation must be enacted, an effective regulatory system needs to be put in place, and physical protection systems must be installed where there are none and upgraded where they do exist. Bilateral support for this work, Murakami noted, is already under way, and the IAEA wants to support and build upon these efforts. In addition to the Russian Federation, there are 11 NIS with nuclear activities (including mining): Armenia, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Tajikistan, Ukraine, and Uzbekistan. Only three of the NIS (Azerbaijan, Moldova, and Turkmenistan) do not have nuclear facilities or mining activities.

The IAEA supports the development of SSACs in the NIS in a number of ways. The agency assists donor countries and the NIS in implementing their SSACs, monitors support activities using a computerized monitoring system, and maintains and distributes a calendar of events and lists of contact persons. The agency also identifies new donor countries, maintains a database on training activities and prepares training profiles, and organizes annual review meetings.

Murakami moved on to what has been accomplished in efforts to support the development of SSACs in Newly Independent States. In the area of legal issues, all NIS have acceded to the NPT, safeguards agreements have been signed and have entered into force in states with nuclear activities and material, nine NIS have signed the Additional Protocol, and the Additional Protocol is in force in five of those states.

With regards to the implementation of safeguards, all nuclear facilities in the NIS (except for Russia) have been placed under safeguards, initial inventory declarations have been verified for their correctness, ad hoc or regular inspections are conducted routinely, and basic SSACs have been established in NIS with nuclear activities. Activities related to the Additional Protocol include organizing international high-level seminars for decision makers, holding seminars for Additional Protocol implementation at the national and facility levels, training has been provided to assist with submitting initial declarations under the protocol, and computer hardware and specialized software have been provided for facilitating those declarations.

Murakami offered three examples of good cooperation. Over the course of two years, 3,000 spent fuel assemblies for BN-350 reactors were verified and placed in canisters for storage. At the Chernobyl nuclear reactor complex, a coordinated effort has transferred 20,000 spent fuel assemblies to dry storage. And, at the Ulba Fuel Fabrication Plant in Kazakhstan, a multinational effort has reduced inventory discrepancies resulting from small amounts of nuclear material left in pipes and other equipment. Highly enriched uranium at the Ulba plant is being "blended down" to low enriched uranium as part of this collaboration as well.

Murakami also argued that IAEA support activities have improved the ability of agency safeguards inspectors to reach their inspection goals. In one newly-independent state with major nuclear activity, the inspectors were only able to meet 50 percent or less of their goals for verifying material quantities in a timely fashion in 1995. In 2000, 2001, and 2002, however, inspectors met 90 percent of their goals in that same country.[1] Murakami credited training and an action plan

[1]IAEA safeguards inspections have performance targets known as "inspection goals." These goals have a quantity component and a timeliness component. The quantity component relates to the extent of inspection activities that must be performed by the agency to verify that one significant quantity or more of relevant nuclear material has not been diverted during a material balance period, and that there has been no undeclared production of nuclear material. The timeliness component relates to the frequency with which inspections must occur to conclude that no abrupt diversion has occurred over a calendar year. It also is a measure of the timeliness with which discrepancies are corrected. The attainment of these goals—or failure to attain them—is expressed in terms of percentages. See International Atomic Energy Agency, "The Safeguards System of the International Atomic Energy Agency," undated document (approximately 2002), paragraph 24, available at http://www.iaea.org/OurWork/SV/Safeguards/safeg_system.pdf, accessed April 20, 2005.

that was developed during periodic meetings with state and facility authorities for this success. Other examples of good results include work with Euratom to develop a regional SSAC in Europe and work in Hungary and the Czech Republic. Common elements of these successes include adequate resources in terms of staff and equipment, a well-trained and competent staff, good accountancy practices using up-to-date computer technology, a spirit of cooperation within states and between states and the IAEA, and creative, innovative approaches.

Finally, Murakami discussed the agency's plans for future activities as well as lessons the agency has learned. Planned activities included developing norms and guidelines for nuclear material accounting and control (including revised SSAC guidelines and handbooks), SSAC training, the provision of SSAC evaluation services to member states, regional events to exchange ideas and discuss issues of regional interest, and the provision of upgraded SSAC equipment. The lessons that the IAEA has learned through these experiences include that the establishment of an effective SSAC often takes more time than expected, requires significant resources, demands commitment from all parties involved, and needs a clear, focused action plan with a practical timeline.

In summary, Murakami pointed out that strong and well-functioning SSACs are critical for safeguards implementation and nuclear security. The IAEA can help to coordinate state and facility assistance. Assistance from donor states is crucial, given the agency's limited resources. Developing a positive safeguards culture is an evolutionary process because of staff, sociological, economic, and cultural changes. He concluded by saying that positive results have been achieved through the combined efforts of all parties, and that this effort has made a significant difference in improving nuclear security and implementing safeguards.

Anita Nilsson, Head of the Office of Nuclear Security in the Department of Nuclear Safety and Security, further described that department's activities in support of improving nuclear security. She argued that an effective approach to MPC&A will acknowledge the interdependence among physical protection, control, and accounting of nuclear materials. The international community should agree on security standards that are both high and sustainable so that, for example, security guards do not simply turn security equipment off when it malfunctions. Nilsson also argued for the establishment of effective mechanisms for exchanging information and learning from bilateral cooperation, a common platform for standards and improvements that facilitates the cycle of program implementation and review, and accountability structures that surpass those required by safeguards agreements, to enable facility-by-facility reviews.

Pierre Goldschmidt, Deputy Director General for Safeguards, provided an overview of the challenges the IAEA faces in implementing the NPT safeguards regime. He began by noting that the nuclear nonproliferation compliance challenges that have confronted the international community in recent years have arisen even as the IAEA safeguards regime has become more robust than ever before.

