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Center for Global Security Research

A Comparative Analysis of Approaches to the Protection of Fissile Materials

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Proceedings of the Workshop at Stanford University
July 28-30, 1997

Center for International Security and Arms Control, Stanford University

Center for Global Security Research, Lawrence Livermore National Laboratory

Center for Nonproliferation Studies, Monterey Institute of International Studies

May 15, 1998

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A Comparative Analysis of Approaches to the Protection of Fissile Materials

Proceedings of the Workshop at Stanford University July 28-30, 1997

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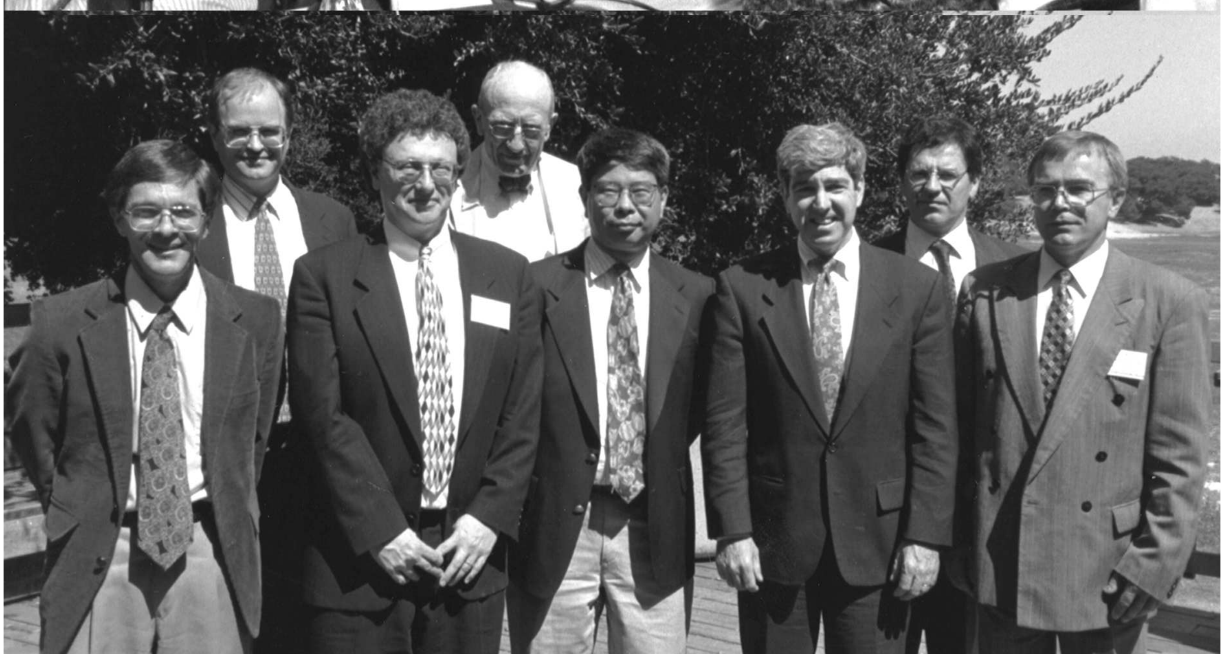


Preface

Events in recent years have caused heightened concern about the security of weapons-usable nuclear material. The possibility of illicit trafficking in, or seizure of, such material, leading to nuclear terrorism, is a worry for all states and their citizens. And given the relatively small quantities required, material obtained in one part of the world could be made into a weapon in another and threaten lives in a third. It is truly a global problem.

Since the beginning of the nuclear era, the physical protection of fissile material has been a responsibility of the individual states possessing the material. These states have different organizational approaches for providing physical protection; and while cognizant of recommended general standards, they tend to follow their own practices, shaped by custom, costs, and threat perception. Moreover, the existence of military as well as civil programs in some states adds another dimension to the physical protection issue.

Because physical protection is a sovereign matter and not part of an international regime (except for transit of civil material across borders), there has been less attention in much of the world community to the issues of physical protection than to the other elements of nuclear safeguards and controls. (An important exception to this situation is the effort being made to assist the states of the former Soviet Union in the disposition of their weapons-usable nuclear materials.) The lack of a general dialog about a problem of growing concern motivated us to hold a three-day workshop at Stanford University to develop a better understanding of some of the important underlying questions and issues, and to undertake a comparative examination of states' approaches to physical protection. We were pleased to have knowledgeable participants from a number of the countries and regions where physical protection of fissile materials is, or will become, a day-to-day matter.

The results of the workshop are reported in these Proceedings. It is our hope that this work will stimulate further analysis and discussion, and lead to greater interest in international standards, cooperation, and supporting programs.

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Acknowledgments

The interest, support, and participation of Stanford University's Center for International Security and Arms Control (CISAC) and in particular that of its Co-Directors, Dr. Michael May and Dr. David Holloway, were instrumental in bringing this workshop to fruition. We also want to recognize and thank those participants from other countries whose perspectives provided very useful insights into the many facets of the problem.

The three sponsoring institutions (CISAC, the Center for Global Security Research, and the Center for Nonproliferation Studies) each contributed to covering the cost of the workshop, the publication of the proceedings, and the travel and lodging for many of the attendees. But the Lawrence Livermore's Center for Global Security Research made by far the most generous contribution, thanks to its director Ronald Lehman.

Two Stanford graduate students, Kevin Harrington and Katya Drozdova, were responsible for going carefully through the tape recordings of the three days of meetings as well as their own notes, and assaying the contents of the contributed papers, to produce a summary of some of the major findings of the workshop.

Matthew Bunn of Harvard's John F. Kennedy School of Government was the designated rapporteur, and in addition he authored an important paper that appears in the first section of the proceedings.

David Elliott, Rosemary Hamerton-Kelly, and Elaine Wai of CISAC, and Jeff Richardson of Livermore, worked diligently to organize and facilitate the conference. The publications office of Livermore's Arms Control and Nonproliferation group put in long hours to edit and publish the Proceedings.

Introductory and Summary Papers

Physical Protection of Fissile Material: The Experience of the Post-Soviet States

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1

Introduction

Space does not permit a review of many of the relevant physical protection issues for the post-Soviet states. Accordingly, this paper provides a concise summary on a different approach to dealing with weapons-grade material in the non-Russian republics and the under appreciated problem of spent fuel, and then moves on to the most important and neglected aspect of physical protection—the adoption of a safeguards and nonproliferation culture.

Special Fissile Material Problems in Non-Russian Republics

Buy Up Non-Russian HEU

The West was slow to recognize the extent to which there were special fissile material problems in six of the non-Russian republics, but has been quick to declare victory in their resolution. Although in most cases, international cooperation with national governments and facility directors to upgrade physical protection at non-Russian sites has been excellent, it will be costly and difficult to sustain meaningful Material Protection, Control, and Accounting (MPC&A) of highly enriched uranium (HEU) at sites in Belarus, Georgia, Kazakhstan, Latvia, Ukraine, and Uzbekistan. A more practical approach to the problem of providing and sustaining meaningful MPC&A at these locations is simply to buy up the small quantity of HEU there—approximately 500 kg.

This represents a low-cost, high-return, nonproliferation strategy. This is especially true for sites such as Kharkiv in Ukraine, which has 75 kg of weapon-usable HEU in bulk form, and Sukhumi, Georgia, where several kilograms of weapons-grade HEU remains unsafeguarded because the site is on Abkhaz territory and not under Georgian control. No International Atomic Energy Agency (IAEA) safeguards are in place at Sukhumi.

Spent Fuel

Until recently, spent fuel received practically no attention from the standpoint of physical protection. It is appropriate that emphasis first be given to enhancing security for fresh HEU and Pu. But it is a mistake to neglect the potential proliferation and terrorist risks posed by the enormous quantities of virtually unsafeguarded spent nuclear fuel in the former Soviet Union (FSU)—especially fuel that was never highly irradiated or has been sitting long enough to see its radiation barrier decline greatly. Spent naval fuel, for example, typically has a large HEU content, while that in fast breeder reactors may contain significant quantities of low-irradiated plutonium. The fast breeder reactor in Aktau, Kazakhstan, on the Caspian Sea poses a special risk because of the very large quantity of low-irradiated plutonium which remains on the plant site. Currently, the United States and Kazakhstan are cooperating to address this issue.

Adoption of a Safeguards Culture

Much more needs to be done to upgrade MPC&A at all major civilian sites in the FSU that handle weapons-usable material. Not all safeguards problems, however, are amenable to "technical fixes." Probably most difficult to correct, but also significant for the long-term security of the ex-USSR's nuclear assets, is what may be thought of as an underdeveloped safeguards culture among the staff and custodians of the post-Soviet nuclear industry.

One of the problems on the nonproliferation safeguards culture front is that the term itself is somewhat amorphous, intangible, and difficult to quantify or measure.[1] As a consequence, there is a strong bureaucratic disinclination to focus on the issue. Given every government agency's need to demonstrate that its expenditures and efforts are producing tangible results, those which favor investment in promoting a safeguards culture face a hard sell, but the case is not hopeless.

A working definition of safeguards culture proposed by Steve Mladineo and Jim Doyle: "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."[2] The indicators or "performance metrics" proposed by Mladineo and Doyle also are quite useful in developing criteria by which to measure the growth of a safeguards culture in the FSU. Among the indicators are: leadership awareness, emergence of indigenous MPC&A advocates, investment in MPC&A, development of independent nuclear regulatory bodies, and training and development of a cadre of MPC&A specialists.

Utilizing these indicators, as well as additional anecdotal evidence that is more difficult to pigeon-hole, I am persuaded that a situation now exists where there are greater differences with respect to both safeguards equipment and safeguards culture *within* the Russian nuclear complex than there are *between* certain Russian and U.S. facilities.

Progress Made

Areas in which progress has been made in the growth of a safeguards culture include:

1. A rise in awareness of the importance of MPC&A activities among the leadership at selected nuclear facilities in Russia and the other post-Soviet states. Indeed, one of the most positive indications of the impact of the U.S. assistance effort is the extent to which safeguards values appear to have been internalized among a fairly broad segment of the senior staff at a number of nuclear research institutes. Most impressive is the manner in which staff at these facilities increasingly recognize their individual and institutional responsibilities for tackling safeguards problems, with or without U.S. assistance. Although places such as the Kurchatov Institute, Obninsk, and Electrostal are most often mentioned in this context, I also recently was very impressed by the safeguards *esprit de corps*—from the plant director on down—at the Nuclear Research Institute in Tashkent, Uzbekistan.
2. Another positive sign is the growth of indigenous advocates of effective MPC&A activities in a number of the post-Soviet states in both the non-governmental organizations (NGO) and governmental sectors, as well as the emergence of a private sector indus-

try in the field of safeguards technologies. Also particularly encouraging is the appearance of new Russian-language publications that focus on nonproliferation and safeguards issues.

3. In addition, one can point to growth in the number of post-Soviet states with nuclear industries that have relatively independent, if underfunded and understaffed, nuclear regulatory bodies. There also has been a very slow but positive trend in these states toward adoption of legislation to provide the legal basis for independent regulatory action. Unfortunately, there has been an even slower enactment of enforcement measures for MPC&A violations.
4. Perhaps most encouraging with respect to the outlook for the maturation of a safeguards culture in the FSU are the emergence of indigenous safeguards training programs. These include the MPC&A training center at Obninsk and the safeguards curriculum to be introduced this fall at the Moscow Physical Engineering Institute (MEPhI), supported by the Center for Nonproliferation Studies at the Monterey Institute of International Studies, the Department of Energy (DOE), and the Center for Policy Studies in Russia (PIR) in Moscow.

Sources of Concern

Having identified a number of positive developments from the standpoint of the growth of a safeguards culture, one must also note areas in which progress has been less visible.

Level of Political Support

Notwithstanding the growing awareness of MPC&A by some facility directors and senior government officials, there is little evidence of high-level political support in most NIS states today for treating nonproliferation in general, or safeguards in particular, as priority national security issues. (Parenthetically, if one looks at resources committed rather than declaratory policy, one also might make a similar case with respect to the U.S. Congress.) This assessment is based not only on the very scant resources devoted to MPC&A activities by the post-Soviet states, but also by the lack of candor on the part of most of the relevant organizational actors regarding the extent of the problem.

Last year while visiting one nuclear facility where a large stock of HEU is kept in Russia, I was struck by the proximity of the main storage site to a busy city street and the absence of perimeter defense, vehicle barriers, metal detectors, surveillance cameras, guards, etc. When I asked the assistant director of the facility about the steps being taken to guard against terrorist threats, he characterized the risk as minimal since “Chechens look different than us” and would be recognized before they could get close to the site. Even if they were recognized, it is difficult to see how much force could be marshaled quickly at the scene. Indeed, heavy firepower is more visible at most banks, nightclubs, fur stores, and governmental dachas in the FSU than at many nuclear facilities.

One of my staff just returned from a visit to a nuclear site in one of the non-Russian republics where she had occasion to observe another disturbing example of the lack of resources devoted to the safeguards problem. While escorting her through the facility, the director explained that she shouldn’t judge the physical protection of the facility based on her visit because it was on the weekend when few guards were present. In other words, a safety culture was only active from 8 to 5 p.m., Monday through Friday.

At another facility in Central Asia visited by my staff last year, due to funding shortages, the work force was present only four days a week and had not been paid in months. After state regulations required the institute to contract for protection with the Ministry of Internal Affairs (MVD) from its own budget, this particular facility, which used to be protected by MVD troops, eventually let them go because of lack of funds.

Indigenous MPC&A Advocates

The "good news" is the emergence of individual and institutional advocates for strengthened MPC&A activities. The less welcome news is the relatively small number of these individual advocates—many of whom are former IAEA inspectors. Indeed, with the exception of those individuals with an IAEA background, most of the MPC&A work force has at best a very vague understanding of why safeguards (or nonproliferation) are important. What one finds, therefore, is an emerging MPC&A work force that has excellent technical skills, but a far less well developed appreciation of the broader political dimension of nonproliferation.

This concern has been reinforced by intensive interactions by my staff in Monterey with nonproliferation trainees from the post-Soviet states who have moved from their prior careers as nuclear scientists to work for inchoate nuclear regulatory bodies. As one brilliant nuclear physicist from Uzbekistan told us, only after his study in Monterey did he understand why he was performing the regulatory tasks he had been assigned.

Deference to Authority

There is another dimension of the safeguards culture which appears to be particularly difficult to counter in the FSU: the tendency of most Russians to be extraordinarily deferential to authority. During the Soviet period, this trait was reinforced by a political and economic system that penalized individual initiative and encouraged the avoidance of personal responsibility. These habits persist today and find expression in behavior that undermines nonproliferation safeguards.

Time and time again senior officials at FSU nuclear facilities circumvent physical protection measures installed with U.S. assistance, sometimes to show off to visitors the latest improvements in MPC&A. Unlike the inconvenient but thorough process which precedes anyone's entry to the plutonium storage vault at Los Alamos, senior plant officials at every site I have visited in the FSU can readily escort their guests past the guards, portal detectors, two-person access controls, personnel identification equipment, and motion-detection alarms. Until everybody—from plant director to visiting American professor—is subject to the same set of access rules and regulations, one cannot really speak of the presence of a well-developed safeguards culture.

Limits on Public Information

In the post-Soviet states, those NGOs and the press who wish to perform a role as nonproliferation watchdogs or whistle-blowers are in a precarious position. As one Russian observer recently put it, more progress appears to have been made in controlling information about nuclear smuggling and nuclear security than in controlling the material itself.[3] This constriction of public information on nuclear security issues coincided with the arrest of the Russian environmentalist Alexander Nikitin, and continues to impede the ability of the Russian press and independent researchers to perform a public information and watchdog function. As a consequence, it is impossible to ascertain from open sources the extent to which penalties for safeguards violations (including material diversion) are being enforced. My sense from discussions with officials from the U.S. government and various international organizations with nonproliferation responsibilities is that Russian authorities have been no more forthcoming in government-to-government channels. The failure to make progress, despite the formal pledge to share such information at the April 1996 Nuclear Safety and Security Summit, raises further doubts about the internalization of safeguards values among the Russian political leadership.

Next Steps

There is no shortage of good recommendations about the urgent MPC&A problems in the former Soviet Union. Steps to accelerate the growth of a safeguards culture, however, have received scant attention.[4] Let me suggest some general and more specific measures that need to be undertaken.

Education

An influx of money alone will not solve the safeguards culture problem. A sustained educational effort is required to change attitudes and to instill a new nonproliferation and safeguards philosophy or culture. Because of the time required to effect this change, governments will find it difficult to sustain the effort. Therefore, a much greater partnership is needed between the U.S. government and NGOs, as well as between FSU government agencies and NGOs in the provision of such educational assistance.

To be sure, the establishment of a MPC&A training facility at Obninsk and the new safeguards curriculum at the MEPhI in Moscow are steps in the right direction. They are, however, drops in the bucket compared with the magnitude of the proliferation problem, which is aggravated by complacency and ignorance among parliamentarians and the public at large.

If one takes seriously statements made by Secretary of Defense Cohen, Senator Lugar, former Senator Nunn, among others, that the danger of weapons of mass destruction proliferation is the paramount national security threat to the United States, we can not sit back and simply hope that a safeguards culture takes root in the FSU by the time U.S. funding for MPC&A runs out. One very useful step that could be taken in the United States would be the passage of legislation to create a National Nonproliferation Education Act, which would, among other things, provide fellowships to U.S., Russian, and other graduate students for advanced training in the sphere of nonproliferation.

In short, education is an important but underutilized nonproliferation strategy in both the United States and the FSU. It is an approach that needs to be embraced more fully by national governments and the NGO community if we are to succeed in fostering the development of nonproliferation and safeguards cultures, norms, and political constituencies.

Indigenize MPC&A Activities

A key to the long term viability of a safeguards culture in the FSU is the effort to indigenize MPC&A capabilities. The 1997 report of the National Research Council of the National Academy of Sciences, in which I was involved, identifies the following recommendations:

- Continue to emphasize the importance of MPC&A as a nonproliferation imperative at the highest political levels in the FSU.[5]
- Prior to initiating MPC&A projects at specific facilities, obtain assurances at both the ministry and the institute levels that the upgrade programs will be sustained after improvements have been made.[6]
- Involve institute personnel to the fullest extent possible in determining how to use available funds for upgrades.[7]
- Give greater emphasis to near-term training of local specialists.[8]
- Reward those institutes that are making good progress in upgrading MPC&A systems by giving them preference for participation in other U.S.-financed cooperative programs.[9]
- Encourage the establishment of new income streams that can provide adequate financial support for MPC&A programs in the long term (e.g., earmarking for MPC&A activities a portion of the revenue from Russian sales of HEU).[10]
- Rely increasingly on domestically produced and locally available equipment for MPC&A.[11]

- Encourage a system of incentives, possibly including monetary rewards, that will stimulate participants in MPC&A programs to report promptly to the central authorities any irregularities in the implementation of MPC&A systems.[12]
- Create a MPC&A work environment that stresses individual responsibility and places a high value on full implementation of rules and regulations.[13]
- Continue to stress the nontechnical aspects of MPC&A and the relationship of MPC&A to broader nonproliferation objectives.[14]
- Promote greater communication and cooperation among ministries and facilities in MPC&A in each of the countries where United States and international assistance programs are being implemented.[15] The DOE-sponsored MPC&A Conference held in Obninsk in early 1997 is an excellent example of what needs to be done with greater regularity.

Conclusion

It is naive to assume that it will be easy to overcome the economic, political, and cultural barriers in the FSU to a deeply rooted and widely shared belief in the proliferation significance of effective MPC&A. However, it is also naive and counterproductive to assume that we can effect the long-term solution to the problems of MPC&A in the post-Soviet states without creating meaningful safeguards cultures there.

Many of the deficiencies that have been highlighted in the development of a safeguards culture in Russia and the other post-Soviet states are not limited to those countries. Indeed, were the nuclear facilities of many countries—East and West, North and South—subjected to the same scrutiny as those in the former Soviet Union, we might well conclude that the problem of an underdeveloped safeguards culture is much more global in scope. That is one of the principal research questions I hope we will be able to answer at this conference.

References

1. The term “safeguards,” as well as “safeguards culture,” is subject to different interpretations and has been used to describe a wide range of national and international nonproliferation measures. International safeguards usually connote the system of measures applied by the IAEA to detect and deter national governments’ diversion of nuclear material from peaceful uses to military purposes. National safeguards, in contrast, refer to measures undertaken by national governments to detect, deter, prevent, or respond to the unauthorized possession of nuclear materials through diversion and sabotage of nuclear facilities. They tend to emphasize the provision of physical security and are directed at nonstate actors. My use of the term emphasizes the physical protection, national safeguards perspective.
2. Steve Mladineo and Jim Doyle, “Assessing the Development of a Modern Safeguards Culture in Russia, the NIS and the Baltic States.” Presentation at the Center for Nonproliferation Studies, Monterey Institute of International Studies (June 19, 1997).
3. Vladimir Orlov, Comments at the Carnegie Endowment Conference on “Nuclear Non-Proliferation: Enhancing the Tools of the Trade,” Washington, DC (June 9–10, 1997). See also Orlov cited by Jessica Stern, “Preventive Defense,” Washington Post (June 23, 1997), p. 19.
4. I am aware of only two publications in which recommendations are proposed to address the problem of an underdeveloped safeguards culture. See John Shields and William Potter, eds., *Dismantling the Cold War: U.S. and NIS Perspectives on the Nunn-Lugar Cooperative Threat Reduction Program* and National Research Council, *Proliferation Concerns: Assessing U.S. Efforts to Help Contain Nuclear and Other Dangerous Materials and Technologies in the Former Soviet Union* (Washington, DC Press, National Academy Press, 1997), pp. 74–76, and 79–81. A number of important suggestions are implicit in the ongoing study by Mladineo and Doyle.
5. NRC, p. 75.
6. *Ibid*.
7. *Ibid*.
8. *Ibid*.
9. *Ibid*., p. 76.
10. *Ibid*.
11. *Ibid*., pp. 76–77.
12. *Ibid*., p. 80.
13. *Ibid*., pp. 80–81.
14. *Ibid*., p. 81.
15. *Ibid*., p. 82.

Protection of Fissile Materials: Policy Context and Issues for Consideration

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2

The Policy Context

Two major developments dominate the policy context of fissile material protection—and I am using that term very broadly. The first is the unprecedented draw-down in nuclear weapons, including nuclear warheads, by the United States and the Russian Federation. The second is the evidence that a new form of terrorism is emerging, one that is more willing to use weapons of mass destruction than terrorist groups we have known in the past. A third development, the growth of the global economy, may also have a substantial impact on fissile material protection because of the accompanying demand for electricity. I will expand briefly on each of these points.

Reductions in Nuclear Weapons

Russia and the United States probably are dismantling somewhere between 500-2,000 warheads each per annum as they become excess to national defense needs. Although there have been discussions between the two governments regarding greater transparency in the process of moving fissile materials out of the military arsenal, little has been accomplished aside from arrangements in connection with the sale to the United States of highly enriched uranium (HEU) derived from Russian warheads. Nor has much been done to ensure the irreversibility of that process. Nonetheless, it is reasonably certain that the ultimate transfer of hundreds of tons of fissile material from military to potential nonmilitary uses is underway in Russia and the United States.