Goldschmidt explained that the "comprehensive" system of NPT safeguards that was negotiated in the early 1970s, and that forms the basis of most of the safeguards agreements between the agency and NPT signatories, operates on the assumption that the state has furnished the agency with all relevant information. Under comprehensive safeguards, therefore, inspector access is usually restricted to specific locations within nuclear facilities, which limits the ability of the agency to detect activities or materials that have not been declared. Inspectors are only able to verify the correctness of a state's declaration, not its completeness. The Additional Protocol was created to remedy this weakness by requiring much more information from member states, granting agency inspectors broader rights of access (often referred to as "complementary access"), and permitting the inspectors to use more invasive verification methods. The agency synthesizes this wide array of information with open-source data such as the news media and professional journals to assess both the correctness and the completeness of a member state's nuclear declaration. In the process, the agency develops an understanding of a state's nuclear complex as a whole, rather than focusing only on individual facilities, as was done in the past. Once the agency is confident that it has a complete picture of the state's nuclear facilities, activities, and materials and that no materials have been diverted to military uses, it has reached its goal of "integrated safeguards" for that state.[2] Integrated safeguards will provide the agency with the most potent set of tools yet available for ensuring that nuclear material is being used in accordance with treaty stipulations.

Goldschmidt explained that a number of legal, technological, and financial challenges must be overcome before the strengthened safeguards system that is envisioned can be fully implemented. The primary legal, or political, challenge that the agency faces is that strengthened safeguards can only be implemented in states that have both a comprehensive safeguards agreement and an Additional Protocol in place. Goldschmidt urged that member states accept the Additional Protocol, noting that relatively few states have done so to date.[3]

Goldschmidt cited a number of technical challenges as well. The state of the art in nuclear technology is constantly evolving, as demonstrated by the fact that Iraq explored six different uranium enrichment techniques in its clandestine nuclear program. At the same time, the technology and expertise required for a covert nuclear weapons program have become more accessible. The fact that

[2]More information about integrated safeguards may be found in sections A and H of International Atomic Energy Agency, "The Safeguards System of the International Atomic Energy Agency," available at http://www.iaea.org/OurWork/SV/Safeguards/safeg_system.pdf, accessed April 20, 2005.

[3]This situation has improved since the workshop was held in September 2003, but quite a few NPT signatories have yet to conclude their initial comprehensive safeguards agreements with the agency. Of the 189 states party to the NPT, 150 have comprehensive safeguards agreements in force. Of these, 65 had additional protocols in force as of 1 March 2005. See "Safeguards Current Status," at http://www.iaea.org/OurWork/SV/Safeguards/sir_table.pdf, accessed April 20, 2005.

only a few laboratories in the world have the capability of analyzing the hundreds of samples that the new inspection regime will produce is a specific challenge. Still, the changing technical realities of nuclear energy offer the agency some opportunities as well. The agency is participating in research into ways to build "proliferation resistance" into new nuclear reactor and fuel cycle technologies by making them unattractive as sources of material for nuclear weapons. Goldschmidt also expressed support for multinational approaches to managing and disposing of spent nuclear fuel and radioactive waste.

The third general challenge that must be overcome to implement strengthened safeguards is that of insufficient funding for agency activities. Goldschmidt applauded the recent decision of the IAEA Board of Governors to significantly increase the agency's budget, with most of the increase intended for verification activities. However, this was the first such increase in over a decade, and the safeguards program will continue to be stretched financially as demands on the program increase. One idea that has been considered is adding a surcharge for the cost of IAEA activities to the cost of electricity generated by nuclear energy. Goldschmidt said that he did not expect this proposal to be approved, however.

In addition to these general issues, Goldschmidt noted that the international nuclear nonproliferation regime faces specific challenges in North Korea, Iran, and Iraq. These challenges, in his view, underscore the need for the safeguards system to be not only effective and efficient but also adaptable in its response. He closed by expressing his belief that the best hope for progress in nuclear nonproliferation and disarmament is that those individuals, agencies, and governments that are involved work together effectively.

Nikolai Khlebnikov of the Department of Safeguards discussed the challenges for the future development of safeguards equipment. He began by pointing out that, drawing on 30 years of experience, the IAEA has developed a wide, sound range of equipment and techniques to support safeguards and verification activities. There are 25,000 items in the agency's safeguards equipment inventory, worth more than $90 million. There are over 100 types of equipment that are authorized for use by inspectors, and the equipment has an average life span of 7 years. Approximately $11 million is spent on equipment annually.

The first of the future challenges for IAEA safeguards equipment that Khlebnikov discussed was sustainability, which he defined as "having the capability to maintain a sound equipment management infrastructure in a rapidly developing technical environment." He noted that equipment can become obsolete rapidly because of the evolving character of the market for technical products. As a result, new research and development work is required to replace the obsolete instruments. In turn, this leads to requirements for testing, documentation, and training.

The second challenge was the need to upgrade equipment. The efforts to strengthen and integrate safeguards described by Goldschmidt imposed new requirements on existing equipment. These might include modifications of the instruments as well as testing, documentation, and training. The new requirements include

- the capability to operate in tandem with an SSAC, and the ability for the agency to retrieve data remotely, without compromising data security
- the ability to operate for extended periods without attention between inspection visits
- an extended remote data transmission capability
- increased sensitivity for detecting nuclear materials
- improved portability for use with complementary access visits

Another challenge for IAEA equipment is that it must be able to operate in new facilities that present new monitoring and verification challenges. Some new nuclear facilities are automated and remotely operated. To address this challenge, Khlebnikov explained, the agency was developing facility-specific unattended assay and monitoring systems, with the goal of minimizing the equipment's impact on facility operations while providing highly reliable and authentic data. Key elements of this approach included designing and installing monitoring systems well before a facility was commissioned and designing a system that integrated different sensors.

Khlebnikov explained that detection of undeclared nuclear material and activities also presents an important challenge for safeguards equipment. The move toward state-based (rather than facility-based) safeguards assessments mandated a shift in equipment development objectives. Khlebnikov said that there was a need for more sensitive devices for detecting nuclear material and for systems that could monitor environmental and other parameters that might indicate the presence of undeclared facilities and activities. He discussed several specific examples of equipment, including

- a hand-held monitor and a "suitcase" neutron detector with improved sensitivity to gamma and neutron radiation
- detection of Trace UF6 concentrations using laser spectroscopy
- anti-neutrino measurements for the detection of undeclared plutonium
- ground penetrating radar to verify facility design information and detect undeclared activities
- monitoring of Krypton 85 levels for detecting undeclared reprocessing facilities
- wide area monitoring to facilitate implementation of the Additional Protocol
- use of satellite imagery to detect undeclared material or facilities

Next, Khlebnikov described some possible features of the next generation of safeguards verification technology. Features of the next generation of digital surveillance technologies will likely include full color displays, adjustable zoom and focus for specific images, transmission using secure encryption techniques, and laser ranging and scanning techniques to confirm that spent-fuel casks had not been moved. The next generation of non-destructive assay equipment will probably be more "intelligent," have enhanced sensitivity and accuracy to help it deal with new verification challenges like hold-up (known in the United States as "material unaccounted for") and nuclear waste, and be able to integrate data from other computer systems used by inspectors.

Khlebnikov also discussed technology designed to facilitate safeguards verification when IAEA inspectors are not present. He explained that the IAEA is increasingly turning to unattended monitoring systems that monitor the flow of nuclear material. There are over 80 such systems operating in more than 20 states. The agency has also installed a number of remote monitoring systems that use video cameras to monitor activity. Transmission of the video data to the agency is a major cost factor with regard to these systems. Finally, the agency is replacing the metal, Cobra, and electronic seals it used in the past with new ones that include improved authentication and tamper-indicating features and allow verification results and other information to be directly sent to the agency.

Khlebnikov also discussed some of the ways in which his office supports the IAEA's efforts in the nuclear security arena to detect malicious activities involving nuclear and other radioactive materials. One of these support functions is to develop new technical measures to detect and respond to illicit nuclear trafficking. This includes developing, testing, and publishing specifications for border monitoring equipment; improving hand-held isotope identification equipment; and improving verification of legal shipments of nuclear and radioactive materials. It also includes supporting the work of the agency's Nuclear Security Equipment Laboratory.

Next, Khlebnikov summarized some of the limitations and restrictions relating to IAEA verification technology

- some agency requirements are unique and necessitate special development programs
- field equipment must be able to operate in harsh environments
- instrumentation must be as non-intrusive as possible and must protect confidential information
- techniques must be reliable and cost-effective, particularly in light of the agency's limited financial resources
- agency safeguards technology can only be used where inspectors have access

Khlebnikov added that the IAEA has no independent ability to develop equipment, but rather is dependent upon member states' "technology holders." He encouraged workshop participants to share the results of their research and development activities with the IAEA, in order to increase IAEA detection capabilities, particularly for the detection of undeclared nuclear activities. Khlebnikov ended his presentation by concluding that the IAEA is facing a number of challenges in the area of safeguards equipment, but that a systematic equipment development program is under way.

Domestic MPC&A Programs

Although, as the preceding sections illustrate, the majority of presentations at the workshop addressed the context in which materials protection, control, and accounting (MPC&A) programs operate, much of the discussion focused on the particulars of specific programs. These presentations sought not only to share ideas about MPC&A practice, but to demonstrate the importance of sharing these ideas for increasing security around the globe. For each of the five countries whose MPC&A programs were discussed, this section summarizes what the presenter (or presenters) saw as the most important features and challenges of MPC&A activity in their country.

INDIA

K. Raghuraman of India's Department of Atomic Energy (DAE) introduced India's nuclear energy program by explaining that the program has developed in three stages. Stage one has emphasized pressurized heavy water reactors (PHWR), with more than 18 reactors operating, under construction, or planned. This stage also includes two operating boiling water reactors (BWR) and two pressurized water reactors (PWR) under construction. Fast breeder reactors are being developed under stage two, with one reactor in operation and another under construction. Stage three focuses on thorium-based reactors, with one reactor in operation and another in development.

Raghuraman then explained that India's MPC&A program comprises three basic elements: the legislative and regulatory framework, an integrated physical protection program for facilities and materials, and a comprehensive "Nuclear

Material Accounting and Control System" (NUMAC). The NUMAC cell of the Department of Atomic Energy is primarily responsible for nuclear material control and accounting activities in India and for meeting India's international safeguards obligations.

Raghuraman reviewed the elements of the NUMAC structure. There are facility-specific NUMAC arrangements at nuclear fuel cycle facilities, research and development complexes handling nuclear materials, and heavy water plants. An Officer in Charge oversees each facility. There is also an Inventory Information and Control and Data Management Section and a control laboratory. The activities of all NUMAC facilities are coordinated through the central NUMAC cell at DAE. Above this there is a Senior Coordination Committee, which reviews NUMAC reports and initiates actions as needed.

NUMAC has a number of responsibilities. These include identification of nuclear material by type, nature, and amount; implementation of accounting and control mechanisms; ensuring that measurement capabilities and statistical analysis of reported data are efficient; overseeing auditing practices and implementing inspection and verification practices; and ensuring the compliance of containment and surveillance measures. NUMAC activities include non-destructive and destructive measurements, periodic inspection, verification and auditing, and documentation of inventory changes and discrepancies.

Raghuraman said that DAE has taken the physical protection of nuclear facilities and material against theft and sabotage very seriously from the program's inception. A multi-layered security system has evolved over the years to address the complexities of security. An integrated system of physical protection for nuclear facilities and materials—during use, storage, and transport—has been established. A Design Basis Threat analysis has been performed following international guidelines but taking the Indian perspective and context into account regarding external and internal threats. DAE has also developed technical measures for physical protection, including an access control and delay system; access control for personnel and for nuclear materials; surveillance, intrusion, detection, and alarm systems; training on operation and maintenance of security systems; technical reviews to address obsolescence issues; and reviews and audits of physical protection systems to ensure that they are functioning properly and maintained appropriately.