In the case of HEU from Russian warheads, a commercial transaction underway between Russia and the United States will convert this material into low enriched uranium (LEU) fuel elements for civilian reactors. Plutonium from warheads may also be used in civilian reactors, particularly if the current activities sponsored by the Summit of Eight work out. Agreements reached at Helsinki in March 1997 between Presidents Clinton and Yeltsin concerning nuclear warhead dismantlement and deeper reductions in deployed warheads should result in still more fissile material being declared excess to national defense needs.

These developments in nuclear arms reductions are probably not the last. Still deeper reductions are advocated by many non-government specialists and organizations, including ceilings on the total numbers of warheads, not just deployed warheads. Of course, at some point in the reductions process, other nuclear weapons and threshold nuclear weapons states should join Russia and the United States in limiting and reducing their nuclear arsenals.

These events will have an impact on the protection of fissile material for at least two reasons: first, as nuclear weapons are reduced, the difficulty of protecting material released from military control will increase; second, as these reductions proceed, and with increasing emphasis on tracking non-deployed warheads, a greater premium will be placed on keeping tight control over fissile material in the civilian sector to avoid unpleasant surprises.

Terrorist Use of Weapons of Mass Destruction

The second major development affecting fissile material protection is even more apparent than the first: it is the fear of terrorists armed with weapons of mass destruction. The bombing of the World Trade Center in New York and the use of sarin nerve gas in a Tokyo subway line were alike in the sense that the perpetrators were willing to risk worldwide public opprobrium by potentially inflicting death or serious injury on tens of thousands of innocent people. That so few actually were hurt or killed was not the result of compassion but of bungling. Terrorists in our previous experience have had rather limited objectives and have used force in limited ways.

Now we see a terrorism that has almost boundless ambitions, few scruples, and access to chemical and biological agents and possibly, in the future, to fissile materials. In the past, the issue of nuclear proliferation referred to acquisition of nuclear weapons by states. Now it refers to sub-state entities as well. I think of this as "the new medievalism," a situation in which the central role of states may be weakened or at least contested. This fact already has had or should have had an impact on the way we think about protecting fissile materials.

Growth of Global Economy

The growth of the global economy and the accompanying increase in demand for electricity will affect the nuclear power industry. Hans Blix is probably right when he says that the choice of energy resources for the future will not be between nuclear power and renewable resources but between nuclear power and fossil fuels. The less nuclear energy is used, the more fossil fuels will be used. The implications for global warming deserve attention. It is too early to predict how those choices will be made but the public concern in most of our countries over the safety and the security of fissile materials is very clear. Assurances are required that fissile materials are receiving protection—not just adequate protection but protection against worst-case scenarios if growing power needs are to be met in part by the nuclear power industry.

And so these three developments—dismantling thousands of nuclear warheads, the threat of nuclear terrorism, and the potential demand for nuclear power—constitute the policy context. The first two are new and have still not been totally assessed or absorbed but they will increasingly influence our thinking about the protection of fissile material. The third, the potential demand for nuclear power, was advertised so often in the past without making an appearance that the very notion has become discredited. But we are learning that nuclear power is not the only Faustian bargain with which humans are confronted. The large-scale use of fossil fuels is also such a bargain.

Issues for Consideration

Presentations and papers made available to us have explicitly or implicitly identified the issues to keep in mind as we consider the similarities and differences in our national approaches to physical protection and to material control and accountability. To those whose ideas I may be borrowing without specific acknowledgment, be assured that your contribution is recognized and much appreciated. Three fundamental issues, it seems to me, permeate the whole subject of fissile material protection: risk management, response to change, and responsibilities.

The Problem of Managing Risks

The consequences of an illicit diversion of fissile material are potentially catastrophic. Even the suspicion of diversion raises questions and promotes doubts that undermine confidence in the nuclear industry and create tensions in international relations. But resources to devote to improving protection are finite. Appeals in my country for the expenditure of additional tens of billions of dollars for this purpose have been heard by our legislators and the response has been generous—but hardly on the scale some experts think necessary. Furthermore, in all countries commercial competitiveness comes into play as well as competition for a share of the government budget. Requests for more and better physical protection or accountability systems encounter concerns about the economic viability of the nuclear industry. Obviously, the disparities in wealth among nations also causes differing assessments about how much can be allocated to protecting fissile materials.

All of these considerations underlie discussions about standards and support the need for an international regime to help level the playing field at a point above the minimally acceptable. But, still, I think we need to share our thinking about assessing and measuring risks, about making our responses to risks cost effective, and about cooperation in the interest of strengthening the weakest links in the chain of protection. I hope our workshop can shed some light on these matters.

Adapting to Change

A second very broad question that should also be discussed in the workshop, in my opinion, is the question of adapting to change. The world has been changing very rapidly, probably on an almost unprecedented scale. Nuclear arms reductions and the widening scope of terrorism are only two examples. The spread of technology, the information explosion, the communication revolution—each is transforming our societies. Cultural changes, many of them grist for political mills, are taking place in most of our countries under the twin pressures of globalization and technological change. So we need to think about whether protection methods suitable for the relatively quiet past are relevant for the stormy present. Protection of fissile material obviously must take account of societal change. We cannot simply assume that the level and type of the threat to the security of fissile material will remain constant in a time of rapid change.

The Balance Between National and International Responsibilities

A third major question is the balance between national and international responsibility for protection of fissile materials. In my country, the International Atomic Energy Agency (IAEA) was criticized—unfairly, in my opinion—for failing to detect the Iraqi nuclear weapons program. Clearly the IAEA had not been encouraged to find undeclared facilities, the result of instructions given to it by national governments. And even with a new mandate that gives the IAEA greater scope in its safeguards efforts there will be limits on how much it can do. Financial limitations impose other restrictions on the IAEA. The differences in the safeguards responsibilities of the IAEA with respect to the nuclear weapons states in contrast to the non-nuclear weapons states is rooted in a certain reality. But if the IAEA is asked to help ensure the irreversibility of the process of converting nuclear warheads to civilian purposes, the nuclear/non-nuclear distinction will be eroded at least a little bit.

So I think we should ask ourselves whether we have pushed the envelope of international cooperation as far as it can be extended. Have we overlooked possibilities for strengthening national fissile material protection systems through more effective international cooperation, whether through the IAEA or any other mechanism? Are we doing enough, for example, to use external audits to check the effectiveness of systems of physical protection and material accountability? Obviously, as we consider questions like these, we also have to consider how to avoid the potential downside of international cooperation: that greater transparency would reveal vulnerabilities in systems that someone could exploit. An unintended consequence could be the spread of technology necessary to the manufacture of nuclear weapons.

The Specific Questions

In addition to these three fundamental issues, there are more specific, less abstract questions likely to surface during our workshop. The first relates to best methods of dealing with the insider threat. Obviously, physical methods of preventing illicit diversions will help. Personnel security should also play a part. What are the most cost-effective techniques? Which are most essential to have in place to deal with that threat? Are there methods we can learn from each other about these techniques ?

Another question is the mix of physical security and material accountability systems that we each apply in our different circumstances. It seems that different nations believe in different approaches, perhaps more because of cultural attitudes and societal factors than because of a systematic, completely objective analysis of the threat. We probably could benefit from a discussion of the cultural assumptions that underlie the approaches we have adopted. But in any case, we can ask ourselves whether the philosophies of protecting fissile material that we have individually adopted stand up to critical scrutiny.

Have we effectively integrated each of the responsible government agencies with each other and with the nuclear industry? It is no secret that turf battles are a way of life in many, perhaps all, bureaucracies and that a "them" versus "us" attitude is endemic in most assemblages of organizations. President Clinton used a phrase in a speech last fall that I thought was quite apt. He spoke of breaking down "the walls in our minds," referring to the roles we have assigned in our thinking to domestic agencies and policies and those we have assigned to international operations. Counterterrorism efforts, to be effective, must break through those "walls in our minds" because diplomacy, intelligence, law enforcement, and industrial management each is a necessary part of the struggle to defeat nuclear terrorism.

Related to the counter-terrorism question is whether emergency plans exist to deal with attacks or attempted thefts. Facilities and transport equally could be targets of individuals or gangs intent on acquiring fissile materials. Contingency planning can show what might be done to thwart such attempts and will reveal the need for any special communications or other equipment.

Finally, the question of research and development to improve physical protection and material accountability techniques is one that I hope we will discuss during the next two days. Here is an area where sharing ideas should be extremely useful in generating plans for research into better ways of achieving our common goals.

In sum, the protection of fissile materials is a matter of global concern. A new brand of terrorism has appeared, more apocalyptic in philosophy, less constrained by public opinion, less interested in achieving any specific goal—a terrorism that understands weapons of mass destruction and may not shrink from using them. The prospects for the nuclear power industry depend on the confidence people everywhere have in the safety and security of fissile materials. Reports of nuclear smuggling and attempts by cults to acquire weapons of mass destruction obviously create the impression that nuclear power is a risky business. The risk actually may be very low but the effects of even one successful terrorist attack using fissile materials could be catastrophic.

Clandestine diversion of fissile material by governments still may be a problem. In the cases of Iraq and North Korea membership in the Nonproliferation Treaty was a cover for secret attempts to build nuclear bombs. I hope the International Atomic Energy Agency will be able to use effectively new authority to give early warning of non-declared facilities. The IAEA deserves the support of all of us, and with financial resources, not just moral support. I think that the outgoing Director General, Hans Blix, has done a very fine job. His successor, Mohammed El Baradej, of Egypt, is an extremely good choice to be the next Director General. I'm sure, with the help of Bruno Pellaud, he will continue to strengthen the Agency.

The issues and problems that we will discuss here affect every country in the world. You are here not just because of your interest in protecting fissile material but because each of you has accomplished a great deal in your own country to make all of us safer. I want to thank you for that and thank you for coming here to share your experiences with us.

Security for Weapons-Usable Nuclear Materials: Expanding International Cooperation, Strengthening International Standards

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Limited access to fissile materials—the essential ingredients of nuclear weapons—is the principal technical barrier to nuclear proliferation in the world today. With access to a sufficient quantity of separated plutonium or highly enriched uranium (HEU), many nations and even some terrorist groups would be capable of building a nuclear bomb.[1] The amounts required are small: the U.S. Department of Energy (DOE) has officially declassified the fact that four kilograms of plutonium is potentially enough for a nuclear weapon; the amount of weapon-grade HEU required is roughly three times as large. Were such material to fall into the wrong hands, a proliferator's bomb program could potentially be shortened from a decade to months or weeks. The international community could be faced with a terrifying new threat with virtually no warning—and virtually no time to dissuade the proliferator from building a bomb.

Hence, ensuring that all weapons-usable materials are secure and accounted for is an absolutely fundamental nonproliferation responsibility of all states handling such materials.[2] Given that proliferating states have been willing to spend billions of dollars on their efforts to produce fissile material—and given that a single bomb could threaten tens of thousands of lives—the level of effort devoted to securing and accounting for stocks of even a few kilograms of fissile material should be even higher than that devoted to protecting stores of millions of dollars worth of cash, gold, or diamonds. Indeed, as argued later, a strong case can be made that the essential ingredients of nuclear weapons should be protected roughly as rigorously as nuclear weapons themselves are. As the DOE regulations on physical protection put it, "use of weapons of mass destruction by a terrorist(s) could have consequences so grave as to demand the highest reasonably attainable standard of security."[3]

While security for nuclear materials has traditionally been seen as solely a national responsibility, the potential effects of a theft of plutonium or HEU would threaten the entire international community, not just the state where the theft occurred—even more than in the case of a nuclear accident. Thus, the international community has an overwhelming interest in seeing that all such material is secure and accounted for. Ensuring that nations have effective security and accounting programs for such materials should occupy as central a place on the international agenda as ensuring that they have effective export control systems and that non-nuclear-weapon states open their nuclear facilities to full-scope safeguards.[4]

Today, a broad range of factors, from documented seizures of kilogram quantities of weapons-usable fissile material to the newly demonstrated capability and will of terrorists to use weapons of mass destruction, suggest that there is an unprecedented urgency to ensuring effective security for all weapons-usable material worldwide. The threat of nuclear theft appears to be higher than ever before, and the systems designed to meet that threat are under unprecedented stress. The need for increased international cooperation and strengthened international standards for security and accounting for these dangerous stockpiles has never been greater. Fortunately, the opportunities for such expanded cooperation and revised standards have probably also never been greater. The remainder of this article will be devoted to describing these needs and opportunities, making the case for a substantial expansion of international cooperation in physical protection, and for new efforts to put in place more stringent international standards and to increase the role of the international community in ensuring they are met.

New Threats, New Stresses on the System: The Need for Improved Security and Accounting for Nuclear Material

Inevitably, approaches to security and accounting for nuclear materials must adapt to changing conditions. Today, the threat of nuclear theft appears greater than ever before. There is far stronger evidence than ever before that there are actors on the international scene who would be extremely interested in acquiring stolen stocks of fissile material:

- The Aum Shinrikyo incident in Japan graphically demonstrated that terrorists with both the capability and the will to use weapons of mass destruction—and which governments fail to deal with until after they have struck—are not merely the stuff of nightmares[5];
- The Oklahoma City and World Trade Center incidents in the United States, among others, demonstrated that Aum Shinrikyo was not alone in seeking to cause mass destruction, rather than simply to gain attention through terror, as was typically the case with terrorists in the past;
- Iraq, Iran, and North Korea have all been reported by U.S. and European intelligence services to be seeking illegally acquired fissile material from abroad—and Iraq's willingness to spend billions of dollars on its fissile material production program demonstrated just how much some states are willing to pay for the wherewithal to produce a nuclear arsenal;
- While past proliferant nuclear weapons programs have been based on building an indigenous fissile material production capability, Iraq's "crash" program to build a nuclear bomb after the invasion of Kuwait, based on the safeguarded HEU research reactor fuel in its possession at the time, provides a clear demonstration of a state's willingness to base its weapons effort on a small amount of diverted or stolen material, in order to acquire one or two bombs while a larger production capability is being built—and the U.N. Special Commission has repeatedly expressed concern that even its extremely intrusive ongoing monitoring system might not be enough to detect a bomb program based on stolen fissile material.

At the same time that the threat appears to have increased, the systems to manage nuclear material have been placed under unprecedented stress:

- The collapse of the Soviet Union, and the subsequent political, social, and economic transformations in the post-

Soviet states, have created enormous stresses, with inadequate funding to maintain security systems or even pay nuclear custodians, fundamental changes in management and oversight of nuclear activities, and weapons-usable material left in states that have never before required a national system for dealing with it—even in areas with active armed conflict (such as the facility at Sukhumi).

- The post-Cold War dismantlement of tens of thousands of nuclear weapons in the United States and Russia is freeing hundreds of tons of excess fissile material, which must be secured, accounted for, opened to monitoring, and ultimately used or disposed of;
- The opening of the first modern, large-scale reprocessing plants in France and Britain, combined with the continued operation of smaller facilities, has led to a drastic expansion in processing, storage, transport, and use of separated weapons-usable plutonium in the civilian cycle. There are now more than 160 metric tons of civilian separated plutonium in storage around the world, and since reprocessing continues to outpace fabrication of this material into uranium-plutonium mixed oxide (MOX) fuel, this figure is expected to continue to increase. Tens of tons of this material are processed each year, and tons of it are shipped across international borders.

Most of the physical protection systems in place today were designed before these new threats and stresses arose. It is perhaps not surprising, therefore, that a variety of reports, analyses, and accounts of visits to facilities suggest that physical protection in many countries may not be sufficient to deal effectively with these new conditions. There are many facilities in the world today where the chance that a determined attack by a small but well-armed and well-trained terrorist group would succeed in stealing weapons-usable material remains unacceptably high. The possibility of conspiracies of knowledgeable insiders working together to covertly steal material is even more difficult to address. Judging the vulnerability of individual facilities to such threats is quite difficult; U.S. experience has repeatedly shown that systems that are excellent on paper can sometimes perform poorly in realistic tests, particularly when the "adversary" in the test has detailed knowledge of the strengths and weaknesses of the system.

Different countries have very different physical protection and safeguards cultures, and these affect both how physical protection is implemented and the effectiveness of the resulting systems. In Russia, for example, there remains a heavy emphasis on armed force, though a new emphasis on modern technology is slowly taking root. The U.S. approach places heavy emphasis on both well-armed protection forces and modern technology. In Japan, by contrast, where possession of firearms by private citizens has been forbidden for centuries, nuclear facilities do not have armed guards—even if hundreds of kilograms of weapons-usable separated plutonium are present. Instead, reliance is placed on detection and barrier technologies to provide warning and then delay any attempted theft until nearby police forces could arrive. A variety of other countries, such as Canada, also have no armed guards at their nuclear facilities. Experts from some countries argue that they require less stringent protection measures than other countries do because they face a smaller terrorist threat. Approaches to ensuring that the personnel assigned to manage and guard nuclear material are reliable—a critical element of effective physical protection—vary widely from one country to the next.

In recent years, however, terrorist and criminal threats have become increasingly global. Aum Shinrikyo, for example, operated on at least four continents. Terrorists have been arrested in New York who were planning terrorist acts on the other side of the world. Organized crime connections span continents and cross oceans. Thus, it is essential to ensure that variations in safeguards cultures do not result in some physical protection systems being substantially easier to overcome than others; the threat is composed of intelligent and mobile adversaries who may well be able to identify and strike the weakest link. This again highlights the need for stringent international standards of physical protection.

Today, the risk of theft of weapons-usable nuclear material is particularly acute in the former Soviet Union. As of 1994 (when current cooperative programs to address these issues first got underway on a substantial scale), essentially no former Soviet nuclear facilities had effective detection equipment (known as "portal monitors") at the gates to sound an alarm if a worker were carrying out plutonium or HEU. Fences at many facilities had holes or were overgrown with vegetation. The principal devices in use to indicate whether materials had been tampered with were easily-faked wax seals (and most workers with access to the material had the appropriate stamp needed to create a new seal). No accurate, measured inventories of the material on hand at most sites existed. And no accurate national accounting systems or effective regulatory frameworks were in place. While work is underway to correct these deficiencies, it will take years to complete. For these reasons, the U.S. Director of Central Intelligence has testified that weapons-usable nuclear materials "are more accessible now than at any other time in history—due primarily to the dissolution of the former Soviet Union and the region's worsening economic conditions," and that none of the facilities handling plutonium or HEU in the former Soviet states has "adequate safeguards or security measures" in place.[6]

Vulnerabilities are not limited to the former Soviet Union, however. A few examples from the 1990s suggest the difficulties that may exist elsewhere[7]:

- One U.S. team visiting a non-Soviet facility handling several hundred kilograms of separated plutonium was greeted by a single armed guard; when they left, after visiting the plutonium-handling areas, the guard was on break, and nowhere to be seen.
- At another non-Soviet facility with several kilograms of fresh HEU, security was sufficiently poor that the facility's managers themselves urgently asked for international help, possibly including removing the material for safekeeping.
- At yet another non-Soviet facility, lightly irradiated HEU research reactor fuel, which had been cooling long enough that it was no longer self-protecting, was in a storage pond secured only with an ancient chain-link fence and a single watchman.

These accounts are all anecdotal; in none of these incidents was a full vulnerability analysis done to confirm or deny the apparent vulnerability. But at a minimum, these incidents and countless others like them suggest that there needs to be a better way for the international community to know whether problems really do exist, and where additional resources for physical protection might best be focused.

This description of the problem should not be interpreted as an American complaint about the rest of the world; the fact is that U.S. physical protection systems have had serious weaknesses over the years as well. Early on, little account was taken of the risk of subnational theft, and it was perfectly legal, for example, to ship kilogram quantities of plutonium by commercial freight, or to store separated plutonium in facilities without 24-hour guard forces.[8] As recently as 1986, inspections revealed that there were no portal monitors to prevent nuclear material from being carried out at some of the exits to Pantex, the U.S. nuclear weapons assembly and disassembly facility, perhaps the most sensitive facility in the entire U.S. complex. (Monitors were installed within days of the inspection, along with other new measures.) In that time period, in a test at the Savannah River Site, the guard force failed to prevent a mock terrorist force from gaining access to the facility and making off with mock plutonium—even though the guard force had received unauthorized warning as to exactly when and where the terrorists would attack—and the guards were still shooting at each other 45 minutes after the terrorists had left.[9] Incidents such as these, combined with withering Congressional investigations, and the successful attack on the U.S. Marine barracks in Lebanon, provoked a large-scale effort to improve security (and later, material control and accounting) throughout the U.S. complex. (An early and fast-paced part of this effort was dubbed "Operation Cerberus," after the mythical guardian of the gates of hell.) Total spending on safeguards and security within DOE doubled.

Today, U.S. MPC&A programs are probably among the most stringent and effective in the world. Nevertheless, improvement is a never-ending process, and important issues continue to arise that require correction.

To take a just few essentially random examples reported in recent years:

- A 1995 inspection at Pantex found that security problems identified there in 1988—shortly after the period when it had not even had portal monitors—had still not been fixed;[10]
- In early 1997, the security chief at Rocky Flats quit "in disgust," complaining that he could not guarantee security at the site, and the Secretary of Energy acknowledged that "significant" security problems existed at the site (most of which DOE officials believe have since been addressed);[11]
- In 1995, DOE's Office of Security Evaluations issued a report on accounting for nuclear material which found that no accurate inventories exist for thousands of kilograms of scrap plutonium and HEU in the U.S. complex, and that even though physical protection was expected to be reliable, "an accurate inventory is necessary for continued assurance against theft or diversion." (Here, too, a major effort is underway to address the issues identified.)[12] In short, the need to increase physical protection for nuclear material in the face of the new threats and new stresses is a global problem, not limited to any one country or region;
- In late 1997, a series of internal government reviews and harsh press reports pointed to serious weaknesses in DOE physical protection programs, including excessive reductions in the size of armed guard forces, aging alarm systems that no longer functioned properly, and the like. As a result, Congress mandated the creation of a new "Department of Energy Security Management Board," including senior officials of the Energy and Defense Departments, the CIA, and the FBI.[13]

As a result of the inadequacy of some physical protection systems—particularly some of those in the former Soviet Union—the 1990s have seen a disturbing level of genuine incidents of theft and smuggling of weapons-usable nuclear material. While the vast majority of such reports are scams, or involve material with no relevance to nuclear weapons, this should not obscure the importance and urgency of the documented seizures of stolen weapons-usable material that have occurred. The following represent the confirmed cases involving hundreds of grams or kilograms of weapons-usable material:

- 1.5 kilograms of weapon-grade HEU from the "Luch" production association in Podolsk, Russia, in 1992;
- 1.8 kilograms of 36% enriched HEU from the Andreeva Guba naval base near Russia's Norwegian border in July 1993;

- 4.5 kilograms of material enriched to over 19% U-235 from the Sevmorput naval shipyard near Murmansk in November 1993;
- Over 360 grams of plutonium seized in Munich on a plane from Moscow as a result of a German "sting" operation in August 1994; and
- 2.73 kilograms of essentially weapon-grade (87.7% U-235) HEU seized in Prague in December 1994.[14]

In short, theft of kilogram quantities of directly weapons-usable nuclear material is an ongoing reality in the 1990s. While there is no evidence that enough material for a bomb has yet fallen into the hands of states such as Iran, Iraq, Libya, or North Korea, it is impossible to know what has not been detected. It is essential to ensure, as quickly as practicable, that all weapons-usable nuclear material worldwide is secure and accounted for—to prevent such a catastrophe from occurring—through expanded international cooperation and strengthened international standards.

Opportunities I: Expanding International Cooperation

The most important immediate step is to expand real, on-the-ground efforts to improve security and accounting for nuclear materials. International cooperation can be a critically important tool, spreading both MPC&A resources and expertise.

International cooperation to improve MPC&A measures has expanded to unprecedented levels in recent years. The largest single cooperative effort is the U.S. cooperation with the states of the former Soviet Union, a program which is expected to receive $137 million in U.S. funding during fiscal 1998; the U.S. goal in this effort is to work cooperatively with experts from the former Soviet states to ensure that by the end of 2002, modern security and accounting systems are in place for all separated plutonium and HEU throughout the former Soviet Union. Work is already underway at more than 40 sites, involving both work under formal government-to-government agreements and more informal lab-to-lab cooperation, and many hundreds of U.S. and former Soviet experts are actively involved. Several European nations and Japan are also engaged in limited MPC&A cooperation with the former Soviet states, as are the International Atomic Energy Agency (IAEA)—which has played a useful coordinating role for international cooperative efforts in the former Soviet states outside of Russia—and EURATOM.

There are many other examples of international cooperation in this area all over the world. The United States, for example, has long sponsored international courses in physical protection, as have some other countries, and the United States has worked cooperatively with many countries to which it exports nuclear technology and materials to ensure that their material is effectively secured and accounted for. Following on the model of measures taken to improve nuclear safety, where international peer review teams organized by the IAEA and the World Association of Nuclear Operators (WANO) have played an extremely helpful role in reviewing individual facilities and making suggestions for improvement, the IAEA has recently begun organizing similar international peer reviews of physical protection, at the invitation of individual member states.[15] The MPC&A community—represented to a large degree by the Institute for Nuclear Materials Management—is increasingly working together on an international basis.

There are still substantial opportunities, however, for further expanding international cooperation:

- *Accelerating cooperation in the former Soviet Union.* In testimony to the Russian Duma in November 1996, senior officials of the Russian Ministries of Atomic Energy and Defense pointed out that only a small fraction of the amount needed for physical protection of nuclear materials and nuclear weapons was available from the Russian federal budget, and estimated that the total cost to upgrade physical protection in Russia to the levels they believed necessary would be several hundred million dollars per year—far beyond what the United States and Russia are currently spending on the task.[16] The United States and Russia should certainly increase the funding they provide for their cooperative MPC&A modernization programs. But other countries should pitch in more substantially as well. So far, the contributions from other potential donor countries do not come close to matching the U.S. contribution in this area. Major nuclear states such as Germany, Britain, France, Japan, and others should be encouraged to make larger contributions to this effort, which is critical to the security of each of these states. Many of the facilities that require modernized MPC&A systems are completely civilian facilities—such as HEU-fueled research reactors—where non-nuclear-weapon-states such as Germany and Japan could participate as readily as weapon states could. The overall MPC&A cooperative program should be accelerated as much as practicable, with the goal of having modern security and accounting systems in place at all the sites where separated plutonium and HEU are located as soon as that can be achieved, and of building a new safeguards culture based on modern safeguards technology. Moreover, there is a substantial broader agenda of cooperation on other measures to reduce the threat posed by nuclear theft, from training and equipping forces to deal with nuclear smuggling, to monitoring and disposition of excess fissile material, to helping Russia's closed nuclear cities diversify to civilian tasks, that requires substantially more funding than it is currently receiving, and in which many countries in addition to just the United States and Russia could potentially take part.[17]

- *Expanded IAEA-organized peer reviews.* The IAEA initiative to organize physical protection peer reviews is so far a small, nascent effort. Every effort should be made to expand this program over time, making physical protection peer reviews as regular a part of international nuclear activity as nuclear safety peer reviews are becoming; ultimately, occasional physical protection peer reviews should become a normal part of the operations of major nuclear facilities. In many cases, countries will have security concerns regarding allowing foreign experts to conduct such peer reviews, but with time and experience, it should be possible to work out means to allow meaningful peer reviews to be conducted even at relatively sensitive facilities without compromising information that must be protected. In particular, the major weapon states, including the United States, should voluntarily invite the IAEA to organize international peer reviews of physical protection arrangements at selected facilities on their soil. As part of this effort, the IAEA should make a much more energetic effort to discuss physical protection issues with member states, to identify states that would be interested in taking part in MPC&A cooperation, and to identify sites where modernization of MPC&A systems may be required.
- *New MPC&A cooperation with China.* The People's Republic of China has extensive military nuclear activities and plans to rapidly expand its small civilian nuclear power program. In recent years, China has strengthened its MPC&A standards and regulations. Chinese experts have expressed interest in cooperating with U.S.

experts in modernizing MPC&A systems. In the Chinese case, there is the opportunity for such a cooperative program to install modern safeguards and security systems while the nuclear system remains under firm central control. Moreover, as the Chinese nuclear complex is comparatively modest in size, the cost of a complete program to ensure that all weapons-usable nuclear material in China was protected by the best available security and accounting systems would be comparatively small. Lab-to-lab MPC&A cooperation between U.S. and Chinese facilities would be an especially promising approach. There may also be a role for other regional states with physical protection expertise—such as Korea and Japan—to expand their cooperation with China as well, though the fact that most of China's weapons-usable material resides within its military programs will inevitably limit the possible role for non-nuclear-weapon states. Now that the U.S. administration has decided to implement the Agreement for Cooperation permitting civilian nuclear technology transfers to China, the door is even more widely open for the United States and China to move forward quickly in developing wide-ranging MPC&A cooperation.

- *Expanding MPC&A cooperation in other countries.* There are, of course, many other countries where cooperation to improve and modernize MPC&A systems could and should be expanded. A wide variety of countries around the world have separated plutonium or HEU on their soil. Outside of the most developed countries, these materials are usually present only in small quantities, often simply a few kilograms of HEU fuel for a research reactor or critical assembly; few people outside the scientific community using that facility may even be aware of the material's existence, let alone its potential implications. There is therefore a fertile field for expanding U.S. and other international cooperative efforts, seeking to ensure that every country that possesses even a kilogram of this material takes appropriate precautions to protect and account for it.

Opportunities II: Strengthening International Standards

Today, there is no international mechanism in place to ensure that all countries using weapons-usable materials provide an effective and consistent level of security and accounting for them. Such a mechanism is urgently needed, and growing international support is creating new opportunities to take the first steps toward creating it.

A 1994 report of the Committee on International Security and Arms Control (CISAC) of the U.S. National Academy of Sciences recommended that the United States pursue new international arrangements to improve safeguards and physical security over all forms of plutonium and HEU worldwide. In particular, because gaining access to fissile material is by far the most difficult technical obstacle to producing nuclear weapons, the CISAC report recommended that, to the extent possible, weapons-usable materials, whether military or civilian, should be guarded and accounted for as though they were nuclear weapons—a goal the report called the "stored weapons standard"—and that international standards should be updated to meet this goal. CISAC also recommended that an international organization be given "authority to inspect sites to monitor whether the standards are met."[18]

Meeting the stored weapon standard would mean that all areas with weapons-usable materials, military or civilian, would be within highly secure vaults or work areas, with multiple layers of protection to prevent any insider or outsider theft, continuous monitoring, and substantial armed guard forces. As in the U.S. and Russian nuclear weapon security systems, no individual would be permitted to be alone with weapons-usable nuclear material without another person present, and individuals with access to such material would be carefully screened for reliability (including examination of their financial status) —and rescreened at periodic intervals. The protection systems would be designed with the goal of providing reliable protection against insider theft by individuals in any position—even in collusion with outside forces—and against covert or forcible outsider theft, even by teams of well-armed and well-trained attackers. None of these objectives would be impossible to achieve for weapons-usable nuclear material worldwide, and indeed, substantial quantities of weapons-usable nuclear material are already protected to such standards. The CISAC report acknowledged, however, that the bulk processing of material "will unavoidably make accounting more difficult than in the case of nuclear weapons, and it may also be institutionally difficult to preserve the strict security arrangements associated with nuclear weapons themselves." But the report argued that "precisely because of the difficulty of the task, it is important to preserve the goal."

Current international standards fall far short of these objectives. Although an attempt to set international standards for nuclear materials security was made in the 1980 Convention on the Physical Protection of Nuclear Material, that convention was drafted at a time when today's threats—from nuclear smuggling to the use of weapons of mass destruction by terrorist groups—did not yet exist.[19] U.S. approaches have changed radically since then, resulting in more than a doubling of annual spending on safeguards and security; other countries' approaches have changed significantly as well. The Convention is quite vague in its requirements, applies primarily to international transport of materials, does not cover military materials at all, and has no provisions for verification or enforcement. Moreover, many countries, including some who possess significant quantities of weapons-usable material, are not parties to the Convention. Similarly, although the IAEA has published more detailed guidelines for physical protection of nuclear materials, these are purely advisory—and even they do not set any standards for how well a physical protection system should perform (that is, what threats it ought to be designed to defeat).[20] Neither the IAEA nor any other organization monitors or compiles accurate, up-to-date information on physical security procedures worldwide; thus, there is no means for the international community to know where remedial action may be necessary, or where the next marginal dollar for international physical protection cooperation could best be spent. Moreover, no comparable convention setting standards for material control and accounting systems exists.

A number of countries, including the United States, have attempted to impose some international standards—and procedures for checking physical protection arrangements—through bilateral agreements. Under U.S. law, the executive branch must periodically certify that countries using U.S.-origin nuclear materials are providing them with adequate physical protection, and to meet this requirement, the United States has long undertaken programs in which selected facilities handling U.S.-origin materials are occasionally visited by U.S. experts to examine their physical protection arrangements. Often, this becomes part of a joint cooperative effort to modernize and improve these arrangements. Following the U.S. lead, the Nuclear Suppliers Group has adopted guidelines for physical protection of material originating within its member states.[21] But these efforts are no substitute for a broad international approach to ensuring effective physical protection for weapons-usable material worldwide.

A major international effort to improve security and accounting for weapons-usable nuclear materials worldwide would be costly, probably adding tens of millions of dollars a year to the costs currently paid for such activities. Physical protection would remain, however, a tiny fraction of the overall costs of nuclear activities worldwide; meeting the "stored weapon standard" would not require measures that would add in any significant way to the overall costs of nuclear-generated electricity (particularly as most such electricity is today generated without the use of directly weapons-usable material). In any case, the cost of mitigating proliferation risks should be considered an essential part of the cost of operating a facility that uses weapons-usable materials—an externality that should be internalized, just as the costs of pollution prevention and mitigation should be paid by the polluters.

There appears to be growing international support for the idea that more stringent international standards, and a greater international role in seeing that they are met, are needed. The U.S. DOE has largely adopted CISAC's "stored weapon standard" for its excess plutonium disposition program, including, for example, a decision to transport MOX fuel with the same vehicles and security measures used to transport nuclear weapons. This will provide a useful demonstration that the stored weapon standard, or something close to it, can be achieved in practice without a substantial increase in overall nuclear operations costs.

In 1995, a Special Panel of the American Nuclear Society, including senior representatives not only from the United States but from Russia, Japan, France, Germany, and Britain as well, issued a unanimous report, *Protection and Management of Plutonium*, which also called for increased international attention to physical protection, specifically endorsing the concept that separated plutonium should be protected as rigorously as nuclear weapons are, and the idea of giving the IAEA the authority to inspect physical protection arrangements.[22]

Most recently, in mid-1997, a broad international committee established by the IAEA to consider new steps in international cooperation in preparation for the IAEA's June 1997 international symposium on "Nuclear Fuel Cycle and Reactor Strategy: Adjusting to New Realities," called for new agreements to provide "strengthened assurance that national physical protection standards and performance meet high standards and that remedial action to correct any deficiency will be taken."[23] This committee recommended making it possible, "though an international convention or other means," for the IAEA to assess physical protection measures at individual sites and "offer advice and assistance to correct deficiencies." Such assessments would be carried out either at the request of individual states, or "in a systematic manner," with the IAEA given mandatory authority under the provisions of a new agreement. The group pointed out that while there are great sensitivities associated with physical protection measures, "the IAEA has established an outstanding record in protecting sensitive State information and this problem would appear to be soluble."

The time has come to begin the hard work of translating this nascent but growing consensus into more stringent international standards and additional authority for the IAEA to take a larger role in physical protection. It is critical, however, that this effort not be allowed to distract from the even more urgent task of correcting known physical protection deficiencies: improvements on the ground are more important, for the moment, than creating stricter standards on paper. But over the long term, stricter standards will have a fundamental role to play—and it should in principle be possible for governments to muster the energy to pursue both.

Creating a regime of greatly strengthened international standards for physical protection will inevitably be difficult, and require the expenditure of considerable diplomatic capital. Many countries still consider their own physical protection arrangements a matter of exclusive national sovereignty, not a subject for international discussion. Cultural differences in approaches to physical protection will complicate discussions of specific strengthened approaches or standards. Nuclear industries using weapons-usable materials will object to the potential for increased costs, and these industries typically have strong influence on their governments with respect to issues perceived to be technical nuclear issues, such as this one. While a regime such as that recommended in the 1994 CISAC report should be the ultimate goal, it is likely that this goal can only be approached step-by-step.

Collecting Information

The first step in creating stringent global standards is to collect information as to where countries are today in approaching such standards. As noted above, no such repository of information currently exists, leaving the international community with no way of knowing where the most significant risks may lie. The IAEA should be given the authority to begin keeping a database of current information on physical protection, provided voluntarily by member states; a questionnaire could ask about countries' specific policies with respect to the individual items recommended in the IAEA's guidelines on physical protection, INFCIRC 225. A request by the IAEA Board of Governors would be sufficient to initiate such a voluntary data-collection effort. At least general information from this database should be made available to member states and to the public, perhaps in an annual publication; more detailed information—particularly information that suggested vulnerabilities at individual sites—may have to be treated as safeguards confidential, at the request of the providing state. At a later stage, this database could be supplemented with data gathered during IAEA visits or inspections, some of which would certainly be safeguards confidential (see below).

Undertaking Binding Pledges

Binding pledges by individual states to meet certain levels of physical protection—and to allow some managed form of access by IAEA-organized peer review teams—could be a useful step toward building momentum toward revised agreements, just as individual states' nuclear testing moratoria played a key role in leading to the successful conclusion of the Comprehensive Test Ban. Individual states could pledge to implement all of the recommendations of INFCIRC 225 for all of their weapons-usable material (both military and civilian), and to allow occasional access by international peer review teams, who could review the physical protection arrangements at an individual facility chosen by the IAEA from a list of all facilities handling weapons-usable material provided by the state making the pledge. These initial pledges would be expected to include a statement that the pledging state reserved the right to choose the level of access to be provided, balancing the need for effective peer review with the need to protect certain information in the interests of nonproliferation and national security. Since the purpose of these voluntary visits would be to help ensure that material at the site was not stolen for military purposes by unauthorized parties, it should be possible for IAEA staff to conduct such visits, even at sites conducting military activities, within the limits of the IAEA's statute and its limitation to verification of peaceful use; if this was considered to be a problem, the IAEA could simply serve as the organizer for international peer review teams, which would not be considered to be IAEA inspectors. If states did not feel comfortable with opening certain facilities to international teams organized by the IAEA, they might work out suitable peer review arrangements within a group of allied or regional states with whom they felt more comfortable, at least as a first step. Such pledges could readily be made binding, by means of a brief document that each pledging state could sign, representing an agreement between itself and the IAEA. This approach would allow states that saw an urgent need for stricter standards to take the lead by first applying these standards to themselves. If a core of key countries could be convinced to make such pledges early on, such an approach might rapidly build momentum toward greatly strengthened international standards.

Clarifying the "Stored Weapon Standard"

If, in the long term, the objective is to convince those who use weapons-usable materials to protect them to the "stored weapon standard," it would be helpful to clarify what exactly that would entail, and to work out specific measures that would be applicable to bulk material rather than only to item-accountable nuclear weapons. An interested state or group of states could organize a meeting at which the weapon states would describe the security procedures for stored nuclear weapons—at a level of generality appropriate for a forum that would include non-nuclear weapon-states—and experts could discuss the measures that would be needed to ensure a comparable level of security for weapons-usable nuclear material. This would not be a negotiating session, but a discussion of the specifics of what the "stored weapon standard" would mean if accepted in the future—providing a template from which negotiators could later draw, if and as desired.

Strengthening INFCIRC 225: Design Basis Threats and Armed Guards

While there have been some revisions of the INFCIRC 225 recommendations in recent years, there has been no attempt to carry out a "bottom up" review of these recommendations in light of changed world circumstances. There are a wide range of ways in which the specific recommendations in INFIRC 225 might be strengthened, which should be considered. One possibility would be to incorporate some elements of a "performance-based" approach, specifying the level of performance that should be achieved, rather than relying solely on the current prescriptive approach, specifying individual measures to be taken. A performance-based approach would include at least a minimal "design basis threat" that everyone agreed physical protection systems should be designed to defeat. With the increasingly global nature of terrorist groups and organized crime, it is difficult to argue that there is any country in the world where theft attempts by well-placed insiders or attacks by small groups of well-trained and well-armed terrorists are *not* serious possibilities; hence, all physical protection systems for weapons-usable material should be defined to be capable of defeating such threats. Regular and realistic performance testing is critical to understanding the real performance of a physical protection system, and recommendations for such testing should be included in INFCIRC 225.

Another important agenda item, given the stakes, is to include provisions for armed guard forces for all weapons-usable material; it is simply never likely to be possible for technology alone, backed up by police forces some distance away, to provide the same level of protection that can be achieved by combining technology, on-site armed guard forces, and remote police (and military) backup. Work should begin now to design culturally acceptable approaches to providing armed guard forces for weapons-usable material facilities in countries that do not yet have them. Britain, for example, which has prohibitions on private firearms similar in some respects to those of Japan, has resolved this problem by establishing an armed special-purpose national police force for nuclear facilities; Japan and other countries could consider similar approaches.

Providing Authority for IAEA Inspection

As noted earlier, the IAEA is already organizing voluntary "peer reviews" of physical protection arrangements in a few countries. Over time, however, efforts should be made to increase the IAEA's authority to inspect to ensure that effective physical protection measures are being implemented. As a first step, the IAEA should be given the authority to collect information related to physical protection observed by its safeguards inspectors in the normal pursuit of their business. This could potentially be done through a new direction approved by the Board of Governors. Over time, however, this authority should be further increased, allowing the IAEA to request inspections at designated facilities specifically designed to examine physical protection arrangements, and requiring states to permit the inspections, with some form of managed access balancing the benefits of such inspections with the protection of proliferation-sensitive information. This might be accomplished through the adoption by individual states of a new protocol—as in the case of the recently approved protocol giving the IAEA the authority to implement those 93+2 safeguards measures not already within its existing authority[24]—or as part of a new agreement. As noted above, since the purpose of these inspections would be to ensure that appropriate measures are in place to prevent removal of material for unauthorized military or terrorist purposes, and no direct access to materials in military use or in military forms would necessarily be required, it should be possible to carry out such inspections at both civilian and military facilities within the bounds of the IAEA's existing statute. Of all these measures, creating a binding inspections regime may be the most difficult to achieve, provoking the greatest political resistance from some states; while this measure is important, and steps should be taken in this direction, resistance to binding inspections should not be allowed to stymie progress toward the other elements of a strengthened international physical protection regime.

Modifying the Physical Protection Convention?

A more ambitious and far-reaching goal would be to negotiate amendments to the Convention on the Physical Protection of Nuclear Material. Suggestions have been made ranging from simply extending the coverage of the convention's current provisions to cover domestic material (rather than almost exclusively material in international transport, as is currently the case), to extending them to cover military material as well, to radically revising the entire document to include new standards—up to and including the "stored weapon standard." Ultimately, such a modified international convention—or a new one, as described below—will be needed. But the negotiation of such amendments is likely to be a difficult and painful process, and is not likely to be successful until other measures that can be implemented in the nearer term have built up a stronger base of international support for change.

A New Nuclear Terrorism Convention?

Yet another approach would be to start from scratch and negotiate a new convention, designed to include a range of measures to reduce the threat of nuclear smuggling or nuclear terrorism—which could include new standards for physical protection of weapons-usable material, the most fundamental and cost-effective measure to prevent these dangers. The Russian government, for example, has recently proposed a draft of a new convention on nuclear terrorism, which includes at least a requirement that states adopt "all necessary" physical protection measures.[25] It is by no means clear whether the framework provided by the existing Convention on the Physical Protection of Nuclear Material would allow the negotiation of more stringent international standards to be accomplished more quickly by modifying that Convention, or whether the obstacles posed by the accumulated inertia of past ways of doing business under that Convention mean that it would be simpler to start from scratch and negotiate a new agreement. Both options should be considered. A new agreement would have the advantage that a variety of measures beyond physical protection—relating to nuclear smuggling cooperation and other related issues—could more readily be included.

Conclusions

Ensuring that all weapons-usable nuclear material worldwide is secure and accounted for is a fundamental nonproliferation priority. The threats of nuclear theft and the stresses on the systems designed to prevent it have never been greater. Considerable opportunities are available to expand international cooperation in improving security and accounting for weapons-usable materials, and to strengthen international standards. In particular, steps should be taken to:

- Accelerate current cooperative programs to ensure that modern MPC&A systems are installed for all weapons-usable nuclear material in states of the former Soviet Union, and to foster the development of a strengthened "safeguards" culture in these states;
- Establish similar cooperation to install modern MPC&A systems for all nuclear material in China;
- Drastically expand the IAEA program of peer reviews of physical protection, ultimately making such international peer reviews a regular part of the operations of major nuclear facilities worldwide;
- Expand other international MPC&A cooperation, with the goal of providing modern physical protection, accounting, and control for all weapons-usable nuclear material worldwide;
- Direct the IAEA to begin compiling data on states' physical protection systems, beginning with voluntarily-supplied data concerning states' approaches to the individual elements of INFCIRC 225, and continuing to include data relevant to physical protection acquired during IAEA safeguards inspections;
- Initiate a series of binding pledges by individual states to meet stringent standards of physical protection, and to allow peer review of their physical protection arrangements, with appropriate managed access to protect national security;
- Convene a conference of experts to identify specific measures that would be included in a program designed to meet the "stored weapons standard";
- Strengthen INFCIRC 225, giving consideration in particular to including performance-based approaches and performance testing, and strengthened recommendations for armed guards for all weapons-usable nuclear material;
- Begin taking steps toward creating a binding requirement to accept IAEA inspections or IAEA-organized reviews of physical protection arrangements, with managed access to protect national security;
- Negotiate modifications to the Physical Protection Convention, or a new agreement, to greatly strengthen international standards for physical protection of nuclear material.

None of these steps will be easy. Taking advantage of the opportunities that now exist will require sustained, energetic, and high-level leadership from several countries to overcome diplomatic obstacles and ensure that the necessary resources are provided. Few tasks, however, could be more deserving of the effort than ensuring that the essential ingredients of nuclear weapons do not fall into the wrong hands.