Raghuraman reported that a review of security systems and procedures took place after the terrorist attacks of September 2001, and that DAE determined that the old approach to security was no longer valid. As a result, efforts were made to quickly and comprehensively strengthen nuclear security. A new assessment of threats was performed and various terrorism scenarios considered. DAE also explored the linkages between safety and security and their impacts on one another. In addition, the Indian authorities have undertaken "root cause analysis" to improve counter-terrorism efforts by developing a better understanding of why terrorism occurs. They determined that renewed vigilance, as well as improved cooperation to facilitate information sharing and agreed-upon minimum physical protection standards, was necessary.

Next, Raghuraman discussed his organization's approach to security culture. Elements of this approach include encouraging a positive security culture as a goal and value of the organization, commitments by senior managers to serve as role models, a belief that it is possible to change culture both through human interaction and objective systems, a goal to set security indicators and follow up on them, encouraging participatory management, and changing perceptions so that security is seen as everyone's responsibility, not an external requirement. Raghuraman argued that, to foster a positive security culture, it is important to foster comradeship, identify weak links through participation, emphasize involvement, communication, training, and effective management, pay due attention to internal threats, ensure that workers have appropriate support and encouragement, and train supervisors to notice even small changes in behavioral patterns.

Next, Raghuraman described some of his views on the appropriate approach to MPC&A. He said that his perspective can be summarized in a question that he often puts to himself and his colleagues: "when was the last time that you did something for the first time for MPC&A?" Continuous improvement toward excellence, in his view, is a journey and not a destination. He believes that globalization of MPC&A practices is an ideal concept but may not be feasible. Instead, country-specific practices, in line with international guidelines, may be the best approach. Raghuraman asserted that international cooperation and commerce will not be permitted to degrade MPC&A practice in India. He also noted that the most significant recent change in approaches to physical protection has been the growing interdependence of safety and security, as security has become more important in ensuring safety.

More specifically for the Indian context, Raghuraman noted that technological changes are expected to be evolutionary rather than revolutionary, and that they should be cost effective, reliable, and convenient. He noted that the increase in restrictions (i.e. screening personnel and materials) will probably be unpopular with operators, who are expected to deliver goods and services within time and cost limits. Further, construction of new facilities should factor in the additional cost of increased security. Finally, he explained that aging of the workforce—a problem in some countries—is not a consideration for India.

JAPAN

The presentation on Japan was given by **Keisuke Kaieda** of the Nuclear Material Control Center (NMCC) in Tokyo, and described Japan's State System of Accounting for and Control of Nuclear Material (SSAC). The domestic legal basis for Japan's SSAC is the "Law Concerning Regulation of Nuclear Raw Materials, Nuclear Fuel Materials and Nuclear Reactors," which was enacted in 1957, four years after U.S. President Dwight D. Eisenhower's famous "Atoms for Peace" speech. The international basis for Japan's SSAC is embodied in a series of bilateral agreements between Japan and six other states. These agreements facilitate the trade in nuclear components and materials that is necessary to sustain Japan's nuclear energy industry. By 1977, Japan had joined the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and ratified its safeguards agreement with the International Atomic Energy Agency (IAEA). Japan was one of the first states to ratify an Additional Protocol, in 1999.

To meet its domestic and international legal obligations, Japan created an SSAC that features regular national and international reviews of its safeguards system. SSAC activities include providing accounting reports, accompanying of IAEA inspectors during inspections, performing destructive assays, and organizing seminars and working groups. As of October 1, 2002, there were 33 government-authorized nuclear inspectors on the staff of the Japanese government.

The Nuclear Materials Control Center (NMCC), a non-profit organization of which Kaieda is Executive Director, was established in 1999 to provide independent verification of Japan's nuclear safeguards. NMCC's activities include managing safeguards information; compiling reports required by IAEA safeguards inspectors, including those stipulated by the Additional Protocol to Japan's Safeguards Agreement with the IAEA; inspections and analysis of samples; and research and development in support of safeguards and physical protection. NMCC is the only organization that has been approved by federal law to carry out national safeguards inspections in Japan. NMCC uses potentiometric titration and isotopic dilution mass spectrometry to analyze uranium concentrations, and surface ionization mass spectrometry to assess the isotopic composition of uranium samples. For analyzing plutonium concentrations, NMCC uses isotopic dilution mass spectrometry; to identify the isotopic composition of plutonium, the agency uses surface ionization mass spectrometry and alpha spectrometry. As of December 31, 2002, NMCC inspectors had spent 2,311 person/days doing safeguards inspections at 259 locations in Japan, filing 4,143 reports.

Kaieda noted that Japan took an active role in developing and negotiating the model Additional Protocol, which is the basis for Additional Protocols to individual nations' safeguards agreements. Japan's MPC&A system, regarded by many as representing the state of the art, is designed to facilitate and complement the safeguards activities of the IAEA. Cooperation between Japan's SSAC and IAEA included preparation of technical procedures for implementing integrated safeguards for light water reactors that do not use mixed-oxide fuels. One of Japan's goals for its MPC&A system is the establishment of a State System of Accountancy and Control that is operated cooperatively with the IAEA.

Kaieda concluded by explaining the goals of Japan's nuclear control complex. They are ensuring that nuclear material is used for peaceful activities, providing assurance of planned uses of nuclear materials, protecting nuclear materials, and implementing international agreements.