References

1. For a useful unclassified discussion of the possibility that terrorists could build nuclear explosives, see J. Carson Mark et al., "Can Terrorists Build Nuclear Weapons?" in Leventhal, Paul, and Yonah Alexander, eds., *Preventing Nuclear Terrorism.* Lexington MA: Lexington Books, 1987. That article, drafted by U.S. nuclear weapons designers, represented a negotiated statement agreed to by both advocates and skeptics of the thesis that terrorists could readily build nuclear explosives; unfortunately, it concludes that the answer to its title question is yes. Subsequent work in the U.S. design laboratories has tended to confirm this conclusion. In addition, it must be remembered that

subnational thieves may provide stolen fissile material to states, where it can then become the basis for national nuclear weapons programs—probably the most plausible and dangerous threat posed by potential theft of nuclear material. Indeed, all of the seizures of stolen weapons-usable material to date involved thieves planning to sell the material to others, not thieves belonging to a subnational group planning to produce a bomb itself.

2. In this article, I use the term "weapons-usable" fissile material to refer to all separated plutonium, of whatever grade, and to all HEU (that is, uranium enriched to more than 20 percent U-235). While much of this material is not "weapon grade," and would not be preferred by nuclear weapons designers, it can be used to make nuclear explosives. In particular, reactor-grade plutonium can be used to make a bomb with an assured, reliable yield in the kiloton range, and a probable yield significantly higher than that, using technologies no more sophisticated than those used in first-generation nuclear devices such as the Nagasaki bomb; sophisticated weapon states could also use reactor-grade material such as that coming from light-water reactors today to make weapons with reliability, yield, weight, and other characteristics comparable to those made from weapon-grade plutonium; and states with intermediate design sophistication could build weapons from reactor-grade plutonium with intermediate capabilities. The United States has recently declassified the most detailed information yet about what could be done with reactor-grade plutonium; see U.S. Department of Energy, Office of Arms Control and Nonproliferation, *Final Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives*. Washington DC: DOE, January 1997, pp. 37–39.

   While this article focuses on directly weapons-usable material, which requires the highest level of physical protection, the need for adequate security and accounting of material in less attractive categories should not be ignored. Producing weapon-grade HEU from low-enriched uranium (LEU), for example, requires dramatically less enrichment work than producing it from natural uranium; if a proliferator were able to acquire a secret stockpile of LEU, the plant needed to complete the remaining enrichment would be far smaller, less costly, and easier to hide. Similarly, it would be far easier to keep secret a program to separate plutonium from a stock of illegally acquired spent fuel than it would to keep secret the combination of such a separation program and a nuclear reactor for producing the plutonium in the first place.

3. U.S. Department of Energy, "Protection and Control of Safeguards and Security Interests," Order 5632.1C. Washington DC: DOE, July 15, 1994.
4. In this article, following International Atomic Energy Agency (IAEA) practice, I use the term "diversion" to refer to actions by the legitimate owners of the material to incorporate it into nuclear weapons in violation of pledges not to do so, and the term "theft" to refer to acquisition of the material by parties other than its legitimate owners. Similarly, as in IAEA practice, I use the term "safeguards" to refer to international safeguards designed to detect diversion of nuclear material by states (or, in more recent programs to detect clandestine nuclear activities at undeclared sites); in this article, the terms "security" and "physical protection" are used interchangeably, referring to states' primarily domestic security systems, designed to prevent theft of nuclear materials by non-state actors (possibly working in conjunction with foreign states). Increasingly, some modern national systems seek to combine material protection, control, and accounting (MPC&A) into an integrated system of "domestic safeguards" to ensure that all material is secure and accounted for.
5. As is well known, Aum Shinrikyo was also exploring nuclear material, particularly uranium, in a preliminary way.
6. Deutch, John, "The Threat of Nuclear Diversion." In *Global Proliferation of Weapons of Mass Destruction*, hearings before the Permanent Subcommittee on Investigations, U.S. Senate Committee on Government Affairs. S. Hrg. 104-422, Vol. 2, 104th Congress, 2nd Session. Washington DC: Government Printing Office, 1996. Since nuclear weapons themselves are easily counted, are typically stored in heavily guarded vaults, and are managed by a military organization (the 12th Main Directorate of the Ministry of Defense) that continues to have substantial cohesion, Deutch indicated that the CIA's judgment was that nuclear weapons themselves remained secure, but that "the threat from within the Russian military and the deteriorating economy mean that this judgment could change rapidly."
7. Based on interviews with U.S. government and IAEA officials. I have not named the facilities, in order to focus the debate on the general point concerning the need for stringent standards worldwide, rather than on the specific circumstances at individual facilities.
8. For a journalistic critique of these early practices that was influential in changing them, see John McPhee, *The Curve of Binding Energy*. New York, NY: Farrar, Strauss, and Giroux, 1974; see also Willrich, Mason, and Theodore B. Taylor, *Nuclear Theft: Risks and Safeguards*. Cambridge, MA: Ballinger, 1974.

9. See *Nuclear Weapons Facilities: Adequacy of Safeguards and Security at Department of Energy Nuclear Weapons Production Facilities*, hearings before the U.S. House Committee on Energy and Commerce, H. Hrg. 99-143, 99th Congress, 2nd Session. Washington DC: Government Printing Office, 1986.
10. See DOE's Office of Evaluations web page summary of Pantex, available at http://tis.eh.doe.gov/web/eh2/profiles/prof_pansp.html (updated December 1996).
11. See Jim Carrier, "Flats Security Lax, Ex-Officials Warn," *The Denver Post*, May 20, 1997; Mark Eddy, "Flats Theft Risk Discounted—But DOE Confirms Security Problems," *The Denver Post*, June 10, 1997; and Jim Kirksey, "Flats Security Rating Higher—Facility Ranked `Satisfactory'," *The Denver Post*, September 12, 1997. The U.S. DOE rates facilities' physical protection systems as being "unsatisfactory," "marginal," or "satisfactory." Rocky Flats reportedly had a history of "marginal" ratings, with a mid-1996 review showing "endemic deficiencies," and a series of tests over the years leading to knowledgeable individuals succeeding in removing test "plutonium" from the facility without authorization or detection. In January 1997, matters got even worse and the facility was rated "unsatisfactory;" the security director at the site quit in April of 1997. The site received its first "satisfactory" rating in several years in September 1997. However, a DOE report in mid-1997 reportedly pointed out that there was "reason for skepticism" about the improvements, as Rocky Flats "has a long history of improving its protective systems only to allow them to degrade once again when priorities shift or external pressures abate." Perhaps it was not surprising, then, that a November 1997 DOE review described security at Rocky Flats again as "less-than-adequate," indicated that "DOE protection standards were not beeing met with respect to the protection of special nuclear materials against theft," and pointed to "on again, off again" management attention to physical protection there. See U.S. Department of Energy, Office of Oversight, *Interim Report on the Status of Safeguards and Security in the Department of Energy,* November 1997. This phenomenon of shifting levels of attention and priority, of course, is not limited to Rocky Flats, or to the United States.
12. *Increasing Fissile Inventory Assurance Within the U.S. Department of Energy,* Deputy Assistant Secretary for Security Evaluations. Washington DC: DOE, January 1995. (Available at www.tis.eh.doe.gov/web/eh2/reviews/fiss_rep.html.)
13. See, for example, Peter Eisler. "Reduced Budgets Erode Security at Nuke Plants." *USA Today,* October 22, 1997; Peter Eisler. "Unit to Probe Nuke Safety is Approved." *USA Today,* November 7, 1998; and U.S. Department of Energy, Office of Oversight, *Interim Report on the Status of Safeguards and Security in the Department of Energy,* November 1997.
14. Potter, William C. "Before the Deluge? Assessing the Threat of Nuclear Leakage From the Post-Soviet States." *Arms Control Today*, October 1995, pp. 9–16.
15. This program is known as the International Physical Protection Assistance Service. The IAEA's Board of Governors approved the initiation of such a program in March 1995, and the IAEA announced the service was available in march 1996. So far, the countries that have requested such peer reviews have primarily been countries in Eastern Europe with relatively modest quantities of weapons-usable material on their soil, if any.
16. For an edited English translation of the transcript, see *Yaderny Kontrol Digest,* No. 5, Fall 1997 (Center for Policy Studies in Russia, Moscow.)
17. For a review of the current status of this broad agenda, see Matthew Bunn and John Holdren, "Managing Military Uranium and Plutonium in the United States and the former Soviet Union," *Annual Review of Energy and Environment,* Vol. 22, 1997.
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22. American Nuclear Society, *Protection and Management of Plutonium*, Special Panel Report (Glenn Seaborg, honorary chairman). La Grange Park, IL: ANS, August 1995.
23. "Key Issue Paper 6: International Cooperation," (M.B. Kratzer and I. Kouleshov, co-chairmen), in International Atomic Energy Agency, *International Symposium on Nuclear Fuel Cycle and Reactor Strategy: Adjusting to New Realities*. Vienna, Austria: IAEA, 1997.
24. "93+2" is the name given to the package of safeguards measures developed in recent years to provide inspectors with greater access to information and locations, in an effort to improve the efficiency and effectiveness of the safeguards system, and particularly to improve the system's ability to detect undeclared nuclear activities. Development of

the new measures was formally initiated in 1993 and was expected to take two years, hence the name; in the end, it took four years before a protocol embodying those aspects of the new measures that were not already within inspectors' authority was approved. See International Atomic Energy Agency. "Model Protocol Additional to the Agreement(s) Between State(s) and the International Atomic Energy Agency for the Application of Safeguards," INFCIRC 540. Vienna, Austria: IAEA, 1997.

25. Delegation of the Russian Federation, "Convention on the Suppression of Acts of Nuclear Terrorism," UN General Assembly Document A/AC.252/L.3, January 28, 1997.

Analysis of the Proceedings of the Workshop “Comparative Analysis of Approaches to the Protection of Fissile Materials”

Analysis of the Workshop on "A Comparative Analysis of Approaches to the Protection of Fissile Materials"

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4

Introduction

The purpose of this workshop was to broaden the dialog between participating states on the conceptual, organizational, and operational approaches to nuclear material protection, with the hope that this will lead to fruitful collaboration, improved understanding of common problems, and new steps to improve protection of nuclear material. Comparative analysis was both the organizing principle and the goal of the workshop. This report summarizes and analyzes the conference proceedings according to the following categories:

- Motivations and concepts behind approaches to fissile material protection;
- Trends in safeguards and physical protection;
- Role of cultural differences, political and economic conditions;
- International frameworks;
- Legal and regulatory oversight frameworks;
- Lessons learned and directions for further study.

Motivations and Concepts Behind Approaches to Fissile Material Protection

Many factors influence fissile material protection measures, leading to wide divergence among different states' protection and safeguards programs. These factors include the amount and form of the material in their possession and how it is stored, transported, or employed; an explicit (or even more often implicit) assessment of the risk of loss, theft, or seizure; funding realities, technical sophistication, and organizational responsibilities; culture-driven attitudes toward safety and protection measures; the degree of international scrutiny; and perceptions of vulnerabilities and threats. Differing circumstances complicate comparisons between programs but must be taken into account in the development of a true international policy.

Policy Context for MPC&A

U.S. Ambassador James Goodby, in a speech setting the policy background, outlined three major developments constituting the present policy context for material protection, control and accounting (MPC&A). They are: (1) nuclear disarmament by the U.S. and Russia (which is freeing hundreds of tons of fissile material that must be managed and protected); (2) an emerging threat of nuclear terrorism; and (3) the increase in special nuclear material that may accompany a growing demand for electricity produced by nuclear power (thus possibly increasing the processing and use of separated weapons-usable plutonium in the civilian cycle).

Risks, Responses, and Responsibilities

Several distinctions must be made in considering the risks associated with the loss or theft of fissile material. A fundamental one turns on the question of the practical ability of a skillful sub-national group or of a small rogue state to fashion a weapon from the material being considered. Other distinctions that shape the perception of risk include the difficulty of access to nuclear material, the likelihood of early detection of diversions, the opportunity for accumulation of material through repeated small diversions, the practicality of transporting seized material to a safe haven, and the efficiency and trustworthiness of those responsible for protecting the material. Relative vulnerability of material is also affected by the physical context in which it is being used; civilian and R&D environments typically have less inherent physical protection capability than military ones.

The estimation of these risks depends largely on a number of site- and country-specific circumstances, and these assessments have been the responsibility of individual states. The creation, implementation, and monitoring of adequate responses to these risks have also been a state function. However, with the increasing concern about terrorists' possible use of weapons of mass destruction (possibly having a nuclear dimension) greater international attention is being given to how this national responsibility is being carried out, in an effort to assure effective norms are observed and to provide for guidelines and assistance.

International Requirements Differ for Safeguards and Physical Protection

A conceptual distinction between "safeguards" and "physical protection" must be noted. According to INFCIRC 153, which implements the Treaty on the Nonproliferation of Nuclear Weapons (NPT), non-nuclear-weapon states which are parties to the NPT must establish and maintain systems of accounting and control (i.e., safeguards) for all peaceful nuclear material. These safeguards have as their objectives the detection of diversion of nuclear material by states from peaceful uses to weapons programs and the detection of clandestine nuclear activities at undeclared sites. The International Atomic Energy Agency (IAEA) inspectors verify and enforce the safeguards requirements of INFCIRC 153.

The terms "physical protection" and "security" are used to describe domestic security systems put in place to prevent theft of nuclear materials by non-state or foreign-state actors. In contrast to international safeguard requirements, physical protection is not required by the Physical Protection Convention, unless the material of concern is in international transport. INFCIRC 225 is not mandatory — it contains only recommendations. No inspections are required to verify compliance with any existing standards of physical protection standards.

Development and implementation of physical protection of nuclear material has been a direct responsibility of individual states, managed according to domestic perceptions of system needs to reduce and control risks. As the theft of nuclear materials poses a threat to all states, the international community has a legitimate interest in their protection, and therefore gathering information about the current strengths and weaknesses of domestic physical protection systems was a primary concern of the conference.

Trends in Safeguards and Physical Protection

Many specific measures for safeguarding and protecting nuclear material were touched upon at the conference and are discussed in the papers that were submitted by the participants. A few broad characterizations can be made about recent trends in these areas, which we summarize below:

1. States accustomed to physical protection measures consistent with domestic law enforcement approaches and a purely domestic threat spectrum are finding that they may need to upgrade such protection to accommodate the newly international character of illicit nuclear-material traffickers. Lack of experience with recently globalized crime syndicates and terrorist organizations may lead security forces accustomed to past threats of a purely domestic character to underestimate the threat from such actors. Raising protection standards to a level commensurate with these new threats may require new investments in security measures and personnel, new international physical protection standards, and a new mindset on the part of law enforcement organizations.
2. The possibility of coerced or voluntary cooperation by security personnel with illicit traffickers calls for using electronic security measures when possible. This includes electronic monitoring of human security forces to detect situations where they are being coerced or are in duress. Not all states currently have the resources to fully implement such security systems (see #7).
3. The adoption of non-destructive assay systems and the introduction of computerized accounting methods to obtain near-real-time accounting of nuclear materials have improved the accuracy, usefulness, and convenience of material accounting systems for safeguards purposes. These systems are not yet universally in use.
4. Significant personnel training is needed in the techniques of MPC&A systems and the non-proliferation rationale behind them, especially in newly-formed states or states that have recently changed, or are in the process of changing, their safeguards and physical protection systems. Programs to address these needs are ongoing at state, bilateral, and international levels.
5. Regulations for security and safeguards systems have recently shifted from the one-size-fits-all, top-down compliance system to a more site-specific, individualized, performance-based approach in the United States (the Republic of Korea has a similar program). Computerized methods for analyzing site-specific pathways of nuclear material diversion by insiders and attack by outsiders have facilitated this new approach.
6. The IAEA has seized opportunities for technology improvements (such as trace element detection, use of commercial satellite reconnaissance for surveillance, and environmental monitoring) to detect undeclared nuclear programs that may be in violation of the NPT. By extension, such improvements in the IAEA’s program to detect *state* violations of the NPT may also serve as a second line of defense against the acquisition of stolen material by non-state actors who sell it to client states or terrorists.
7. Significant financial hurdles exist on the part of some states in adopting the newer technologies, especially the newly independent states (NISs) of the former Soviet Union (FSU).

The Role of Cultural Differences and Domestic Political and Economic Conditions

MPC&A systems involve more than just technology. Presentations and discussions pointed out the roles that cultural differences as well as domestic, political, and economic conditions play in the development and implementation of MPC&A systems. These factors influence the perceptions of threats and needs, as well as the decisions regarding resource commitment and allocation.

Perceptions of Adequate/Desirable Levels of MPC&A

Perceptions of what constitutes an adequate level of physical protection differ among cultures and countries. These differences are often reflected in the structures of authority and responsibility over nuclear materials and in specific aspects of security. The IAEA provides international guidelines for nuclear safeguards and physical protection, but the specifics of physical protection systems are left to the discretion of individual states.

Discussions revealed, for example, that Japanese guards at nuclear facilities do not carry firearms on duty. If it proved necessary, armed countermeasures would be taken by back-up forces, with attendant delays. Hiroyoshi Kurihara of Japan explained that such security arrangements are shaped by the history of stringent firearms control among civilian populations in their respective countries and a cultural predisposition against the possession and use of guns. He added that Japanese security systems take few specific measures to counter the insider threat, as the cohesiveness of Japanese society raises a high barrier against covert intrusions by foreigners or domestic malcontents. Moreover, the Japanese organizational style structures work so that it takes place in large rooms rather than individual offices, creating an implicit mutual surveillance effect that enhances the initial personal checks made during the hiring process. Opinions differed as to the sufficiency of such measures.

Dr. William Potter of the U.S. emphasized the need for development and maintenance of a "safeguards culture"[1] at nuclear facilities where special nuclear materials are handled. He defined "safeguards culture" as a pervasive shared belief among political leaders, inspectors, and facility technicians that MPC&A systems are important and must be carefully operated and maintained. He cited examples that illustrated a lack of "safeguards culture" on the part of certain groups or at various nuclear facilities. However, the definition and relevance of the concept was contested by some of the participants, who argued that such a culture exists in their respective countries, but may be manifested differently than it is in the United States. Nonetheless, increasing the level of security consciousness among employees was widely agreed to be essential to maintaining safeguards systems. People create MPC&A systems, use these systems, and have the potential to misuse them, intentionally or otherwise. Delegates highlighted the need for careful selection, education, and training of personnel to enhance operator awareness.

Impact of Political Change on MPC&A

Dramatic changes in political regimes, such as the collapse of the Soviet Union or the transition from military to civilian leadership in Brazil, tend to result in changes to the control of nuclear materials. If sufficiently severe, such changes can undercut the whole conceptual, legal, organizational, financial and regulatory basis upon which state systems of accounting and control are built. In the Soviet case, physical protection (primarily against espionage and sabotage) was emphasized over safeguards because absconding with weapons-grade material and successfully transporting it across Soviet borders was extremely difficult. Also, many facilities were affiliated with military installations which simplified the provision of physical protection against external threats. Under the new conditions, threats from both outsiders and insiders have dramatically increased while funding for the old physical protection systems has declined and new safeguards against insider diversions are not yet fully in place.

Large-scale political changes may also place political boundaries between resources that were once available under previous SSAC. Gennady Pshakin of Russia outlined how the disintegration of the Soviet Union resulted in a division, on territorial principles, of nuclear-related industries and scientific and technical competence among the newly independent states. Control and responsibility over nuclear materials, installations, and information shifted to new governments and oversight agencies. Inventory and reporting systems, regulatory agencies, transportation and communication facilities changed. New laws and regulations are taking considerable time to develop, and some old ones remain.

When constructing new MPC&A systems, such transitions of authority have made getting an accurate inventory of fissile material a difficult exercise in "nuclear archeology." The process of navigating institutions and bureaucracies in transition adds to the difficulty of obtaining documents, relating old and new accounting systems, and sharing information between the newly created political jurisdictions, some of which may lack funds to allocate to such projects.

Influence of Economic Conditions

A country's economic conditions impact MPC&A systems by constraining the resources available for their development, implementation and maintenance. Broad recognition of the desirability of comprehensive, technologically sophisticated MPC&A systems that comply with international standards exists; however, these measures demand large resource commitments, and must compete for funding and attention against other politically desirable initiatives.

The Role of International Frameworks

There are several imperatives driving the trend toward international cooperation in the area of fissile material protection. Sharing technical and administrative data in this arena creates opportunities to improve MPC&A methods, increase high-level attention by the foreign policy and military branches of participating states (who have ultimate jurisdiction over international cooperation efforts), speed the detection and notification of illicit diversions, and increase the coordination of international efforts against such diversions. These cooperative efforts have taken many forms, which we categorize below into three types: bilateral, regional, and global.

Bilateral Cooperation

Three kinds of such cooperation were discussed:

1. Mutual bilateral inspection regimes in which inspections of nuclear facilities are carried out jointly in both countries. (To date, such regimes have not included the inspection of physical protection provisions.)
2. Inspections of physical protection facilities in a state receiving nuclear technology or materials by experts from the providing state.
3. Bilateral technical support relationships in which nuclear experts from a state cooperate with experts from a donor state to improve physical protection.

An instance of the first kind of cooperation is the inspection regime recently created by Argentina and Brazil under the auspices of the Bilateral Agreement called the Common System of Accounting and Control of Nuclear Materials (SCCC). This provided for joint inspection of all nuclear facilities in the two countries and imposed requirements consistent with INFCIRC 153. The two parties created the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC) to implement and administer the SCCC. This cooperation, like the EURATOM system, includes accounting and control but not physical protection, which remains the sole responsibility of the states involved.

Many instances of the second kind of bilateral cooperation exist. Some became part of the international material safeguards regime overseen by the IAEA, as safeguards were usually insisted upon as a condition of technological assistance or nuclear materials transfer by the sponsoring country. Little discussion took place as to what physical security measures have been required by donor countries as a condition of technology transfers and whether a study of such requirements could prove to be a model for future international agreements on physical protection. The Non-Proliferation Act of the United States requires U.S. officials to certify that U.S.-origin materials are adequately protected; the U.S. sends teams to recipient states on a regular basis to verify such protection measures. Inspections and consultations carried out under the Japan-U.S. Bilateral Governmental Cooperation Agreement is one example of this kind of relationship. Also all members of the Nuclear Suppliers Group require minimum standards of physical protection.

The third kind of bilateral relationship often grows out of the second kind of relationship discussed above. Sometimes these relationships have been coordinated by the IAEA and thus are not strictly bilateral. These relationships involve a donor country rendering assistance (called Coordinated Technical Support Plans, or CTSPs) to recipient states (usually non-Russian NISs within the borders of the FSU) on such matters as nuclear legislation, SSAC at state and facility levels, physical protection, and export/import control.

Regional Cooperation

The prime example of this kind of cooperation is the EURATOM agreement between various Western European states. Under the EURATOM treaty of 1957, the European Commission is the proprietor of fissile materials. The EURATOM Safeguards Directorate (ESD) issues safeguards regulations which are binding on EURATOM states. Because European law requires that facility operators employ process techniques that are amenable to the application of the ESD safeguards, the ESD has a *de facto* licensing function for nuclear facilities. The ESD cooperates extensively with the IAEA (such cooperation is required by Article III of the NPT), which makes full use of the ESD's system of safeguards and cooperatively carries out inspections with the ESD in joint teams. The ESD has full access to facilities that are subject to safeguards. The ESD leaves physical protection to the discretion of individual states.

Global Cooperation

Role of the IAEA

Assistance to NISs and Other States. The IAEA has established a program to assist NISs consisting of Coordinated Technical Support Plans (CTSPs) (see also Bilateral Cooperation). The objectives of each plan are to define the needs to be addressed in the recipient countries, determine the time scale over which activities to address these needs will be undertaken, estimate the resources needed to carry out the plans, and allocate responsibilities for assistance between donor countries. To date, the IAEA has found donor countries to assist NISs with 78% of the tasks identified in these plans, and donors are being actively sought for the rest.

The CTSPs are being carried out in three phases. Phase I addresses immediate needs in such areas as legislative frameworks; MPC&A; export/import control; and preparation for safeguards implementation. Phase II involves the completion of the legal regulatory structure and upgrading facility operators' MPC&A and export/import systems, and includes operator training along each of these lines. Phase III addresses future needs for advanced information systems, inspection support measurement equipment, and improved operator measurement systems.

The IAEA has a team of lawyers and engineers that are available to consult with governments that are seeking to establish new or improved legal, organizational, and regulatory frameworks. The agency started a "peer review" program within the last two years in which it sends experts to inspect various aspects of client states' facilities at their request. The agency also offers courses in Eastern Europe to facility operators on physical protection methods and prevention of illicit trafficking.

The IAEA also acts in an unofficial capacity to improve physical protection as part of its safeguards inspection process by taking note of obvious problems with a facility's physical protection program while performing routine records inspections.

Support for Disarmament Efforts. Bruno Pellaud perceives "value added" in having an international agency such as the IAEA put its stamp on bilateral nuclear disarmament efforts. One recent example of this role is the announcement of U.S. and Russian plans to place surplus nuclear material from weapons no longer needed for their military stockpile under IAEA supervision. Pellaud characterized the IAEA's stance as being that, for the IAEA to safeguard these materials, the disarmament must be irreversible; otherwise the IAEA is put in the position of safeguarding material that may later be used for weapons.

The "93+2" Initiative. Because of the Iraqi attempts to violate the NPT, strong impetus was given to the IAEA to detect undeclared nuclear activities. This imperative led to the "93+2" Program, with the following objectives:

- Improvement of efficiency and effectiveness,
- Use of modern technologies,
- Environmental monitoring,
- Expanded declarations,
- Complementary access.

The so-called Part I measures (environmental sampling in declared facilities and improvement of safeguards technologies) require no new legal basis for action and can be implemented as soon as is practicable. For the Part II measures, such as expanded declarations and complementary access, the IAEA will need new authority. This led to the negotiation of a Model Protocol aimed at establishing new IAEA rights and new obligations on the part of member states. Such rights would include access to facilities, companies, sites, and research establishments involving nuclear fuel cycle technologies and R&D that do not involve nuclear material but that relate to enrichment, processing, and reprocessing of waste material categories.

Upgrading the IAEA. The IAEA faces many new challenges in the aftermath of the Cold War. It has taken on many new tasks, including aiding the NISs in developing proficiency in their safeguards programs. It must deal with redoubled efforts on the part of certain states to take advantage of the power vacuum resulting from the post-Cold War international environment by developing clandestine nuclear programs capable of producing weapons. It may also take on responsibilities related to the nuclear arms-reduction efforts of the U.S. and Russia, will see its safeguards budget double if a fissile cutoff is obtained, and may oversee the implementation of any future international agreements requiring physical protection of nuclear materials.

Treaties

The NPT proscribes state parties from providing unsafeguarded nuclear material to non-nuclear-weapons states and requires non-nuclear-weapons states to negotiate a Safeguards Agreement with the IAEA for all nuclear material used for peaceful purposes (the avowed nuclear weapons states, NWSs, have voluntarily accepted IAEA safeguards on some peaceful nuclear activities). It *does not* require the adoption by signatories of domestic statutes or regulations prohibiting illicit trafficking by non-state actors or the physical protection of nuclear material.

The Convention on Physical Protection of Nuclear Material requires all states to adopt domestic standards for physical protection and statutes prohibiting illicit trafficking by individuals. However, the physical protection requirements only apply to nuclear material for peaceful purposes in international transport or during storage incidental to such transport.

There is thus a major gap in international laws and treaties that attack these problems. To correct this deficiency, some have suggested that the international community require all parties to provide appropriate physical protection to the nuclear material under their control and allow IAEA inspectors to check such protection during their inspections.

An objection to this is that such a proposal makes international inspections of physical protection apply to weapons material, and this would be an unacceptable breach of military secrecy. To allay such concerns, it has been suggested that IAEA inspectors would only verify the physical protection measures and not inspect the weapons themselves, but even this would have to be approached extremely carefully to have any chance of being acceptable to NWSs and threshold states and perhaps the IAEA as well.

A weaker form of this proposal would require states to report each year to the IAEA on what physical protection measures were in place for their various nuclear facilities. This at least partially rectifies the current situation, in which it is difficult for any state to know what manner of physical protection provisions are being made by other states.

National Legal and Regulatory Frameworks for MPC&A

Much of the conference and the submitted papers detailed the organizational structures in different states that are responsible for ensuring adequate MPC&A, setting security and handling procedures and regulations, and compliance with international norms. Understanding such structures is important for anticipating systemic weaknesses that may arise with changes of political regimes or shifts of control between military and civilian agencies; appreciating the character of different safeguards cultures that tend to develop within such organizational structures; removing impediments to intra- and international information flow; implementation of a common set of safeguards; coordinating the prevention, detection, deterrence, and detention of illicit traffickers; and assessing the compatibility of different state structures in proposed systems for future international cooperation. A brief synopsis of each participating state's organizational structure follows.

Brazil and Argentina

These two countries implemented the SCCC, a full scope safeguards system designed to ensure the non-diversion of nuclear material to other than peaceful uses. This followed a Bilateral Agreement between the two countries agreeing on the exclusively peaceful use of nuclear material in the two countries. The SCCC also encompasses the General Procedures and Implementation Manuals for each type of facility to be inspected, consistent with the IAEA's INFCIRC 153.

The two countries created the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC), headquartered in Rio de Janeiro. ABACC is charged with ensuring that the SCCC is correctly applied, and alerting the two Parties to the Agreement of any anomalies in the implementation of the SCCC or noncompliance with the Bilateral Agreement. The Secretariat of the ABACC oversees the ABACC inspectors.

The Quadripartite agreement (between Argentina, Brazil, ABACC, and the IAEA), ratified in March 1994, allows the IAEA to apply full-scope safeguards in Argentina and Brazil to verify the SCCC's findings.

China

The Ministry of Energy authorizes the China National Nuclear Corporation to manage nuclear material throughout the country. Within this Corporation, the National Office for the Control of Nuclear Materials (hereinafter, referred to as the “Office”) is responsible for the concrete implementation of controls. The Office submits quarterly reports of both civilian and military nuclear materials balances to the National Nuclear Safety Administration (NNSA) and annual reports to the Commission of Science, Technology, and Industry for National Defense (COSTIND). If loss, unauthorized diversion, sabotage, or theft is detected, the Office immediately takes measures and reports quickly to the NNSA and the Ministry of Public Security.

The Office makes regulations and specifications for nuclear material control, is the licensing agency for nuclear material handling, establishes MC&A systems, audits the nuclear material inventory management, and verifies security measures.

For physical protection purposes, there are three site categories depending on the amount and kind of nuclear material present generally consistent with the graded protection approach recommended in INFCIRC 225. Category I sites are the highest security sites (typically possessing several kilograms of highly enriched material or greater than 10 grams of tritium), at which there are armed guards, strictly controlled access, two complete and reliable physical barriers, special vaults for storage of category I material, and technical protection systems equipped with alarms and monitors. Category II sites also have armed guards and access to the facility requires possession of special passes. There are two physical barriers, one of which is complete and reliable. Storage of category II material is in a “strong room” or “solid container” protected by alarms and surveillance equipment. Category III facilities have a designated person for ensuring the safety of the material, and the facility possesses only one complete and physically reliable barrier.

Each nuclear facility has its own professional security organ to ensure physical protection. The physical protection measures are established under the guidance of the local security organization and direct communication is established between it and the facility. Major facilities are guarded by the armed forces.

Physical protection of nuclear materials during transport is the joint responsibility of the consignor for shipment of nuclear materials and the authorities concerned with transport, products management, safety protection, and public security. Transport of category I or II materials is required to report in advance to the local security organ, and category I shipments must be accompanied by an armed escort.

Germany

In Germany, there is no unified organization concerned with the control of nuclear material, but a number of state and federal authorities are active within the framework of the Atomic Energy Act or international and regional agreements. Germany does not have a national MC&A system, as this function is performed by EURATOM’s Safeguards Directorate (ESD).

Implementation of the IAEA safeguards is carried out by the Federal Ministry of Education, Science, Research and Technology (BMBF). Within this framework, the BMBF finances a support program for IAEA safeguards that is handled by the Programme Group Technology Assessment (TFF) of the Research Centre Julich, which also maintains a databank system for evaluating IAEA INFCIRC 153 Sections 90(a) and (b) safeguards implementation.

Licensees must provide physical protection to be granted licenses, and these plans must be coordinated and dovetailed with police protective measures. The licensing and regulatory authorities of the federal states responsible for implementing the Atomic Energy Act, and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety have presented guidelines for the protection of nuclear power stations comprising mechanical barriers, communication and key systems, access controls for personnel and material, staff security clearances and security guards. Such regulations are augmented by standards requiring rugged facility construction designed to withstand earthquakes, explosions or aircraft crashes.

Germany is a party to the Convention on Physical Protection for Nuclear Material. The Federal Office for Exports (BAFA) regulates border-crossing transport of nuclear material.

Great Britain

The Cabinet Office has responsibility for government-wide security and would take charge in the event of a serious breach of physical security. The Department of Trade and Industry (DTI) is responsible for the operation of the Directorate of Civil Nuclear Security (DCNSy) and the United Kingdom Atomic Energy Authority Constabulary (UKAEAC). The Secretary of State of the DTI ensures that information is safeguarded and nuclear material is protected. The UKAEAC is an armed police service not under the control of the Home Office but coordinates with the Home Office County Police Forces directly via joint exercises, contingency planning, and intelligence, and indirectly on the national level through police committees under the auspices of the Association of Chief Police Officers (ACPO). The Security Service, in association with the Directorate of Civil Nuclear Security, is responsible for independent audits of security arrangements and personnel vetting. Security standards are disseminated by the DCNSy on behalf of the DTI. These include minimum standards for physical protection, the manuals of Protective Security and Counter-Terrorist Measures, the Nuclear Generating Stations (Security) Regulations, and Classification Guides.

Great Britain is a party to the EURATOM Treaty and safeguards are carried out under its auspices.

India

All reactors, fuel processing and fabrication centers are under the control of the Department of Atomic Energy, and the Prime Minister is in direct charge of this department. Only a few power reactors are under IAEA safeguards, with a number of both research and power reactors lying outside the bounds of international scrutiny.

India generally follows IAEA recommendations regarding physical protection. Some recommendations have had to be modified because of site-specific issues.

Nuclear facilities are designed so the penetration time is longer than the countermeasures response time. When necessary (depending on the materials present), a double-barrier system is used, which is equipped with intrusion alarms and TV cameras under the control of security staff inside the facility. Internal security guards are not armed, but back-up is provided by special armed state police forces, which are in close proximity to the facility but keep a low profile. Commandos from the National Security Guard (NSG) are available if needed. Access to such facilities is controlled by magnetic cards, turnstiles, etc. India is currently developing a fingerprint access system.

An independent organization called NUMAC oversees MC&A. Access to nuclear materials is controlled by a three-person key system (all three people must be present to operate the lock). NUMAC regularly audits the material accounting, which is entirely computerized.

India has not signed the Convention on Physical Protection, voicing concerns about the Convention's possible intrusiveness. After the discussion, however, which pointed out that the Convention is not intrusive and does not call for any inspections, some Indian participants indicated that they would support India joining the Convention.

Japan

The Science and Technology Agency (STA) is responsible for overall coordination, implementation of the state system of accounting and control (SSAC) and physical protection of nuclear R&D facilities, nuclear fuel cycle facilities and research reactors. The Ministry of International Trade and Industry (MITI) oversees the physical protection of commercial power reactors, and the Ministry of Transport (MOT) ensures physical protection of nuclear material during transport.

The STA Safeguards Division establishes policy, promulgates regulations, coordinates R&D activities on SSAC technology, and implements safeguards inspections. The operators of each nuclear facility under STA's oversight must submit a nuclear material accountancy system for approval prior to operation and must report inventory changes, material balance, and export/import of nuclear material to the STA.

Facility operators must submit their physical protection plans to state authorities for approval. State authorities have issued technical standards for physical protection that are based on IAEA INFCIRC 225. Each facility has a protection manager. In keeping with IAEA's guidelines, the Japanese system classifies facilities into three categories based on the quantity and kinds of nuclear material present. State authorities (STA, MITI and MOT) have the authority to check compliance with these regulations and to evaluate the effectiveness of any specific physical protection system. STA will inspect facilities under its control, with category I sites receiving more frequent inspections. The United States also sends inspectors every five years to ensure the physical protection of nuclear material that it transferred to Japan under the Japan-U.S. Bilateral Governmental Cooperation Agreement.

Pakistan

The Pakistan Atomic Energy Commission (PAEC) is vested with executive authority to plan and implement Pakistan's nuclear program and make regulations. The exceptions to this are military facilities such as the Kahuta Uranium Enrichment Plant which is believed to be a dedicated nuclear-weapons facility, and due to its lack of mention in the PAEC reports is presumed to be under the direct control of either the national executive authority or the Pakistan Armed Forces. There has been no official statement as to the organizational hierarchy in relation to Kahuta or its associated Khan Research Labs.

Kahuta has extremely tight internal security supplemented by the deployment of machine guns and anti-aircraft missiles to ward off intruders, saboteurs, and aerial attacks. The Advisory Committee on Fuel Cycle and Reactor Safety (ACFCRS) assists the higher PAEC authorities in the control and protection of nuclear materials and maintaining reactor safety. The IAEA guidelines on safety and protection pertaining to civilian facilities are generally followed.

Republic of Korea

Regulation and oversight are carried out by the Minister of Science and Technology (MOST). The Nuclear Control Division of this ministry is the authoritative organization for safeguards implementation and the official government conduit for all international nuclear control issues. The Technology Center for Nuclear Control (TCNC) at the Korea Atomic Energy Research Institute renders technical assistance in developing safeguards technology.

Each facility must develop its own accounting, control and physical protection plan by itself and submit it to the MOST for evaluation and approval. If approval is given, the MOST Nuclear Control Division will inspect the sites. Inspections are being carried out by the MOST site resident inspectors with the technical assistance of the TCNC on a pilot basis for seven nuclear facilities in 1997. This will be expanded to all facilities in 1998 after the inspection program undergoes review and revision.

Russia

Agencies responsible for materials control and accounting (MC&A): Minatom is responsible for effecting state MC&A of nuclear material for both peaceful (following Gosatomnadzor standards) and defense purposes, and the Ministry of Defense for state MC&A of nuclear material intended for military purposes and military-related power facilities.

The control of nuclear material transport across customs borders is effected by the State Customs Committee. Gosatomnadzor is responsible for general oversight of nuclear material intended for peaceful purposes.

The Gosatomnadzor structure consists of a headquarters organization which develops regulations and standards on MPC&A and issues licenses to facility operators to enforce these standards. It oversees 70 nuclear facilities through regional directorates, which are charged with carrying out inspections and developing guides and instructions under the aegis of the headquarters organization. Other responsibilities include the creation of a data bank for MC&A and determination of R&D spending priorities.

In Russia, state MC&A includes ascertaining quantities of nuclear materials on hand; maintaining accounting and reporting documents; preventing loss, unauthorized use, or theft of nuclear material and reporting any such occurrences; providing executive agencies with information on existing levels, movement, and import/export of nuclear material; and monitoring of Russia's compliance with its international nonproliferation commitments.

No federal regulatory documents specifying regulations for effecting MC&A of nuclear material exist. The current MC&A regulations are a patchwork quilt of departmental documents predating the 1991 change of regime and individual orders and instructions issued by individual agencies at the sector and facility levels. Gosatomnadzor has been charged with the task of drafting legislation to remedy this shortcoming.

The operating organization responsible for MC&A for a particular facility also has responsibility for its physical protection. State agencies having jurisdiction over a particular facility have the responsibility to effect both MC&A and physical protection for such facilities.

The "old" (Soviet) approach to physical protection focused on external threats. The insider threat must now be taken much more seriously and physical protection systems must reorient to this new reality. The General Provision for Physical Protection of Nuclear Materials and Installations approved by the government in March 1997 requires that protection systems take both insider and outsider threats into account, that the vulnerabilities of all existing physical protection systems must be analyzed from this point of view and remedial actions taken. The Rules of Physical Protection of Nuclear Materials defines requirements to all utilities operating nuclear facilities, federal agencies coordinating or supervising nuclear activities and materials and their physical protection, and determines their functions and responsibilities in arranging and applying physical protection of facilities and also materials in transport. All utilities operating nuclear facilities are requested to take the measures necessary to meet these Rules by January 1, 1999.

In the 1960s the "man with a gun" system began to be partly replaced by detectors, monitors, etc. Much of this old detection equipment is still in use and there is no possibility of replacing it due to financial constraints.

United States

In the United States, the responsibility for nuclear material physical protection and safeguards involved in national security programs and R&D has rested with the Department of Energy (DOE) since 1977. The Nuclear Regulatory Commission (NRC) regulates the private sector of the nuclear industry, which is responsible for providing its own physical protection. Within the DOE, the Office of Safeguards and Security was established in 1979 to develop policy and support safeguards and security applications to assure nuclear materials inventory at the contractor facilities. DOE sites are responsible for providing physical protection that complies with the Office of Safeguards and Security orders, and compliance is overseen by this bureau. Independent oversight is provided by the DOE Office of Security Evaluation.

Security forces used to be a mix of government and private personnel but were privatized to contractors in the 1980s. However, special response teams were also created to increase the flexibility of response options. The regulatory framework has shifted from mandatory compliance with specific requirements to performance-based requirements, which specify the conditions to be met but not the methods used to achieve them, allowing individual sites the flexibility to adjust safeguards and security according to site needs.

Unexplored Paths

The papers and comments offered a wealth of detail about the various regulatory and legal structures of the participating countries but there was neither enough time nor preparation for in-depth discussion of what comparative conclusions could be drawn from it. Possible avenues for future conferences and studies might include a discussion of what this mix of systems implies for increased international cooperation or international standards for physical protection; the stability of regulatory regimes against sudden political changes; the overlap or underlap of different government agencies tasked with protection and safeguards and how this affects their effectiveness; communication between governments and international agencies in the event of a security breach or loss of nuclear material; and the relationship and interplay between regulatory systems and the "safeguards cultures" that arise within such systems.

Also absent from the discussion of regulatory and legal structures was a description of the NIS systems of the former Soviet Union. There were no representatives from these countries present, but as these countries have the most rapidly changing systems, it would be valuable to obtain information about the current state of their programs.

Several countries did not discuss in depth what provisions for physical protection their governments have taken. It is hoped that future workshops and studies will rectify this deficiency.

Lessons Learned and Directions for Further Study

The requirement for the NPT signatories to adhere to IAEA safeguards standards and other international norms tends to standardize the levels of fissile material accounting and control across the world. However, no international standards are enforced for physical protection, and significant differences remain in the countries' approaches to implementation of physical protection. The proceedings illuminated many factors underlying these differences, including cultural differences, subjective threat perceptions, technical capabilities, political and economic circumstances, and legal and regulatory frameworks. No discussion focused on how the knowledge and analysis of these differences can be used by participating states to learn from each other, improve domestic systems, and strengthen international cooperation. Such a discussion could be the next step in the study of comparative approaches to protection of fissile materials.

The "Guidelines to Speakers" outlined the following objectives and intended topics for discussion:

- Concepts behind implemented (or planned) structures and mechanisms for control of fissile materials;
- Evaluation of the cost of fissile material control, accountability, and physical protection;
- The means used to measure the effectiveness of MPC&A programs;
- Some specific discussion of questions such as the forms in which material exists, facility security, near and far field monitoring and detection, and personnel behavior standards;
- Any new legal and regulatory bases that had to be established;
- The role of international regimes and standards related to the protection of fissile materials;
- Lessons learned in the implementation of fissile material protection,

control and accountability, including what seems to be more effective and what less.

These guidelines were followed to varying degrees and with mixed success.

Concepts

The concepts behind structures and mechanisms for control of fissile material were not directly discussed, although the concepts and motivations that became evident throughout the proceedings are reflected in the first sections of this report. A further discussion of these concepts and how they find concrete expression in different state programs could prove useful in establishing a better understanding and common ground between the participants.

Costs

Evaluation of the costs of MPC&A and the means used to measure the effectiveness of MPC&A programs were briefly mentioned in some of the papers, but not discussed during the proceedings. A comparative study of these issues could help to identify practical levels of protection, in both the technical and economic sense, and could prove particularly useful for states with limited means to devote to MPC&A in setting their program's priorities.

Specific Questions

The forms in which material exists, facility security, and personnel behavior were discussed selectively by some of the participants. This information is important because the type of fissile material and its physical form determine its desirability as a target of theft and diversion. Near and far field monitoring were not reviewed. Discussions of facility security and personnel behavior standards were particularly insightful in highlighting the cultural differences in approach to security and differing threat perceptions. However, problems of classified information make a detailed discussion of security provisions difficult.

Legal and Regulatory Bases

Nearly all of the participants presented a detailed account of their domestic legal and regulatory frameworks of oversight over nuclear facilities and materials. A plethora of differences emerged from the presentations. In most countries, rules and regulations governing the handling, accounting and protection of fissile materials are developed in advance, and the facilities are required to adhere to these standardized guidelines. However, in the Republic of Korea, each facility develops its own protection plan and submits it for government approval to ensure that it meets general standards (the United States is also moving in this direction). Germany has no unified organization vested with MPC&A responsibility, while several state and federal authorities assume this task. Brazil and Argentina implemented a common system of accounting and control.

These differing regulatory structures will require analysis and development of a framework for discussion. More attention will need to be given to why particular structures have arisen in different states, and how effective they were. Were these regulatory structures instituted because they were the best way to achieve MPC&A objectives, or did they come into being as a result of political compromise? Are there overlaps among the responsibilities of different regulatory bodies or are there gaps in responsibility? If so, how does this impact the effectiveness of protection mechanisms? When rules and regulations are updated in response to emerging threats or domestic and international developments, what processes or procedures are undertaken, and how are they initiated? What management and implementation lessons have been learned throughout the history of regulatory bodies and documents? A comparative analysis of these and related issues would help states to learn from each other's successes and mistakes in order to reduce system vulnerabilities. Such findings can also be used for further development and implementation of international fissile material protection standards. Knowledge of domestic standards and frameworks is essential in devising realistic international standards that can be effective and compatible with domestic conditions of participating countries.