KAZAKHSTAN

Timur Zhantikin of the Committee on Atomic Energy in Kazakhstan began by explaining that his committee is responsible for nuclear and radiation safety and security and for nuclear nonproliferation operations in Kazakhstan. He described Kazakhstan's nuclear complex, which comprises three facilities: the National Nuclear Center, which is a nuclear reactor research facility with four research reactors; the Mangyshlak Nuclear Power Plant, featuring a BN-350 fast breeder reactor that is in the process of being decommissioned; and the Ulba nuclear fuel fabrication plant in Ust-Kamenogorsk. The government has been working to consolidate the country's nuclear materials, including those from the decommissioned power plant, at one site. Kazakhstan joined the NPT in 1993 and was in the process of negotiating its Additional Protocol with the IAEA at the time of the workshop.[1] Preparing the initial declaration needed to finalize the Additional Protocol was a challenge in part because of uncertainties about materials remaining at Soviet-built nuclear sites. Their efforts to consolidate nuclear materials in one storage site and to decommission their BN-350 reactor are also among Kazakhstan's challenges.

Kazakhstan's MPC&A system includes safeguards, export control, and nuclear security measures. The country's technical policy goals are to develop its domestic nuclear material control capabilities and to minimize the costs of safeguards both for Kazakhstan and the IAEA by using advanced technology and methods. Zhantikin argued that, in Kazakhstan at least, an effective safeguards system must operate on a number of fronts, including legal and organizational as well as technical measures. This has included preparing to operate under the Additional Protocol, ensuring the security of nuclear material transfers, and adapting to the nuclear-weapon States' differing approaches to export controls. Zhantikin concluded by observing that safeguards practices include legal, organizational, and technical measures.

RUSSIA

There were several presentations about MPC&A in Russia. **Evgeny Avrorin** discussed the MPC&A system at the Zababakhin Russian Federal Nuclear Center-All-Russian Scientific Research Institute of Technical Physics (VNIITF) in Snezhinsk. VNIITF is one of the largest scientific research institutes in Russia. Since 1955, it has been involved in developing nuclear weapons and studying the effects of nuclear explosions. The institute carries out the full cycle of nuclear weapon activities, from basic and applied physics, to designing weapons, to developing instruments for studying nuclear explosions. VNIITF began collabo-

[1]Kazakhstan signed its Additional Protocol on February 6, 2004. Source: http://www.iaea.org/OurWork/SV/Safeguards/sg_protocol.html, accessed April 20, 2005.

rating on MPC&A with the U.S. Department of Energy (DOE) in 1995, with the goal of improving nuclear materials protection, control, and accounting systems. The agreement supporting this work was signed in 1999, and the following goals were identified: further developing existing national MPC&A programs; improving MPC&A systems, including those related to transporting nuclear materials; installing modern MPC&A systems at Russian facilities with material that can be used in nuclear weapons; and combating illicit nuclear trafficking.

Avrorin explained that the Pulse Research Reactor Facility at VNIITF was chosen as a test site for cooperative MPC&A activities because of the large amount of nuclear materials at the site, the wide array of types of nuclear materials at the site, and the facility's physical layout, which facilitated the creation of a prototype "mini-site" that was somewhat independent of the rest of the facility. VNIITF established a special research center intended to carry out the MPC&A work and coordinate with other VNIITF divisions. The U.S. project team includes representatives of many of the U.S. national laboratories. Trial operations began at the Pulse Research Reactor Facility in May 1998. A demonstration for officials from DOE and the Russian Ministry of Atomic Energy (now the Federal Atomic Energy Agency) examined the upgraded systems and decided to further develop and strengthen work in this area.

Avrorin argued that the adoption of new MPC&A technology is only successful when nuclear technicians and security staff receive appropriate training. Therefore, VNIITF established the Ural-Siberian Methodology and Training Center. According to Avrorin, the United States was in favor of this idea, but did not provide funding for it; funding was provided by European institutes.

The scope of work for upgrading physical protection systems at VNIITF includes

1. alarm and video assessment systems (including intrusion detection sensors, tv surveillance equipment, and information transfer facilities)
2. physical barriers (metal grates on windows and vents, enhanced metal doors, anti-burglary equipment, and "safe"-type doors)
3. automated systems for personnel access control (including pin-code plastic card readers, access control booths, biometric identification systems, and scales)
4. monitoring systems to prevent access with weapons and unauthorized exit (such as metal detectors and nuclear material detectors)
5. effective telephone and radio communications
6. computer software and hardware to coordinate and interconnect alarm, video assessment, access control, and monitoring systems

Other facilities where VNIITF has worked to improve MPC&A include the Beloyarsk Nuclear Power Plant, the Ural Electrochemical Integrated Plant, the State Scientific Center for Virology and Biotechnology (Vector), and the Leningrad Nuclear Power Plant.

The remaining presentations about MPC&A in Russia focused on the Kurchatov Institute in Moscow. **Alexander N. Rumyantsev** described Kurchatov's participation in U.S.-funded cooperative MPC&A programs in Russia. He began by explaining that the efforts of states to contribute to nuclear nonproliferation and prevent nuclear terrorism rely on:

- preventing unauthorized access to nuclear facilities, nuclear material, nuclear technologies, and knowledge of nuclear technologies
- improving MPC&A systems as well as systems for handling nuclear material
- research and development of nuclear energy technology that is proliferation resistant, increases nuclear and radiation safety, and mitigates the risks of terrorism and sabotage
- strengthening the national and international legal basis for the nuclear nonproliferation regime to support efforts to curb nuclear trafficking and mitigate the dangers of nuclear terrorism
- developing and improving national and international safeguards against proliferation.

The Kurchatov Institute is one of Russia's largest nuclear research centers, located in downtown Moscow about 10-12 km from the Kremlin. The facility faces threats of unauthorized access, sabotage, and terrorism. Intensive international cooperation, primarily with the United States, has provided Kurchatov with modern MPC&A systems. MPC&A upgrades, which have emphasized radiological as well as nuclear threats, include a modern computerized material control and accounting system that provides real-time control and accounting of nuclear material, radioactive material, and radioactive sources and development of an improved access control system that includes sensitive systems for detecting nuclear or radiological materials. Rumyantsev explained that Kurchatov has also worked to improve MPC&A at Russian Ministry of Defense sites. With financial support from the United States, Kurchatov has installed MPC&A upgrades at many Russian Navy sites. Work performed at the sites varied from full upgrades of physical protection systems, to computerized control and accounting systems, to short-term "rapid upgrades."