International Regimes and Standards

George Bunn drew attention to the need for increased international cooperation in combating illicit trafficking in nuclear material and discussed the pros and cons of several proposals designed to strengthen international anti-trafficking and physical protection norms. Others pointed out that in designing international cooperation regimes, care must be taken to avoid compromising other elements of the MPC&A system by implementing new elements. One example of this that has been posed is granting too-wide access to repositories for accountability audits having the effect of reducing physical protection by furnishing individuals or organizations with information useful in defeating the protection system. (In the U.S., several exercises have shown that a great deal of information that would be useful in attacking a facility can be obtained from readily available environmental impact reports.)

Regional regulatory arrangements (such as EURATOM and ABACC) that either grew out of or superseded national regulatory structures are a rich area for further research. Problems experienced and solutions achieved by the countries involved might have relevance to the architectures of future global and regional regulatory regimes that may be proposed. That history has special relevance to the possible inclusion of new states (such as the NISs of the F.S.U.) into existing regional systems and identifying potential synergies that can be achieved by the formation of new regional systems for groupings of such states. While regional regulatory regimes have not been involved heretofore in setting standards for physical protection, they may play a useful role in constructing future international frameworks of physical protection that accommodate the different circumstances and sensitivities of participating states.

Lessons Learned

Technical and management lessons learned from development, implementation, maintenance, and upgrading of MPC&A systems in different countries were intended to be a major focus of the conference. However, little discussion actually occurred on this matter. Neither were there discussions of threat assessment methods or contingency plans in case of an actual security breach (though some portions of this may be sensitive information). In-depth sharing of knowledge and experience in technical and management approaches to MPC&A can be very useful for individual countries' analysis and improvement of their own systems, as well as for development of new international norms and standards. To avoid compromising sensitive information about particular facilities and systems, future discussions can be restricted to a conceptual discussion about approaches taken and lessons learned.

Epilogue

The papers and proceedings of the conference covered a broad range of issues regarding conceptual, organizational, and operational approaches to fissile material protection. The proceedings showed that the comparative analysis framework is rather complex because of the diversity of topics and the differing perspectives and perceptions of the participants.

More questions seem to have been raised rather than answered throughout the proceedings. This is to be expected of such conferences, but may also have been caused by the "Guidelines to Speakers" requesting too broad a range of information, which may not be within each participant's sphere of expertise, or may be classified and therefore unavailable for public discussion. In consequence, many participants focused on various niche issues rather than covering all topics requested in the guidelines.

However, this broad scope was appropriate in that it provided an environment in which individuals representing diverse regional interests and responsibilities could identify areas for which there appeared to be common approaches and those for which there were major differences. By identifying areas for further focused analysis and exchange to facilitate improvements in the international system to protect fissile materials, the workshop met one of its major objectives.

Only a small number of the countries and institutions over which a truly international regime would have to apply were represented at the workshop. It should be expected that with broader representation even more differences in philosophy and implementation would be revealed. Therefore, one objective for follow-on workshops should be to expand the database by including the Newly-Independent States formerly in the Soviet Union and Southeast and Southwest Asian states.

Each of the Guidelines topics provide background material and directions for further comparative study of approaches to physical protection and safeguarding of fissile material. Other proposed topics for further study include, but are not limited to:

- International intelligence sharing about threats to the safety of fissile materials;
- Prospects for an Asian regional safeguards systems similar to EURATOM;
- Strengthening international standards for physical protection in a manner similar to the strengthening of international standards for safeguards pursuant to the IAEA's "93+2" program;
- Increasing the robustness of national physical protection and safeguards against sudden political or economic changes;
- Proposals for international funding of MPC&A to achieve globally uniform standards;
- Education of the next generation of facility operators, inspectors, and security providers in the subject of fissile material protection to inculcate a "safeguards culture."

Reference

1. The term "safeguards" was used differently throughout the conference. To some it encompassed all actions to protect nuclear material against misuse; to others it was reserved for actions intended to inhibit states from diverting nuclear material, contrary to international agreement, from civil to military programs. Though experts understand these differences, public dialog may be confused by the use of the same term for different purposes. Since it is likely that greater public interest will be needed to generate political support for enhanced protection, clearer terminology will be helpful.

Guidelines to Speakers and Contributed Papers

Guidelines to Speakers and Contributed Papers 5

Guidelines to Speakers

The focus of the presentations should be on the actual problems in the control of fissile materials and what is being done to address these problems. This workshop is not intended to cover issues related to fissile material cutoff discussions nor issues related to the role of fissile materials in arms control discussions. The following guidelines were intended as major topics of presentations and discussions throughout the workshop:

- Concepts behind implemented (or planned) structures and mechanisms for control of fissile materials;
- Evaluation of the cost of fissile material control, accountability, and physical protection;
- The means used to measure the effectiveness of your programs;
- If possible, some specific discussion of questions such as the forms in which material exists, facility security, near and far field monitoring and detection, and personnel behavior standards;
- Any new legal and regulatory bases that had to be established;
- The role of international regimes and standards related to the protection of fissile materials;
- Lessons learned in the implementation of fissile material protection, control and accountability, including what seems to be more effective and what less.

Synopses of Papers Presented by the Participants

Current Status of Nuclear Materials Control and Accountability in Russia

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6

Introduction

The nuclear industry in the USSR was created in the 1940s as a nuclear shield against a military threat posed by the West, and in the process, special conditions were set up that ensured the safekeeping of nuclear materials, including their control, accounting, and physical protection.

The basic principles underlying control and accounting of nuclear materials were as follows: a system of top secrecy regarding nuclear materials (NM) at all stages of the production cycle, painstaking selection and training of personnel, the organization of special services for NM control and accounting at nuclear installations, the implementation of additional measures for the protection of NM and of personal responsibility for those measures, the establishment of so-called discard or unprocessed quantities of NM for each production operation, and shift-by-shift recording of NM products and residues.

The functions of the managing and regulatory organization of the installations and the oversight of the status of control and accounting of nuclear materials were performed by the USSR Ministry of Medium Machine Building—the precursor of Minatom, the Russian Ministry for Atomic Energy.

In 1992, substantial changes were initiated in the management restructure of the nuclear sector and redistribution of authority in terms of the regulation and oversight of control, accounting, and physical protection of nuclear materials.

The following documents defined the legal basis and principles for the regulation of the relations that emerge in the use of nuclear energy, and consolidated the authority of federal executive bodies and the state regulation of security in the control, accounting, and physical protection of nuclear materials:

- The Ukase of the President of the Russian Federation No. 1923 "On Top-Priority Measures for the Improvement of the System of Accounting for and Safeguarding Nuclear Materials."[1]
- The decree of the Government of the Russian Federation No. 34 (issued in compliance with the Ukase) "On Top-Priority Work to Develop and Implement a State Material Control and Accounting System for Nuclear Materials for 1995.[2]
- The Federal law of the Russian Federation "On the Use of Atomic Energy" (passed by the State Duma on 20 October 1995).[3]

The Concept of the System for State Material Control and Accounting (MC&A) of Nuclear Materials that was approved in the 14 October 1996 decree of the Government of the Russian Federation No. 1205[4] defined the function, purpose, and principles of the MC&A of nuclear materials and drew up a list of nuclear and special non-nuclear materials subject to control and accounting in the Russian Federation.

The Ukase of the President of the Russian Federation, No. 26, dated 21 January 1997, [5] set up the federal executive bodies that are responsible for state regulation of nuclear, radiation, technical, and fire safety associated with the use of nuclear energy.

Finally, the Government of the Russian Federation by its decree No. 264 dated March 7, 1997, approved the Rules of Physical Protection of Nuclear Materials, Nuclear Facilities and Stores of Nuclear Materials.[6]

This report outlines the basic principles of regulation and oversight in the Material Protection, Control & Accounting (MPC&A) area in Russia and clarifies the status of the work being done to create the state MC&A system for nuclear materials, the role played by Gosatomnadzor (Federal Inspectorate for Nuclear and Radiation Safety) in that process, and the assistance provided by foreign organizations to improve the MC&A systems at nuclear installations and to create the state MC&A system for nuclear materials in Russia.

Legal Basis for Regulation and Oversight of MC&A of Nuclear Materials

Federal Law

The Federal law "On the Use of Atomic Energy" defines the legal basis and principles underlying the regulation of relations that emerge in the use of nuclear energy for peaceful and defense purposes, with the exception of activities associated with the development, manufacture, testing, operation, and utilization of nuclear weapons and military nuclear power installations and that are carried out under other federal laws.

The law (Article 4) regards the following as separate types of activity in the use of nuclear energy:

- MC&A of nuclear materials, physical protection of nuclear materials, nuclear installations, and nuclear material storage sites;
- Export and import of nuclear facilities, equipment, and technologies; nuclear materials; and special non-nuclear materials.

The law establishes that all nuclear materials, all radioactive waste containing nuclear materials, and all defense-related nuclear facilities are federal property. Nuclear facilities that are not defense-related are also federal property, unless otherwise established by law.

State control of the use of nuclear energy is effected by agencies for the control of nuclear energy use whose jurisdiction, under the statutes for those agencies, includes the physical protection of nuclear facilities and nuclear materials and the state MC&A of nuclear materials (Article 20).

The law allows federally owned nuclear materials to be transferred for use solely to legal entities that have a license issued by state safety regulation authorities to perform operations associated with the use of nuclear energy and on the basis of contracts concluded by a state agency specially authorized to do so (Article 5).

State regulation of safety in the use of nuclear energy is effected by state safety regulation agencies that, within their jurisdiction, have the authority to perform licensed activities involving the use of nuclear energy (Articles 24–25). The licenses are issued by operating organizations, as well as by organizations that perform operations and render services involving the use of nuclear energy (Article 26).

The operating organization bears full responsibility for the safety of a nuclear facility, as well as for the proper handling of nuclear materials (Article 35). The operating organization does the following: uses nuclear facilities solely for the purposes for which they were intended; performs MC&A of nuclear materials; effects physical protection of nuclear facilities and nuclear materials.

Article 22 stipulates that nuclear materials are subject to state MC&A at the federal and departmental levels in the state system of MC&A of nuclear materials, and it specifies the procedures for setting up such MC&A. The agencies that perform such control and accounting are also specified by the Government of the Russian Federation.

Article 61 specifies the disciplinary, administrative, or criminal liability of officials of state agencies, local self-government-agencies, agencies for managing the use of nuclear energy, operating organizations, and employees of nuclear facilities for, among other things, the following:

- Violation of the terms of the license to perform operations involving the use of nuclear energy;
- Noncompliance or improper compliance with the orders issued by state safety regulation agencies;
- Obstruction of the performance by officials of state safety regulation agencies of their functions;
- Noncompliance with the requirements for physical protection of nuclear facilities or nuclear materials;
- Violation of established procedures for MC&A of nuclear materials; theft of nuclear materials;
- Violation of established procedures for the export and import of nuclear facilities and nuclear materials.

MC&A

The Concept for the state system of MC&A of nuclear materials defines the three basic functions of that system:

- Development and implementation of rules and regulations for MC&A of nuclear materials;
- MC&A of nuclear materials;
- Oversight of state MC&A of nuclear materials.

In conformance with the presidential Ukase No. 26, the following federal executive agencies are defined as agencies responsible for state safety regulation in the use of nuclear energy: Gosatomnadzor of Russia, the Ministry of Health of Russia, the Ministry of Internal Affairs of Russia, and Gosgortekhnadzor (Federal Mining and Industry Inspectorate) of Russia.

The Concept of the state MC&A system for nuclear materials specifies the following:

- Minatom of Russia is responsible for effecting state MC&A of nuclear materials intended for use for peaceful and defense purposes;
- The Ministry of Defense of Russia is responsible for effecting state MC&A of nuclear materials intended for use for defense purposes.

The Concept also specifies the organizations responsible for effecting oversight of state MC&A of nuclear materials at the federal level:

- Gosatomnadzor of Russia, for oversight of nuclear materials intended for use for peaceful purposes;
- The Ministry of Defense of Russia, for oversight of nuclear materials intended for nuclear weapons and defense-related nuclear power facilities.
- Control of the transport of nuclear materials across the customs border of Russia at the federal level is effected by the State Customs Committee of Russia.

Thus, Gosatomnadzor of Russia, Minatom of Russia, the Ministry of Defense of Russia, and the State Customs Committee of Russia are responsible, within their specific jurisdictions, for the system of state MC&A of nuclear materials.

According to the Concept, the main objectives of the system of state MC&A of nuclear materials are as follows:

- Ascertain the quantities of nuclear materials on hand at the locations where they are kept;
- Draw up, record, and keep accounting and reporting documents;

- Provide notification of losses, unauthorized use, or theft of nuclear materials and to prevent them;
- Provide federal executive agencies with information concerning the existing levels and movement of nuclear materials, as well as concerning the export and import of such materials;
- Monitor the Russian Federation's observance of its international obligations in the nonproliferation of nuclear weapons.

Federal Regulations

Rules of Physical Protection

The recent Rules of Physical Protection of Nuclear Materials:

- Define requirements to all utilities operating nuclear facilities, to all federal agencies coordinating or supervising nuclear activities in accomplishing proper measures to protect nuclear materials and nuclear facilities against internal or external threat;
- Determine functions and responsibilities of the agencies in arranging and applying physical protection and define basic requirements to protect nuclear facilities and nuclear materials during their transportation.

All of the utilities operating nuclear facilities are requested to take necessary measures to meet these Rules by January 1, 1999.

Unfortunately, there are no federal regulatory documents that specify rules and regulations for effecting MC&A of nuclear materials. The existing rules for MC&A of nuclear materials are based on the following:

- A system of departmental regulatory documents that were developed, by and large, in the 1980s and that do not take into account the changes that have taken place in Russia;
- Individual departmental regulatory documents and guidelines that were developed or reworked in the 1990s and that are devoted to specific aspects of the MC&A of nuclear materials;
- Individual administrative documents at the sector level (orders and instructions issued by agencies for managing the use of nuclear energy) and at the facility level (such as discard or unprocessed quantities of NM).

The further development of the legal and regulatory base for the MC&A of nuclear materials is underway. However, several years are needed to transform it into a streamlined hierarchy of laws, federal regulations, and regulatory documents and guidelines of various levels that will specify the requirements and procedures for the functioning of all components of the systems of state MC&A of nuclear materials at all levels.

Among the federal-level documents being developed are the following:

- Statute on the System of State Material Control and Accounting of Nuclear Materials in the Russian Federation;
- Basic Rules for the Material Control and Accounting of Nuclear Materials;
- Procedures for Setting Up the System of State Material Control and Accounting of Nuclear Materials in the Russian Federation;
- Concept of Physical Protection of Nuclear Materials and Installations.

Authority of Gosatomnadzor of Russia

At present, the authority of Gosatomnadzor of Russia in the regulation and oversight of MC&A of nuclear materials is defined by the above-mentioned documents, as well as by the Statute on Gosatomnadzor of Russia approved by the 5 June 1992 Order of the President of the Russian Federation No. 283-rp, with amendments approved by the 12 November 1992 Ukase of the President of the Russian Federation No. 1355 and the 16 September 1993 and 26 July 1995 orders of the President of the Russian Federation Nos. 636-rp and 350-rp, respectively.

According to that statute, Gosatomnadzor of Russia, in conformance with the task charged to it (Article 7), shall do the following:

- Generate proposals for draft legislation and other legal acts regarding aspects of the MC&A of nuclear materials and the implementation of safeguards for the nonproliferation of nuclear technologies and nuclear materials and for the physical protection of nuclear facilities and nuclear materials, and submit those proposals to the Government of the Russian Federation in the proper manner for review;
- Issue permits (or licenses) for types of activity that are related to the use of nuclear energy;
- Set up and effect state oversight of the status of MC&A of nuclear materials and the physical protection of nuclear facilities and nuclear materials;
- Establish reporting procedures and forms;
- Analyze incidents that take place at facilities that are under oversight and create a databank;
- Implement international cooperation within the limits of its jurisdiction regarding aspects of the nonproliferation of nuclear technologies and materials and their physical protection.

In accordance with the statute, Gosatomnadzor of Russia has the right to do the following:

- At facilities under its oversight, perform inspections and obtain requisite explanations, reports, and information on matters that arise;
- Issue to directors and other officials of enterprises and organizations binding orders to correct license-term violations and violations of requirements specified by rules and regulations and to temporarily suspend operations being performed when there are violations of requirements specified by rules and regulations, as well as monitor the observance of the terms of licenses that have been issued and the compliance with orders that have been issued;
- Suspend or terminate the validity of licenses that have been issued if a violation of Russian Federation law is identified;
- Obtain from the heads or other officials of ministries, departments, executive bodies, enterprises, or organizations requisite documents and the materials to substantiate them.

The tasks charged to Gosatomnadzor of Russia are carried out by divisions of the Main Office, organizations within the jurisdiction of the Main Office, and regional agencies (districts and on-site inspections).

Principles Underlying the Organization and Implementation of Oversight of MC&A of Nuclear Materials

Management of the oversight of the MC&A of nuclear materials shall be carried out by the Main Office of Gosatomnadzor, whereas organization of the work associated with that oversight and the day-to-day activities, including facility inspections, shall be carried out by the regional offices of Gosatomnadzor of Russia.

Gosatomnadzor Structure

The Gosatomnadzor structure is, in general, the GAN HQ in Moscow, seven regional directorates, Science and Technology Center in Moscow, Interregional Information Center in Moscow, Education and Training Center in Novovoronezh, and the Foreign Trade Organization “Safety LTD” in Moscow.

The GAN HQ accomplishes the state regulatory functions, which are to:

- Develop criteria, rules, and standards in nuclear and radiation safety areas, in nuclear material accountability, and in control and physical protection areas;

- Issue licenses;
- Determine main directions in R&D towards increasing nuclear and radiation safety and improving safeguards.

The regional directorates consist of the head offices, district inspection units and on-site inspections services that are located at the territories of most nuclear installations in Russia. The regional directorates are in charge of carrying out inspections, controlling provisions and requirements of the licenses to be fulfilled by facility operators, issuing special permissions, and developing guides and instructions.

In all, some 70 nuclear facilities (one facility can include several nuclear installations) are now under the oversight of Gosatomnadzor of Russia in terms of the MC&A and physical protection of nuclear facilities and nuclear materials.

The basic principles underlying the organization and implementation of oversight at the regional level are as follows:

- Generation of regional-level regulatory documents;
- Planning;
- Management of inspection services located right at the facilities;
- Inspections;
- Analysis of inspection results;
- Interaction with organizations under oversight;
- Interaction with local executive bodies;
- Keeping higher offices and local government agencies informed;
- Creation of an informational and hardware base and use of it for oversight purposes.

When developing the state MC&A system in Russia, the major elements of the international philosophy of safeguards have been taken into consideration, in particular the categorization of nuclear material and classification of nuclear installations upon NM categories. The Materials Balance Accounting approach is also being introduced in Russia. We have analyzed national MC&A and international safeguards systems used in the European countries (EURATOM, France, the UK), in the USA, and in the other states.

Measures of Strengthening Effectiveness of Inspections

One main component of an effective state MC&A system is the ability of inspectors to perform independent control and verification of NM, which requires equipping inspectors with proper instruments and training.

The following types of instruments are being provided to the GAN regional directorates: hand-held monitors, portable multichannel gamma analyzers with an NaI detector and with a germanium detector, active well coincidence counters, passive neutron coincidence counters, active neutron coincidence collars, Cherenkov viewing devices, and seals.

The current cooperation programs of GAN with foreign collaborators are targeted toward strengthening the GAN role as a national regulatory agency, and increasing the efficiency of inspection activities that, among other elements, require up-to-date instrumentation. Most of the equipment to be provided to GAN is discussed and coordinated under the Agreement between Gosatomnadzor of Russia and the U.S. Department of Energy (DOE), on cooperation in nuclear material control and accountability and physical protection areas within Project 3 (coordinated by the Los Alamos National Laboratory from the U.S. side). Two GAN-EURATOM Safeguards facility-oriented projects envisage deliveries of instruments to the Northern European Region of GAN and of surveillance equipment for two nuclear power plants (NPPs).

Providing inspectors with instruments comprises three major stages: (1) development of specifications and preparation and delivery of instruments; (2) development of methods of measurement, guidelines, and operating instructions; instrument calibration, certification, tests, and standards production; and (3) inspector training, administrative arrangements, and service.

These stages require separate consideration, analysis, and planning to prepare detailed action work plans. Within the DOE-GAN Project 3, substantial efforts were made to develop sub-tasks with completion standards for the Project work plan. At present about 40% of the equipment has been delivered to Russia

Training of inspectors and instructors and pre-operation preparedness of equipment has been completed.

Measures to Accelerate Creation of the State MC&A System for Nuclear Materials

The basic measures that will make it possible to fundamentally improve the control, accounting, and safeguarding of nuclear materials are as follows:

- Developing and implementing the system of State MC&A for NM;
- Developing and implementing, at the state level, regulatory documents regarding MCP&A of nuclear materials;
- Bringing departmental and facility-specific regulatory documents regarding MCP&A of nuclear materials into conformance with current requirements;
- Outfitting nuclear facility personnel and security and Gosatomnadzor and customs inspectors with equipment (instruments) for detecting and identifying nuclear materials;
- Improving the MC&A systems for NM at nuclear facilities by having them meet current international criteria and by using approaches that involve highly accurate measurement instruments and containment and observation hardware;
- Expanding the inspection services of Gosatomnadzor of Russian and the Ministry of Defense of Russia;
- Creating a state-of-the-art automated information system that provides reliable information on the quantities, location, and special features of NM;
- Improving the system for screening nuclear facility employees and monitoring their reliability, and using modern equipment for that (special testing).

The complex of measures needed to create, implement, and operate the system of State MC&A for Nuclear Materials is included in the draft federal special-purpose program developed by Minatom of Russia, Gosatomnadzor of Russia, and other ministries and departments concerned.

The following are among the main areas associated with the improvement of the activities of Gosatomnadzor of Russia in the MC&A of nuclear materials and in the physical protection of nuclear materials, nuclear facilities, and nuclear-material storage sites:

- Creation of a system of regulatory documents and guidelines for the MC&A of NM;
- Outfitting the infrastructure of Gosatomnadzor of Russia with instruments for measurement of nuclear materials;
- Improvement of the licensing procedure for the use of nuclear energy in terms of specifying the license terms with regard to the MCP&A of nuclear materials and verification of compliance with those terms;
- Improvement of inspection-related activities;
- Creation of an automated system for oversight of the control and accounting for nuclear materials and the physical protection of NM.

The tasks enumerated above should be handled in a manner that takes international experience into account and that is based on a broad international cooperation, primarily with the International Atomic Energy Agency, EURATOM, DOE, and the Nuclear Regulatory Commission.

International Cooperation

Six basic projects are currently actively implemented within the framework of the Agreement on cooperation between Gosatomnadzor and the U.S. DOE. The basic orientation of these projects consists in rendering technical and financial support in development of parts of the system of the state accounting and control of nuclear materials and in modernization of MPC&A systems at several Russian nuclear installations which are not operated by Minatom:

Project 1: Support in development of regulatory documents of the Federal and ministerial level.

Project 2: Development of the federal MC&A information system.

Project 3: NDA instrumentation provision for GAN inspectors.