Rumyantsev explained that quantitative risk assessment methodology was developed during the 1970s and 1980s to assess nuclear safety. This risk assessment approach is also useful for comparative evaluations of safety at nuclear facilities. Rumyantsev explained that the institute's scientists devised a sophisticated methodology for assessing proliferation threats, comparing highly enriched uranium (HEU), low enriched uranium (LEU), plutonium from spent fuel, and weapons-grade plutonium. Most MPC&A experts would argue that, of the various forms and grades of nuclear materials that exist, HEU and weapons-grade plutonium should receive the highest degree of protection because they can most readily be used in an atomic weapon. In the opinion of Rumyantsev and his co-authors at Kurchatov, however, this prevailing view is incorrect. Rumyantsev argued instead that, according to his institute's analysis, LEU poses the greatest proliferation risk. This assertion is based on an assessment of a number of factors. According to the analysis, the most important of these factors for LEU are that the process of building a nuclear arsenal starting with LEU would be highly secret (thus, in Rumyantsev's view, increasing the proliferation risk), and that LEU is extremely plentiful relative to the other materials. Therefore, Rumyantsev recommended that maximum efforts should be put into reducing the availability, production, and consumption of LEU; that spent fuel should be reprocessed for use in nuclear reactors without separating plutonium and uranium; that thorium be used as a nuclear fuel; that fission products be included in nuclear fuel to increase its resistance to theft or tampering; and that work on the international fuel center concept be continued.

Rumyantsev offered several conclusions from his presentation:

1. Analyses of proliferation risks associated with nuclear materials should include the risk of radiological terrorism and unauthorized use of radioactive material and sources.
2. Further improvements to MPC&A should include improvements to the security of radioactive material and sources.
3. Quantitative methods for assessing proliferation risk should be developed.
4. Attention in nonproliferation efforts should be refocused on LEU and natural uranium.
5. Future development of the nuclear energy industry should emphasize building proliferation resistance into nuclear energy technologies and on international nuclear fuel centers.
6. An analysis of all uncertainties linked to economics, nuclear and radiation safety, and nonproliferation should inform future development of nuclear power and innovative nuclear technologies.

Vladimir Sukhoruchkin, also of the Kurchatov Institute, provided an overview of some of the institute's MPC&A challenges. Because of the institute's proximity to residential areas, he argued, the facility's perimeter should be very heavily protected, as if it were a national border. The Kurchatov staff had been unable to convince their American colleagues of the need to fortify the institute's perimeter, however, so it was being upgraded at the expense of the Russian government. He also noted that Kurchatov had installed MPC&A upgrades at a number of facilities elsewhere in Russia. The Kurchatov staff was especially proud, however, of the new computerized material accounting and security system that had been installed at the institute.

Alexander Grigoriev of the Kurchatov Institute provided further details on this new system, dubbed the "MPC&A Operations Monitoring System," or MOM. He began by discussing the definition of safety: "safety means reliable protection of personal and national interests against internal and external threats." The goals of safety are to protect personal rights and freedoms, the material and spiritual values of society, and the state's social and political system, sovereignty, and territorial integrity. Components of national security include economic security, internal political security, social security, international security, information security, military security, border security, and ecological security. Elements of the safety of hazardous nuclear sites include nuclear, radiological, technical, and physical safety; nuclear and radiological safety includes protection against possible military nuclear threats, protection against the consequences of nuclear and radiological accidents, and assurance that materials are used for peaceful purposes. Components of the technical safety of hazardous sites include safe operation and minimizing the number of human errors. Physical protection of hazardous nuclear sites comprises protection against internal and external threats without impeding normal operations. The goals of physical protection at nuclear facilities include preventing unauthorized actions, quickly detecting unauthorized actions, impeding the activities of attackers or violators, suppressing unauthorized actions, and detaining persons involved in such actions.

Grigoriev described the characteristics of the nuclear materials at the Kurchatov Institute site. Enrichment of uranium at the site ranges from 5 percent to 90 percent ^{235}U. The institute has nuclear materials in a number of different forms, including 3 mm-diameters spheres of uranium and graphite, bulk materials, fuel elements, and fuel rod arrays. The sensitivity of the materials ranges from unclassified to highly classified. Storage periods for the materials vary from one or two days at the Central Storage Facility to tens of years at the Central Storage and Test Benches.

Grigoriev noted that although great investments have been made to upgrade physical protection and accounting systems for nuclear materials, decreasing the risk that nuclear material will be lost, problems remain. These include:

- Keeping nuclear materials in the line of sight. Due to the sensitive nature of some of the materials, guards are not permitted to conduct surveillance of nuclear materials.
- Verifying that the physical protection system is operating in accordance with requirements.
- Precisely tracking personnel activities; knowing where they are and why they are there.
- Identifying perpetrators and violations. Grigoriev noted that the institute had recently been putting greater emphasis on the "insider threat."

The institute has 35 "material balance areas"[2] for nuclear materials. Each material balance area is assigned custodians, who are grouped into five departments. The facility has two territories, the "Main" territory and the "Gas Plant." Grigoriev noted that there has been a reduction in the number of custodians, and that there has been a weakening of discipline among institute personnel and guards.

Grigoriev explained that the MPC&A Operations Monitoring (MOM) system, proposed by DOE, was selected as a solution to these problems. The system was installed in Kurchatov's Building 135 and covered three material balance areas and one set of access points. Three additional buildings were under contract for the system. The basic components of the system include equipment to collect and store data, the system server, communication lines, and monitoring stations. Grigoriev's presentation included graphical representations and photos from each of the four groups of video cameras (one for each of the three material balance areas and one group for the access points).

Grigoriev closed by describing some of the barriers to further implementation of the MOM system in Russian facilities. These include MOM's lack of encryption capabilities, the need to use indigenous Russian technology, and the lack of a requirement for a MOM-type system from Russia's federal nuclear regulatory authority.