Project 4: Development of the GAN MPC&A oversight information system.

Project 5: Support in training GAN inspectors.

Project 6: Support in up-grading MPC&A systems at the following non-Minatom facilities:

- Institute of Nuclear Investigations, Dubna;
- Polytechnical University, Tomsk;
- Nickel Combine, Norilsk;
- Institute of Nuclear Physics, Gatchina;
- Karpov Chemical and Technological Institute, Obninsk;
- Krylov Institute, St. Petersburg;
- Baltisky Shipyard Company, St. Petersburg.

At present, the preparatory stages of task specification and project content are completed, and the progress on these projects is good.

Gosatomnadzor has established a long-term program with the U.S. Nuclear Regulatory Commission and is negotiating projects with the Swedish Nuclear Power Inspectorate and the Finnish Center for Radiation and Nuclear Safety that will focus on exchange of experience and information in the MPC&A area.

Gosatomnadzor and EURATOM Safeguards have cooperated on several joint projects, including perfection of inspection activities, creation of the automated information system of MPC&A oversight in the Northern-European district of Gosatomnadzor, development of procedures of physical inventory taking, and verification for some of the Russian installations. These procedures were applied in practice at the fuel fabrication plant NZKhK in Novosibirsk, Kalinin NPP, and Novovoronezh NPP. Beginning in 1997, some complexities in the financing by the Commission of European Union, which had been a negative influence on the performance of the projects, were removed.

References

1. Ukase of the President of the Russian Federation of 15 September 1994, No. 1923 “On Top-Priority Measures for the Improvement of the System for Accounting for and Safeguarding Nuclear Materials.”
2. Decree of the Government of the Russian Federation of 13 January 1995, No. 34 “On Top Priority Work to Develop and Implement a State Material Control and Accounting System for Nuclear Materials for 1995.”
3. The Federal law of the Russian Federation “On the Use of Atomic Energy,” approved by the State Duma on 20 October 1995.
4. The Concept of the System for State Material Control and Accounting (MC&A) of Nuclear Materials approved by the RF Government on 14 October 1996.
5. Ukase of the President of the Russian Federation of 21 January 1997, No. 26 “On the federal executive bodies responsible for state regulation of safety associated with the use of nuclear energy.”
6. The Rules of Physical Protection of Nuclear Materials, Nuclear Facilities and Stores of Nuclear Materials approved by the decree of the Government of the Russian Federation of 7 March 1997, No. 264.

Materials Protection, Control, and Accounting: Recent Experience in Russia

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7

Introduction

The disintegration of the Soviet Union resulted in a number of problems with serious consequences for the Newly Independent States (NIS). The most dramatic changes have occurred within the nuclear arena. As with the rest of the USSR's property, nuclear-related matters were split among the NIS, with Russia assuming responsibility for nuclear weapons and most of the nuclear resources and industries, including nuclear-weapons manufacturing and maintenance and the peaceful uses of atomic energy; scientific resources, including scientists, research installations and facilities; and intellectual property and information.

The resources, industries, and nuclear materials were taken out of military control and divided according to territory. The NIS now face the full spectrum of Materials Protection, Control, and Accounting (MPC&A) problems, especially in connection with signing the Non-Proliferation Treaty and implementing international safeguards as separate, sovereign entities.

The most complicated problem is managing scientific and intellectual properties that are the result of more than 50 years of experience and operation within the USSR's nuclear program.

Present Situation with MPC&A in Russia

Russian nuclear specialists must work under the following conditions:

- Nuclear materials, installations, and information are now under the control of a new government, political system, and national constitution. Under an equally new financial situation, the nuclear program was significantly reduced and most research programs were ended.
- Inventory and reporting, verification, transportation, and communications are completely changed.
- The "old" (Soviet) accounting system is still in force in Russia, but its effectiveness in materials balance is unsatisfactory given the present political and social situation.
- The "old" approach in physical protection, based on external threats, does not correlate with the present situation. Social conditions and criteria completely different from the Soviet time and new "insider" threats must

be accounted for in designing and enhancing physical protection systems.

- Controls over people working with nuclear materials are much weaker than before, and the change of a generation of nuclear specialists make this situation less predictable.

The Russian government is organizing its MPC&A activities using all available resources—the conversion of military-related industries to produce commercial products; the support of scientists in the nuclear-weapons program through the International Science and Technical Center (ISTC) and other cooperative programs; the use of additional technical and financial support offered by different countries and international organizations added to Russia's limited resources. To achieve this goal, it is necessary to solve the following problems:

- The legislative and regulatory base must be adjusted to reflect the present political and economic situation;
- The country's Materials Control and Accounting (MC&A) system must be modernized for communication and information flow;
- The technical means must be established to maintain MC&A, including containment and surveillance, nondestructive analysis and destructive analysis measurements, calibration of instruments and standards for this calibration, and relevant sets of standards and procedures;
- Physical protection systems must be designed to include "insider" threats;
- Institutes for the inspection and verification of nuclear materials' activity must be officially established;
- The program of training personnel in MPC&A countrywide must be improved and the "safeguards culture" in general must be improved.

Legislation

The legislation and regulations are being developed, with the following documents now in force or in the process of approval:

1. Russian Law on the Use of Atomic Energy (in force since 1994);
2. Presidential Decree on MPC&A Development (signed September 1995);
3. Government Order on MPC&A Development (signed January 1995);
4. Draft of the Federal Conception on MPC&A in Russian Federation (accepted by the Russian government but the financing not yet approved by Russian Parliament);
5. General Provision for Physical Protection of Nuclear Materials and Installations (approved by the Russian government in March 1997 and in force now);
6. Draft of General Provision for MC&A (not approved as yet, in process);
7. A set of regulatory documents (standards, instructions, methods, etc.) is being drafted.

The most important document for any future progress in MC&A is the General Provision for MC&A (an analog of DOE Order 5633.3B). Without this document, most of the MC&A activity is just preparation for the future, but it is not necessary to wait until all legal documents are finally approved.

MPC&A Communication and Information

Most of the activity under the collaborative U.S.-Russian MPC&A program has focused on the creation and development of a national database for the Russian MPC&A system. Historically, Minatom, the Russian Ministry for Atomic Energy, existed as the main agency responsible for tracking all nuclear materials in the USSR. In Russia now, under the Law on the Use of Atomic Energy, all nuclear materials are declared as Federal Property and Minatom is the government agency responsible for nuclear materials and reports to the President's office and to the government. It means that, at present (especially after the disintegration of the Soviet Union), the first and most important step is to establish an information system and database using modern data management and data transfer. The database on the nuclear materials now considered Russian property must be revised, necessitating an initial physical inventory on all levels starting at Material Balance Areas.

During the Soviet era, information systems and the database were based primarily on financial balances. Such information systems cannot satisfy current requirements. Several main points need to be considered in upgrading the information system and database and all these upgrades need to be done in very short period of time:

- Recording and reporting systems must be upgraded to match new regulations;
- The most appropriate and reasonable body to be the official agency responsible for handling and maintaining of the national information system and database is Minatom and should be officially designated as such. It could be some other agency (GAN? Ministry of Finance?), but this question has not been completely addressed.
- Information flow must be clarified in accordance with new regulations which have not even been drafted;
- The electronic form and transmission of information into the system and database must be based on modern communication technology.

MC&A Technical Means

The effective functioning of MC&A based on a combination of supporting technical means should include the following main issues:

- Non-Destructive Analysis of nuclear materials for inspections and accounting, including sets of gamma and neutron measurement instruments, relevant calibration and standards, standard procedures for measuring, sampling, reporting results, evaluating results;
- Destructive Analysis, including instruments, sampling techniques, procedures, and results' evaluation;
- Weighing of nuclear materials, including instruments, calibration, results' evaluation;
- Containment and Surveillance (C&S) measures such as Tamper-Indicating Devices (TIDs), seals, video surveillance;
- Evaluating the combination of measurements and C&S measures, reporting and investigating any cases of unauthorized access to nuclear materials.

This part of MC&A is underdeveloped, a holdover from the Soviet era. For example, TIDs are not produced in Russia. Gamma-based instruments could be produced by some organizations, but the industrial infrastructure is undeveloped for mass production. Neutron-based instruments could be produced but investments are needed to convert military-oriented production capacity. Nowadays, it is not necessary to produce everything by ourselves; the best way is to cooperate with experienced manufacturers, but well-known companies are very cautious about such cooperation for reasons we can appreciate. As an example at IPPE, we are working on producing E-cup seals. When we asked through Pacific Northwest National Laboratory about cooperating with an American company, we were told that the company was not interested.

Physical Protection

Physical protection (PP) was traditionally an advanced part of MPC&A in the USSR and in Russia with designs based on threats from "outsiders." In the beginning of the 1960s in the USSR, the "man-with-a-gun" approach was partially replaced with detectors, monitors, etc. These technical means are still in use in many cases and cannot be replaced due to lack of funding, but research and development in PP is progressing and a number of organizations and companies (some of them private) are working in this field. This interest can be explained by the commercial sector (banks, companies, offices) demanding PP systems.

For MPC&A, the extensive experience accumulated in designing and constructing PP systems in the USSR must be revised to satisfy new requirements. The new General Provision for Physical Protection of Nuclear Materials and Installations, approved in March 1997, requires that both "insider" and "outsider" threats are taken into account; this means that all existing PP systems must be analyzed from a vulnerability point of view and remediated as necessary.

Training of Personnel in MPC&A

This is a vital part of MPC&A. Properly planned and conducted training programs increase the effectiveness of the MPC&A systems. Unfortunately, for many reasons, this part of MPC&A is not well organized or planned in Russia. Strategic planning of training programs must consider that most of the experienced personnel working now at Russian facilities are close to retirement. Sometimes, these people have difficulty in accepting new MPC&A technology, for example, new containment and surveillance or access control techniques. Also, these people grew up in a different political society (even in other countries!). The new generation of nuclear specialists have little experience and they too have been educated under a different political situation.

The training of personnel and the sharing of experience through specialized training centers (for example, RMTC, the Russian Methodological and Training Center in Obninsk) can accomplish much. Universities can teach nuclear disciplines. Workshops, seminars, and technical conferences can be conducted at the various nuclear facilities, organized by senior experts and invited trainers.

Our experience acquired over the last two to three years in training personnel at Russian facilities taught us that most of the people coming to RMTC have good technical backgrounds and just need hints to get a sense of modern MPC&A technology. Also, courses, workshops, and seminars are very effective ways to establish and improve a "safeguards culture."

In summarizing the abovementioned problems, it is possible to formulate short-term and long-term goals for MPC&A in Russia:

- Short-Term Goals
  - — Develop the legislative and regulatory base;
  - — Prepare and conduct the Initial Physical Inventory at all Russian facilities;
  - — Develop a computerized Materials Control and Accounting System, starting from single Materials Balance Areas up to the federal level supported by modern technical means;
  - — Upgrade PP systems at the most sensitive facilities;
  - — Train personnel directly involved in MPC&A.
- Long-Term Goals
  - — Create and develop a "safeguards culture" among Russian MPC&A specialists;
  - — Create and develop our own (Russian) capabilities to manufacture and maintain MPC&A equipment;
  - — Create and support a federal accounting system based on modern communication means;
  - — Include the Russian MC&A system with the International Safeguards system;
  - — Establish a "transparent" information system to support the Non-Proliferation Treaty regime worldwide.

There is also an inspection and verification problem important to the effective functioning of an MPC&A system. So far, this problem is still under discussion and no final decision has been made about which agency will independently verify nuclear-materials inventories or how any internal physical verification of nuclear materials will be performed, but this is a question for special discussions.

Improvements of MPC&A in IPPE

The Institute of Physics & Power Engineering is a major scientific research and development (R&D) laboratory in Obninsk, Russia, under the jurisdiction of the Ministry for Atomic Energy of the Russian Federation. IPPE's R&D specialties focus on nuclear power engineering, fundamental and applied investigations, and nuclear technologies for the national economy. Within IPPE are several major facilities with weapons-grade nuclear materials, plutonium and highly enriched uranium (HEU). Within the context of the cooperative US-Russia MPC&A Program, IPPE is implementing improvements.

MPC&A cooperation between the U.S. DOE National Laboratories and IPPE began in September, 1994, and the first tasks were initiated during February, 1995. These tasks were completed and additional ones begun in 1996. The initial two series of tasks focused on MPC&A improvements at specific facilities at IPPE, namely the Fast Critical Facility (BFS), the Technological Laboratory for Fuel Fabrication (TLFF), and the Central Storage Facility (CSF).[1,2,3,4]

The latest series of tasks in 1997 focuses more heavily on site-wide issues. Key elements in this site-wide program are the consolidation of nuclear material, the ongoing construction of a nuclear island, and the establishment and initial functioning of a separate IPPE division for MPC&A. With the expectation that intensive U.S. support will decline in the years ahead, another important theme is the ultimate sustainability of the specific technological upgrades and the improved MPC&A culture.[5]

The administration of the work was described in previous papers.[6,2] The U.S. DOE National Laboratories participating in the work with IPPE are Brookhaven, Los Alamos, Lawrence Livermore, Oak Ridge, Pacific Northwest, and Sandia.

MPC&A Plan

During the past year, IPPE has taken major steps to integrate its material control and accounting functions with its physical protection functions. This includes the organizational placement of both in a new MPC&A division under a single head (see below). In addition, IPPE has begun formulating an integrated MPC&A Plan. This document is intended to be a "living" document with periodic reviews and revisions; a detailed outline has already been written and reviewed.

MPC&A responsibilities will be clearly specified in the integrated MPC&A Plan. It is currently envisioned that there will be two management levels. One will deal with local administration and operation of material balance areas (MBAs); the other will deal with nuclear material management over all IPPE systems.

As delineated in the consolidation program (discussion below), there will be seventeen MBAs using a single accounting system with common requirements and unified procedures. The system nuclear material management functions under consideration for inclusion are:

- Complete nuclear material balance at IPPE;
- Organization and control of MBA activity;
- Organization of physical inventories in the MBAs;
- Data treatment and results;
- Report presentations inside and outside IPPE;
- Nuclear safety, fire safety, and industrial safety;
- Nuclear material transport;
- Personnel training requirements;
- MPC&A equipment provision;
- Physical protection of MBAs.

The IPPE integrated MPC&A Plan will be consistent with Russian and international standards and requirements, but will give consideration to those of the United States as well.

IPPE MPC&A Division

The IPPE MPC&A Division was organized to do scientific R&D funded by IPPE's own resources, to design and improve MPC&A, and to conduct a unified scientific and technological program with other divisions of IPPE in this area. Such a division is new for Russian facilities. It is an independent unit within IPPE and has two scientific laboratories—one for MC&A and one for physical protection—to discharge these functions.

The division head reports to the IPPE First Deputy Director. The division head provides direction for the administration, R&D, organization, and daily operation of the division. Such a division is new for Russian facilities.

The following are the tasks of the division:

- Scientific support for creation at IPPE of a unified MPC&A system;
- Participation in the program to create a national MPC&A system;
- Scientific and methodological support of MPC&A operations at IPPE;
- Evaluation of the threats to IPPE and formulation of means to counter them;
- Explanation of vulnerabilities in MPC&A and potential diversion paths;
- Organization of the development of requirements for design and construction of physical protection and its improvement;
- Participation in the program of nuclear material consolidation at IPPE;
- Development of general functional and system requirements for computerized accounting systems in MBAs and harmonizing of database design for different MBAs;
- Development and operation of the integrated site-wide computerized accounting system;
- MPC&A policy definition and implementation and coordination of the activities of different IPPE divisions in the area of MPC&A;
- Protection of computers and computer data used in the MPC&A system from outsiders and the protection of sensitive information.

Consolidation of Nuclear Materials

To improve MPC&A in an efficient manner, IPPE has initiated a program to evaluate and carry out the consolidation of specific nuclear activities to a limited number of facilities.[2] As a first step, nuclear materials from decommissioned facilities are being transferred to the existing CSF as long as space is available there. In the second stage, fresh nuclear material, primarily HEU, will be transferred from the existing CSF (and from other decommissioned facilities) to another building located adjacent to BFS. These two adjacent buildings, BFS and the new storage building, would comprise a "nuclear island" with several common physical protection elements. The entire consolidation project will lead to the following MPC&A improvements:

- Reduction by approximately a factor of two from the current number of nuclear material locations at IPPE, including a reduction by eight in the number of buildings;
- Creation of a zone of enhanced physical protection for most nuclear materials at IPPE.

Realization and completion of the consolidation project will depend to a substantial degree on the schedule for operation of the new storage location adjacent to BFS.

The structure of nuclear materials allocation and usage created as a result of the consolidation project will serve as a basis for development of the IPPE site-wide MPC&A system. For each nuclear material location, a vulnerability analysis will be carried out and physical boundaries of access control to the nuclear material and MBAs will be determined.

Nuclear material accounting and control and their measurements will also be organized. Depending on nuclear material type and technology-specific features of its usage, all MBAs can be subdivided into five types. Thereafter it would be possible to elaborate a flexible approach to organization and cost of operation of the MPC&A system being developed.

Nuclear Island

Physical protection of nuclear materials at IPPE is being improved by means of the construction of a “nuclear island.” The concept is to add an additional layer of technological barriers around areas in which high concentrations of nuclear materials exist. BFS and the new Central Storage Facility are adjacent to each other and will contain (when completed) most of the nuclear material at IPPE. The concept of making a nuclear island containing these two facilities emerged last year. Preliminary and final designs have been completed and construction is now underway.

The design includes a double fence with barbed wire surrounding the two facilities, with two different sets of detection sensors, lighting, and video assessment to determine the cause of alarms. The sensor and video information is routed to an alarm station located within the nuclear island. An access control portal with badge exchange, entry control turnstiles with biometric identification, weight measurement, and metal and nuclear detectors is included in the design. Packages entering and leaving the nuclear island will be x-rayed by a device similar to those used in airports. A vehicle gate is adjacent to the access control portal and, when completed, will have a movable vehicle barrier and a wait-in nuclear-material monitor for vehicles. A resident response force will also be stationed within the nuclear island to make appropriate response to alarms received from within the nuclear island.

This concept of a nuclear island is more economical than increasing physical protection for each individual facility and creates an additional layer of physical protection for the area where nuclear material is concentrated.

Selected Site-Wide Technical Elements

Computerized Accounting

The new site-wide approach to MC&A at IPPE has been extended to the area of computerized MC&A. Computerized accounting systems are fully or partially operational at BFS, TLFF, and the CSF. In addition a site-wide system is being developed. The work on these four systems is being coordinated by a single project leader. This will enable each facility to develop its own system that meets its own data storage and reporting needs, while maintaining compatibility with the systems at the other IPPE facilities and with the site-wide system. BFS, CSF, and TLFF have their own servers and databases, which will be parts of the distributed site-wide database. The site-wide server will have access to all data needed for IPPE MC&A reports. As other IPPE facilities generate MC&A data, they will be able to link into this network, some of them through client computers installed at these facilities, others through portable equipment. These data will also be stored on the site-wide server. A strong team of computer professionals at IPPE has been assigned to this work.

Bar Coding

Bar coding of fuel disks at the BFS facility is continuing. The personnel at BFS have evaluated and rejected a technique that involved flame spraying a thin coating of aluminum oxide onto fuel disks before bar coding with an inkjet printer. The technique was rejected because the process caused excessive distortion of dummy test disks.

An alternate approach was evaluated and accepted. This new approach uses a thin stripe of white paint to replace the aluminum oxide. The very small hydrogen content of the dried paint is acceptable and ink jet printing will still be used for bar coding. BFS will proceed with plans to document a marking procedure and bar code for approximately 20,000 disks by Spring 1998.

IPPE is also planning to initiate a site-wide bar coding system that will eventually encompass the great majority, if not all, of its nuclear material.

Weight Measurements

The focus of this work has been to upgrade the materials accounting system at IPPE by incorporating high-resolution digital balance technology electronically linked to the material accounting databases. Electronic balances have been installed at BFS, TLFF, and the CSF. The data management system will include quality control procedures to ensure the integrity of individual measurements. Working standards have been acquired and protocols for calibrating balances and other devices in the measurement chain are being developed. The IPPE Metrology Division is responsible for coordinating the site-wide program. It is acquiring certified standards, maintaining working standards, developing maintenance procedures, and establishing a calibration program.

Gamma-Ray Measurements

IPPE staff at BFS completed fabrication and testing of a sodium-iodide-based measurement instrument to scan fuel tubes of the BFS fast-critical assemblies. The instrument automatically counts and identifies by material type the fissile material disks in each fuel tube. This instrument will speed the inventory process on the fuel tubes by eliminating the need to unload them and will also reduce operator exposure to radiation.

CSF and TLFF staff are testing and implementing a high-resolution gamma-ray detector for isotopic measurements for MC&A of nuclear materials stored and processed in these facilities. In addition, they have fabricated five nuclear material quick-identification devices for control of nuclear materials received in, shipped from, and stored in these facilities.

Tamper-Indicating Devices

IPPE has begun implementation of a tamper-indicating-device (TID) program. Steps have included the development of a program plan and implementing procedures and initial implementation of the program. IPPE has designed and implemented a TID for use at the end of BFS fuel rods and BFS storage containers and is developing methods for production of a loop-type TID. IPPE staff members participate as instructors in teaching the TID training course at the Russian Methodological and Training Center. In the coming year IPPE personnel will complete implementation of the TID training program and will continue to work with U.S. personnel to ensure that the TID program meets developing Russian standards. Pilot production of the loop seal will begin this fall, with initial production distributed for testing.

Procedures for Physical Inventory Taking and Material Balance Closure

At BFS, TLFF, and CSF, procedures have been developed and tested for physical inventory taking (PIT), material transfer, and material balance closure. Implementation is at various stages for the three respective facilities. The procedures provide one of several foci for the computerized accounting, bar coding, weight, and nuclear measurements and TID program already described. Finally, a site-wide PIT program is being initiated for certain MBAs that will employ portable equipment.

Video Monitoring Systems for Storage and Critical Assembly Areas

For BFS, TLFF, and CSF, automated and unattended video monitoring was selected as a material control and protection measure designed to provide real-time detection and recording of events in these areas, to show when and where materials are moved, and to provide real-time alarms and live video to protection force personnel during nonworking hours. In these facilities, the camera's video signal is input to a computer where image-analysis software is used to detect events such as personnel entry into a storage vault. Depending on the shift, the event may be recorded and stored for later review with respect to the safeguards significance of the activity, or an alarm signal and live video can be sent to the Nuclear Island's Central Alarm Station (NI-CAS).

At BFS, two critical assemblies and four associated storage rooms are monitored by these cameras. In the BFS-1 and BFS-2 areas, one camera is used to view the critical assembly stand and one to view the fuel-element assembly table. When experiments are being set up or performed, all activities can be recorded for safeguards review, or for general documentation of the experiment. Storage vault rooms containing a variety of materials used for BFS are monitored continuously. During working hours, events occurring in these rooms are recorded for safeguards review; at other times, an alarm signal will be sent to the NI-CAS, along with live video, so that a response can be formulated by protection force personnel.

TLFF is an active facility that is currently recladding materials used by the BFS. Two vault rooms will be monitored by cameras, recording all access to the vaults. Operational procedures for this facility are currently being drafted, but it is possible that the video monitoring system will be used in a similar manner as at BFS: recording working-hour access to areas under surveillance, and providing alarms to the NI-CAS at other times.