UNITED STATES

Donald Solich of the U.S. Department of Energy gave a presentation on DOE's current efforts to strengthen the MPC&A system in the United States. As part of its Material Consolidation program, DOE is closing sites it no longer needs, consolidating nuclear materials, upgrading aging facilities, and building new "hardened" facilities. DOE is also bolstering protection against insider threats through its Insider Protection program, which enhances existing personnel security and human reliability programs and emphasizes administrative procedures, such as the "two-person rule" and the use of passwords or pass codes, where appropriate. The Materials Control and Accounting Modernization program strives to achieve continuous monitoring of protected materials, uses the insider

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[2]Material balance areas are basic units for the accounting of nuclear material. A nuclear facility is sub-divided into multiple material balance areas, and records are kept indicating quantities and types of material for each area. When inventory is taken, the inventory within each material balance area is compared to the previous inventory so that movements, gains, or losses may be tracked. The IAEA's use of material balance areas is explained, for example, in IAEA INFCIRC/153 (Corrected), June 1972, paragraph 46. The document is available at http://www.iaea.org/Publications/Documents/Infcircs/Others/inf153.shtml, accessed April 20, 2005.

threat as its security benchmark, and is implementing an automated process for entering data into the accounting system. DOE also has a New Technology Implementation program. This program incorporates security technologies into the design and construction of nuclear facilities. It also seeks to achieve "Enhanced Protection Capabilities" by integrating strategy, system technology, and operations.

DOE's efforts to enhance information security include improved security protections and transparencies and innovative information security protection and accountability tools and practices. Training programs include a Comprehensive Security-Related Career Development Program and distance learning programs. DOE has changed its Design Basis Threat assessment (DBT) in response to the events of September 2001 and intelligence information. The new DBT incorporates a graded approach. Implementing the new threat assessment will require funding, upgrades, and a risk management approach. Solich closed by discussing some of the new technologies DOE is developing, including integrated access controls, advanced measurement technologies, new simulation tools for vulnerability analyses and attack modeling, active denial capabilities, and new capabilities for detecting explosives.

Concluding Remarks

Mark Mullen of Los Alamos National Laboratories closed the workshop by providing some overall comments on the workshop discussions. He argued that the international community should actively encourage international communication on these issues across the spectrum of professionals with nuclear energy expertise. Mullen suggested that the conundrum described by Charles Curtis—the gap between the significant threats posed by nuclear materials and the lukewarm response to those threats—posed the central question of the workshop: can sharing information on MPC&A practice help to narrow that gap? In Mullen's view, based upon the workshop discussion, the answer is unequivocally yes.

Mullen pointed out that international forums such as this one could provide MPC&A experts with valuable ideas and information, including

- ways of fostering a cycle of continuous MPC&A improvement
- potential use of remote and continuous monitoring technologies for domestic MPC&A (not just for international safeguards and transparency)
- ways of analyzing and addressing problems involving "culture"
  - — security, safeguards, and nonproliferation cultures are distinct
  - — issues such as motivation, attitudes, discipline, complacency are important
- ways of ensuring that effective safeguards practices will be sustained into the future
- ways of managing the consolidation of materials and facilities
- methods of economizing on costs and increasing the efficiency of MPC&A
- methods of, and experience in, analyzing, reviewing, and updating Design Basis Threat assessments

- how to disseminate or propagate technological knowledge, including why some are more successful than others in transferring good ideas and approaches into practical applications
- implementing new technologies
- human reliability issues and dealing with the "insider threat"
- modernization of MPC&A through both incremental and revolutionary improvements

Mullen acknowledged that a number of forums already exist for exchanging information on MPC&A practice. The International Atomic Energy Agency (IAEA) plays a key role in these efforts, and professional societies, symposia, and conferences are all useful and important. He argued, however, that the urgency of the problem should motivate us to develop additional pathways for exchanging information and coordinating activities. Possible avenues for sharing best practices on MPC&A might include additional exchanges of technical information, training courses and seminars, and peer-to-peer exchanges. Further bilateral and multilateral program activities would also provide some important opportunities for sharing ideas, and it may be possible to accelerate some existing programs by opening new pathways for communication.

Mullen argued that there are a number of organizations which also might have a useful role in this ongoing dialogue. Professional societies, such as the Institute for Nuclear Materials Management, nuclear societies of many countries, and security societies might participate. Universities with expertise in nuclear science and technology could contribute significantly and are definitely an underutilized resource in this arena. The participation of industry groups would also be important, and there might be some room to consider forming new industrial associations in support of the effort. Groups such as the Institute of Nuclear Power Operation and the World Association of Nuclear Operators might be important forums, and there might even be room for a "World Association of Nuclear Security Operations." Mullen closed by suggesting that it would also be important to facilitate links among these groups and organizations, so that the exchange of information on best practices in MPC&A is as effective as possible.

Appendix A

Workshop Participants List

Workshop on MPC&A Best Practices
September 24-25, 2003

A Joint Program of the U.S. National Academies and
the Russian Academy of Sciences
With Support from the International Atomic Energy Agency

International Atomic Energy Agency Headquarters
Vienna, Austria (Conference Room C07 IV)[1]

PARTICIPANTS LIST

Committee & Russian counterparts attending

Evgeny Avrorin (VNIITF, Russia)
William F. Burns (U.S. Army, ret.)
Rose Gottemoeller (Carnegie Endowment, U.S.)
William C. Potter, Workshop Co-chair (Monterey Institute, U.S.)
Ashot A. Sarkisov, Workshop Co-chair (Nuclear Safety Institute [IBRAE], Russia)
Frank von Hippel (Princeton University, U.S.)

[1]Vienna International Centre: "C" Building, 7th Floor, Room IV.

IAEA

Pierre Goldschmidt
Nikolai Khlebnikov
Kenji Murakami
Anita Nilsson
Tariq Rauf
Thomas Shea
Tomihiro Taniguchi

Other Participants

Grigory Berdennikov (Russian Federation Mission to International Organizations in Vienna)
Kenneth Brill (U.S. Mission to International Organizations in Vienna)
Charles Curtis (Nuclear Threat Initiative, U.S.)
Alexander Grigoriev (Kurchatov Institute, Russia)
Laura Holgate (Nuclear Threat Initiative, U.S.)
Keisuke Kaieda (Nuclear Material Control Center, Japan)
Igor Khripunov (University of Georgia, U.S.)
Irene Koupriyanova (Institute of Physics and Power Engineering, Russia)
Mark Mullen (Los Alamos National Laboratory, U.S.)
K. Raghuraman (Department of Atomic Energy, India)
Sergey Ruchkin (IBRAE, Russia)
Alexander N. Rumyantsev (Kurchatov Institute, Russia)
Vladimir Shmelev (Kurchatov Institute, Russia)
Donald Solich (Department of Energy, U.S.)
Leonard Spector (Monterey Institute, U.S.)
Carlton Stoiber (Private Consultant, U.S.)
Vladimir Sukhoruchkin (Kurchatov Institute, Russia)
Yukio Takasu (Japanese Embassy to International Organizations in Vienna)
Lars van Dassen (Swedish Nuclear Power Inspectorate)
Yuri Volodin (Gosatomnadzor, Russia)
Timur Zhantikin (Committee on Atomic Energy, Kazakhstan)

National Academies Staff

Christopher Eldridge
Kate Giamis
Jo Husbands
Micah Lowenthal

Appendix B

Workshop Agenda

Workshop on MPC&A Best Practices
September 24-25, 2003

A Joint Program of the U.S. National Academies and
the Russian Academy of Sciences
With Support from the International Atomic Energy Agency

International Atomic Energy Agency Headquarters
Vienna, Austria (Conference Room C07 IV)[2]

AGENDA

WEDNESDAY, SEPTEMBER 24

Session I : Overarching Issues

0900-0930 *Welcome, Opening Remarks, Introductions, Review of Agenda*
- Tomihiro Taniguchi, International Atomic Energy Agency (IAEA)
- William C. Potter, Monterey Institute for International Studies, Workshop Co-chair
- Ashot A. Sarkisov, Russian Academy of Sciences (RAS), Workshop Co-chair

[2]Vienna International Centre: "C" Building, 7th Floor, Room IV.

0930-1115 *Presentations*
Session Chair: William C. Potter
Topic: Issues Facing the Global Nonproliferation Regime
Presenter: Charles Curtis, Nuclear Threat Initiative
Topic: Current Nonproliferation Problems
Presenter: Alexander N. Rumyantsev, Kurchatov Institute
Topic: The Relevance of U.S. and Russian MPC&A Experience to the Promotion of Best Practices Globally
Presenter: Rose Gottemoeller, Carnegie Endowment for International Peace
Topic: IAEA Lessons with Regard to MPC&A Best Practices
Presenter: Kenji Murakami, IAEA

Comment
- Evgeny Avrorin, All-Russian Scientific Research Institute of Technical Physics (VNIITF)
- Mark Mullen, Los Alamos National Laboratory

1115-1130 *Break*

Session II : Domestic Safeguards

1130-1215 *Presentation*
Session Chair: Mark Mullen
Topic: Major Domestic Safeguards Challenges Globally
Presenter: Leonard Spector, Monterey Institute of International Studies

1215-1315 *Panel Discussion*
Moderator: Mark Mullen
Topic: MPC&A Best Practices in Selected Countries
- Keisuke Kaieda, Nuclear Material Control Center, Japan
- Donald Solich, U.S. Department of Energy
- Vladimir Sukhoruchkin, Kurchatov Institute

1315-1445 *Lunch*

1445-1615 *Panel Discussion*
Moderator: Mark Mullen
Topic: MPC&A Best Practices in Selected Countries (continued)
- Yang Dazhu, Permanent Mission of the People's Republic of China to International Organizations in Vienna
- K. Raghuraman, International Studies Division, Department of Atomic Energy (India)
- Timur Zhantikin, Committee on Atomic Energy (Kazakhstan)

1615-1645 *Break*

1645-1800 *Roundtable Discussions: Domestic Safeguards: The Human Factor*
Moderator: William C. Potter
Topic: Education and Training
Presenter: Lars van Dassen, Swedish Nuclear Power Inspectorate
Topic: Safeguards Culture
Presenter: Irene Kouprianova, Institute of Physics and Power Engineering
Topic: Independent Regulatory Bodies
Presenter: Yuri Volodin, Gosatomnadzor
Presenter: Carlton Stoiber (Private Consultant, U.S.)

1830-2000 *Cocktail Reception,* VIC Restaurant

THURSDAY, SEPTEMBER 25

Session III : International Safeguards

0900-1000 *Presentation*
Session Chair: Evgeny Avrorin
Topic: Major International Challenges
Presenter: Pierre Goldschmidt, IAEA

1000-1100 *Panel Discussion*
Moderator: Evgeny Avrorin
Topic: Technological Advances
- Nikolai Khlebnikov, IAEA
- Alexander Grigoriev, Kurchatov Institute

1100-1130 *Break*

1130-1300 *Panel Discussion*
Moderator: Tariq Rauf, IAEA
Topic: Political Initiatives
- Grigoriy Berdennikov, Permanent Mission of the Russian Federation to International Organizations in Vienna
- Kenneth Brill, Permanent Mission of the United States of America to International Organizations in Vienna
- Yukio Takasu, Permanent Mission of Japan to International Organizations in Vienna

1300-1500 *Lunch*

1500-1700 *Roundtable Discussion*
Moderator: William C. Potter
Topic: Next Steps
- Igor Khripunov, University of Georgia (U.S.)
- Mark Mullen
- Anita Nilsson, IAEA
- Vladimir Shmelev, Kurchatov Institute