Currently under reconstruction, the new CSF will provide storage for a large quantity of materials under the IPPE nuclear material consolidation program. The new CSF building will be equipped with more than forty cameras to provide unattended monitoring for stored materials; the existing CSF has nine storage rooms equipped with cameras that will monitor materials currently in storage.

Sustainability

The cooperative MPC&A enhancement program consists of three sets of activities:

- Planning—Preparation activities involving a review of site characteristics, selection of approach, identification of specific MPC&A elements to be upgraded, and formulation of schedules and milestones.
- Implementation—Joint tasks which are periodically reviewed and updated to develop methods, prepare operating procedures, acquire necessary equipment, install equipment, establish maintenance infrastructure, and train personnel.
- Sustainability—Focus on safeguards operation, development of procedures for routine operation, maintenance and evaluation of the MPC&A system, assessment of the effectiveness of the integrated safeguards system, recommendation of additional measures where vulnerabilities are found to exist, and support of the safeguards infrastructure put into place during the implementation phase.

It is important to note that the Russian Federal Nuclear and Radiation Safety Authority (GAN) and Minatom are currently modernizing requirements for MPC&A, and it is these requirements that will govern the MPC&A system.

Thus, the ultimate objective of the cooperative effort is to achieve a robust and sustainable MPC&A system that meets Russian requirements. At this stage, the focus will shift from the improvement of IPPE's MPC&A to the operation, maintenance, evaluation, and effectiveness assessment of its MPC&A system as delineated above. Safeguards technology transfer from the United States to Russia will not be a major element of this phase because technology transfer will be largely completed. The safeguards infrastructure should be in place at IPPE and the operation of the MPC&A system should be funded by the Russian Government. The role of the U.S. team should be to support the sustainability of the MPC&A system through limited technical support, funding, and system modernization as guided by the U.S. DOE.

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The Physical Protection of Fissile Nuclear Material in the UK—A BNFL Perspective

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8

Introduction

This paper describes the regulatory and operational environment in the UK for the physical protection of fissile material, with particular emphasis on the arrangements within British Nuclear Fuels plc (BNFL). It summarizes the international requirements which frame the UK regulations; identifies Government bodies with responsibility for physical protection policy, audit, and implementation; provides examples of UK regulations; and highlights the facilities and policies operated by BNFL. The role of security education, close cooperation between Government agencies, and internal company responsibilities are highlighted for their importance in achieving an effective physical security regime.

International Framework

In common with other Member States of the European Union, the United Kingdom is a signatory to the Convention on the Physical Protection of Nuclear Material (published as INFCIRC 274 Rev. 1), the Nuclear Suppliers Group Guidelines (published as INFCIRC 254 Rev. 2), and domestic UK standards take fully into account the recommendations of the International Atomic Energy Agency (IAEA) published in INFCIRC 225 Rev. 3 under the title "The Physical Protection of Nuclear Material." In consequence, domestic standards for physical protection ensure that the UK meets its international obligations.

UK Responsibilities for Physical Protection

In accordance with INFCIRC 225, responsibility for the establishment, implementation, and maintenance of the physical protection systems within the UK rests with Her Majesty's Government. Responsibility within Government for nuclear security changed during the years that the nuclear industry evolved as a separate entity from its military origins but because of the early, military links the need for effective physical security, including the security vetting of employees, is an engrained feature of our operations. Today, the prime responsibilities within Government for security rest with a small number of Government Departments which work together closely, thereby achieving a high degree of communication and collaboration; an absolutely essential requirement for security to be effective. The four key Government departments are described below.

The Cabinet Office

The Cabinet Office has responsibility for Government-wide security policy and would take the lead in the event of a serious terrorist incident involving a nuclear installation.

The Department of Trade and Industry

The Secretary of State of the Department of Trade and Industry (DTI) is responsible for ensuring that information is properly safeguarded in the interests of national security and that nuclear matter is protected to appropriate levels. BNFL, in common with some other nuclear operators, is subject to Ministerial Directives which define the standards of physical protection that must be implemented at our facilities. The DTI is also responsible for the operation of the Directorate of Civil Nuclear Security and the United Kingdom Atomic Energy Authority Constabulary (UKAEAC). This latter body was specifically formed in 1955 to police and protect nuclear premises, and grew out of the Admiralty and War Department Constabularies which had formerly policed the Ministry of Supply establishments. In the ensuing years, the UKAEAC has evolved into a modern, professionally competent police force serving the needs of BNFL and other nuclear operators at locations throughout the UK. It is important to note that restrictions on the possession and deployment of firearms in the UK are amongst the most stringent anywhere in the world and it is illegal for any private security contractor or employee of a nuclear operator to be armed. Possession and deployment of firearms in the civil sector is restricted to Police forces, including the UKAEAC, which is one of a small number of highly specialized and armed Police services in the UK that do not serve the Home Office. Their dedicated nature and long association with our industry, including their detailed knowledge of our facilities, makes them unequaled in their ability to protect appropriate nuclear materials during production, use, and transport and they provide an intimate link to the Home Office, County Police Forces in whose jurisdiction our facilities are located.

Home Office Police Forces

As a generalization, each County or region of the UK has its own Police Force which is responsible for the basic police functions of protection of life and property, prevention and detection of crime, and the preservation of the Queen's peace. Close cooperation is maintained at all times between Home Office Forces and the UKAEAC, both nationally through police committees under the auspices of the Association of Chief Police Officers and locally, in the context of intelligence gathering, joint exercises, and contingency planning. The importance of this liaison and partnership cannot be overstated because it is through this cooperation that experience and confidence is built in the management of nuclear security and the response to potential incidents.

The Security Services and Secret Intelligence Service

These Services have complementary responsibilities for counter-proliferation and counter-terrorism but it is the Security Service which provides regular assessments of the threat to Government assets in the UK including relevant nuclear facilities. The Security Service, in association with the Directorate of Civil Nuclear Security are also responsible for the independent audit of security arrangements and are the focus for personnel vetting. Inevitably, and beneficially, there is a network of communication between these Services, the Police, Government Departments and nuclear operators and it is very much a strength of our systems that security arrangements and planning takes place in such an integrated way. In over 40 years of operation, the UK's nuclear industry has never been subject to nuclear terrorism and there has been no occasion when nuclear material has been stolen from a nuclear facility or whilst in transit in the UK. Furthermore, no police officer has ever drawn or had to use a firearm to protect nuclear materials despite, or perhaps because of the very high proportion of UKAEAC officers who are deployed and authorized to use them.

Standards for Security in the UK

Security standards in the UK are kept under continuous review by the Government and disseminated, in the case of BNFL, by the Directorate of Civil Nuclear Security on behalf of the DTI. These cover the full range of security requirements including Personnel vetting, IT security, and Physical Protection. The most important in the field of physical security being:

1. Minimum Standards for the Physical Protection of Special Nuclear and other Radioactive Materials;
2. Manual of Protective Security;
3. Counter-Terrorist Measures Manual;
4. The Nuclear Generating Stations (Security) Regulations (1996);
5. Classification Guides.

These are supplemented by regular information relating to threat assessments, alert states, and other material to pitch the operational security arrangements at the appropriate level. The documents are provided to the appropriate Heads of Security within industry who, in collaboration with other senior colleagues, are accountable for implementing the necessary measures. It is this aspect of our operations that I now turn to, because fine words must be complemented by fine deeds for the total system to be effective.

Security Policy in BNFL

The successful management of security in such a large organization depends on at least three prerequisites:

1. Clear accountabilities;
2. Ownership of the issues by every employee;
3. Teamwork.

First, on large, complex nuclear sites it is not unusual for the site to be occupied by a diverse range of Company departments, tenant organizations, and contractors. It is essential, as in our case, that each site has a single person, the Head of Site, who is responsible and accountable for all aspects of security. Inevitably, that person must draw on specialized advice and support but there should not be any doubt over accountability. This does not preclude delegated responsibility, empowerment to take action or proper consultation over security arrangements, but it must avoid confusion and, in the event of an incident, delays in response.

Second, comprehensive Government security standards are necessary in order to implement adequate security measures but they can make dry reading for the majority of employees and contractors who are not security specialists. In my view, too much information can be counterproductive to efficient management and a balance has to be found between the things that employees must know and do and a level of detail that becomes soporific. BNFL has recently introduced a security awareness guide called "Security at Work" which has been given to every employee. It targets aspects of security which we consider essential. In preparing the document, we decided that it must be unclassified, easy to read, succinct, and informative. It also had to describe security in terms that people could relate to their work place, by drawing on experiences in their personal lives. It may not be immediately obvious but most of us go through the same psychological process in deciding how we protect the things that are important to us, be it our health, safety, or property. And the management and protection of fissile material is, in my opinion, no different in principle from these or any other personal or organizational challenges where the consequences of ineffective arrangements could be serious. It is a question of risk management and is entirely consistent with the approach announced by the British Prime Minister in 1994 when he announced the results of a wide-ranging review into Government security.

The five key stages of risk management are to:

1. Identify the asset and its value;
2. Identify the risks to the asset;
3. Identify and implement measures to minimize the risks;
4. Review the effectiveness of the measures;
5. Develop and exercise contingency plans.

There is not time to go into detail in this paper. However, I will summarize the main features of this approach and how they relate specifically to nuclear materials, which are an important asset but not the only asset for which we employ this methodology.

In the UK, in common with other States party to the international security regimes, we use the accepted categorization tables for nuclear material to define the level of physical protection that must be applied, which in turn determines the security categorization of our sites. This then identifies the value of the assets but it is important not to apply these standards without really focusing on what is meant by "value." Clearly, there is a financial value but for nuclear materials it is far more important to assess their value by trying to assess the effect on the business if the 'asset' is lost, damaged, or compromised. Ask the question "What would be the consequential effect of the loss, compromise, or damage on associated business activities; what are the likely financial, strategic, political, operational, or public relations implications? How long would it take to recover from such an event?" One needs only consider the implications of major nuclear safety incidents to recognize that the "value" of the asset is significant, particularly when addressing the inevitable issue regarding the cost / benefit of security measures. Equally, it is important not to be paranoid about the risks or threat to security but to approach it in a logical, informed way. This is the second stage of the risk management process and needs to include a comprehensive analysis of the threats, drawing on the knowledge and advice of specialist Government agencies, including the police, and making sure that the advice and intelligence is current and properly communicated. Out-of-date assessments or attempts to maintain unnecessarily high States of Alert for long periods of time can be counterproductive.

Third, identify the measures necessary to minimize the threat. These form a familiar list and include personnel security (including vetting), security education and training, information security, and physical security. One particular feature of BNFL's security policies is that Capital Expenditure Proposals for new or refurbished facilities that have security implications must be endorsed by the Corporate Security Department before financial approval is given to the Business Group. This means that we work with architects, plant designers, and safety experts at a very early stage in the design process, which has important financial and operational benefits. It is extremely difficult to estimate the cost of security measures in new facilities because so many of the safety requirements (seismic qualification of structures, radiological shielding, access control and independent and redundant safety control systems, etc.) are of direct application to the security regime. On balance, however, I would estimate that between 0.5-2.0% of the capital spent is linked to specific security requirements and that the ongoing operational costs fall into a similar range when expressed as a percentage of annual turnover. On that basis I would estimate that BNFL's direct and indirect investment in security since the mid 1980s has exceeded £250 million in today's money values.

This brings me to the fourth stage, reviewing the success of the measures. If success is measured in managing our nuclear material assets securely and safely, we are successful; however, it is extremely difficult to know whether our arrangements are cost effective. We can never be sure if our investment in security has deterred potential activists or whether an investment of half the amount would have had the same effect. The conundrum which beleaguers every Security Director is when is enough security enough? We believe that physical security standards should be constantly maintained at a level which is above the perceived level of threat and any credible escalation in the threat which could occur faster than we could otherwise respond. Within this policy, we constantly review our arrangements to maximize their cost / benefit, identify performance standards that must be attained, and do everything possible to eradicate unnecessary bureaucracy and overclassification of information.

Finally, we must plan for the worst and ensure that contingency plans are in place and adequately exercised. This returns me to the main theme of this paper, which is the importance of teamwork and collaboration between nuclear operators, Government Departments, and the Emergency Services. In many respects, industries such as ours spend more time and effort considering the possible consequences of an incident, be it safety or security related, than in any other commercial or Government sector. I am confident that our plans are thorough and well exercised. There is, and can be, no place for complacency.

Nuclear Material Control in Germany—Experiences and Perspectives

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9

Introduction

In contrast to other countries, Germany has no unified organization to manage the diverse aspects of nuclear material control or to focus the necessary competencies. On the contrary, various federal and state authorities act within the framework of the Atomic Energy Act (AEA) and participate in international and regional agreements. The Federal Republic of Germany does not have its own national accountancy and control system for nuclear material. This important function is performed by EURATOM as a part of the EURATOM Treaty. The significant aspects of nuclear material control, namely physical protection, export controls, and International Atomic Energy Agency (IAEA) and EURATOM safeguards, are discussed in this paper.

Physical Protection and Export Controls

In Germany, a license pursuant to Article 1 of the AEA may only be granted if protection against malfunctions or other third-party impacts is ensured. The applicant or licensee must provide safeguards for the respective nuclear installation which are coordinated and dovetailed with police protective measures. The licensing and regulatory authorities of the federal states responsible for implementing the AEA and the Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety have guidelines for the protection of nuclear power stations with light-water reactors against malfunctions and third-party impacts. These guidelines (e.g., for mechanical barriers, communication, and key systems) form a basis for assessing the structural and other technical, personnel, and administrative safeguards that must be demonstrated for nuclear power plants by the applicant. Organizational measures include access controls on personnel and material, as well as staff security clearances. Additional measures apply to the security guards and safety engineers.

The establishment of security areas is facilitated in most nuclear installations because licensing requirements for radiation protection and physical protection complement each other. For example, the protection of the nuclear power plant against external impacts for the confinement of nuclear material and fissile products requires, in part, very sturdy construction. Significant external impacts (in the sense of licensing procedures) are defined as the crash of a fast-flying military aircraft, an earthquake, or the explosion of a cloud of gas. Unauthorized access to important parts of the plant is made much more difficult by the construction of graduated security areas. These areas are separated from each other and safeguarded by technical systems to prevent, or considerably delay, forcible entry even if the intruder has appropriate tools at his disposal. The time gained per obstacle must be calculated in such a way that the intruder may be located, the alarm raised, guards informed, and assistance sent for. Examples of mechanical barriers are concrete walls and very heavy doors or gates, which can only be opened by motors actuated by authorized persons who are not in the vicinity. Access controls and optical monitoring are also used.

All the physical protection devices are based on analyses dealing with the possibilities of a third-party assault on the nuclear installation. In these analyses, it is assumed that potential perpetrators or groups of perpetrators have know-how and tools at their disposal, and that the installation is in an operational state favorable for their intentions. Weak points are identified and further appropriate safeguards implemented.

Germany is a party to the Convention on Physical Protection for Nuclear Material. An enquete commission (i.e., commission of inquiry) of the Bundestag on the problem of illicit trafficking in Germany met up to the end of 1996.

As the superior federal authority, the Federal Office for Exports (BAFA or Bundesausfuhramt) falls under the Federal Ministry of Economics.[1] The responsibilities in the field of export controls previously assumed by the Federal Office of Trade and Industry were transferred on 1 April 1992 to the newly established Federal Office for Exports with its headquarters in Eschborn near Frankfurt am Main. The main activities of the Federal Office for Exports are the examination with respect to foreign trade legislation of whether the export of armaments-relevant goods or technology requires authorization and takes decisions on applications.

Permitting obligations and prohibitions are governed by the Foreign Trade and Payments Law (Außenwirtschaftsgesetz or AWG) and the Foreign Trade and Payments Regulation (Außenwirtschaftsverordnung or AWV). The export of weapons of war is additionally subject to authorization pursuant to the Legislation on Arms Control (Kriegswaffenkontrollgesetz or KWKG). The licensing authority is the competent federal ministry. European law is basically valid for the export of so-called dual-use goods. The basis for controls on the export of such goods is the regulation issued by the Council on controls for the export of certain dual-use goods from the European Community (EC regulation No. 3381194 of 19 December 1994). This statutory basis enables, in particular, controls on the export of armaments and dual-use goods including technology transfer. Added to this are EC regulations enforcing UN embargo resolutions. Export controls should particularly contribute to the security of the Federal Republic of Germany and prevent any disturbance of foreign relations.

Safeguards Implementation in Germany

Germany is a party to both the Treaty of 25 March 1957 establishing the European Atomic Energy Community (EURATOM) and the Treaty of 1 July 1968 on the Non-Proliferation of Nuclear Weapons (NPT). Both treaties imply that safeguards are carried out by inspectors on German territory.

Under the EURATOM Treaty, the European Commission is the proprietor of the fissile material which the member states are entitled to consume completely. Agreements are in force between the Commission and the United States, Canada, and Australia, which impose prior consent rights on the use of the nuclear material originating from these states; this requires each batch of material to be coded according to its origin and other bilateral obligations.

In order to comply with the obligations under the NPT, all Non-Nuclear Weapon States (NNWS) party to the EURATOM Safeguards Directorate (ESD) and the IAEA concluded the Verification Agreement (VA) in 1973. The VA essentially corresponds to the IAEA's INFCIRC / 153 model agreement and is complemented by Subsidiary Arrangements that define ESD's and the member states' obligations to the IAEA. As a consequence, ESD amended their safeguards system by issuing Regulation No.3227 / 76, which is binding for the EURATOM states. An integral part of the Subsidiary Arrangements is the Particular Safeguards Provisions (Facility Attachments) which are facility-specific and negotiated between ESD and the Agency. The IAEA makes full use of ESD's system of safeguards (i.e., in Germany, IAEA and ESD cooperatively carry out inspections in joint teams and IAEA applies the observation principle to verify the findings of ESD). However, the Agency retains the right to make independent inspections and conclusions, including the right to examine the records, make independent measurements, verify the functioning and calibration of instruments and other measuring and control equipment, apply and make use of Containment / Surveillance (C / S) measures, and use other technically feasible methods.

Germany from the outset renounced a State System of Accounting for and Control of Nuclear Material (SSAC) as required by INFCIRC / 153, subjecting herself to the multinational EURATOM Safeguards Directorate (ESD) and the ESD system instead. On behalf of the Commission, ESD verifies that ores, source materials, and special fissile materials are not diverted from their intended uses as declared by the users and that the prior consent obligations are met. To that end, ESD inspectors at all times have access to all places and data and to all persons who, by reason of their occupation, deal with materials, equipment, or installations subject to the safeguards.

Operators of nuclear installations must declare the basic technical characteristics (i.e., design information) and keep and produce operating records that account for ores, source materials, and special fissile materials used or produced in their installations. The same applies to transport of source and special fissile materials. Moreover, European law requires operators to use process techniques which allow the successful implementation of safeguards. This implies that ESD has a *de facto* licensing function. This component does not exist in IAEA safeguards.

In Germany, responsibility for the technical part of IAEA safeguards implementation lies with the Federal Ministry of Education, Science, Research and Technology (BMBF), while the Foreign Office is responsible for the political part. Within this framework, the German Federal Government has established a support program for IAEA safeguards financed by the BMBF and handled by the Programme Group Technology Assessment (TFF) of the Research Centre Julich. A databank system for evaluating 90(a) and (b) statements of IAEA safeguards implementation is also operated at TFF.

Program '93+2' and Other Safeguards Perspectives

The NPT of 1968 required the IAEA safeguards system to be applied to the NNWS only. Although the Nuclear Weapons States (NWS) are not obliged to accept safeguards on their peaceful nuclear activities, a few facilities are inspected by the IAEA on the basis of voluntary offer agreements. The essential tasks and objectives of current IAEA safeguards are the timely detection of diversion of significant quantities of nuclear material and deterrence of such diversion by the risk of early detection (i.e., physical prevention of diversion is not intended).

The "Iraq Case" led to the requirement that the IAEA should detect undeclared nuclear activities. As a consequence, the

Agency established its Program '93+2' which envisages the following elements:

- Improvement of efficiency and effectiveness;
- Use of the advantages of modern technologies;
- Environmental monitoring;
- Expanded declarations;
- Complementary access.

The so-called Part I measures of Program '93+2' are considered to be in compliance with the existing legal basis and can be implemented as soon as practicable in facilities handling nuclear material. Such measures are environmental sampling in declared facilities and the improvement of safeguards technologies. In contrast, complementary access and the right to receive an expanded declaration requires new legislative authority. Therefore, '93+2' has resulted in the negotiation of a Model Protocol to amend the existing safeguards agreements and establish new obligations on the part of the member states and new rights on the part of the IAEA.

The expanded declaration should provide additional information from the member state which can be checked against information independently obtained by the IAEA from such sources as:

- Literature and media reports;
- National technical means;
- Environmental sampling at declared sites;
- Remote sensing from satellites;
- Routine inspections of the declared nuclear fuel cycle;
- Information from other Agency activities.

The important consequence of the complementary approach will grant access to nuclear-fuel-cycle-related R&D facilities not involving nuclear material, in particular, related to enrichment, reprocessing, and processing of some waste categories, plutonium, highly enriched uranium, and uranium-233. Complementary access is designed to assure the absence of undeclared nuclear activities. Access should be granted to any place on a site and any location on a selective basis to resolve questions or inconsistencies, and to confirm the decommissioned status of a facility or location outside a facility where nuclear material had been customarily used.

High-precision trace analysis may be an appropriate measure. Commercially available image and data from remote sensing satellites may also provide information on undeclared nuclear activities. Basically, it is a new field but it may profit from methods under discussion in the IAEA Program '93+2'.

The methods for verifying this are well known from NPT verification: accountancy verification of the book inventory by item counting, sampling and analyses, measurements by NDA and especially by Containment and Surveillance measures. Methods discussed under '93+2' for NPT safeguards will also be applicable.

This listing of different safeguards systems currently implemented or under discussion for future introduction indicates that the inspection effort might be different from facility to facility within the peaceful commercial use of nuclear energy.

The Part II measures of Program '93+2' can be better understood if details of the Model Protocol are examined. The expanded declaration involves:

- Description of all relevant facilities, sites, and activities throughout the nuclear fuel cycle—even for decommissioned facilities—including all nuclear-fuel-cycle-related R&D activities not involving nuclear material (i.e., development and manufacturing of components for enrichment, reprocessing, and specified processing facilities have to be declared);
- Additional information on operational issues of nuclear facilities and on-site buildings previously not declared;
- Information on export and import of nuclear material, non-nuclear material, and equipment;

- Information on nuclear source material currently not under IAEA Safeguards;
- Upon IAEA request, information about facilities and activities in the vicinity of nuclear facilities and elsewhere.

If there is good reason, the IAEA shall be granted the necessary access (i.e., complementary access). Such access can comprise visual inspections, including access to operational records, environmental sampling, and, as approved, other technical means. In order to prevent the dissemination of proliferation-sensitive information, to comply with safety and physical protection requirements, and to protect proprietary and commercially sensitive information, the principle of managed access is provided for the Model Control.

The new approach is that the Agency's access rights are to be extended beyond nuclear material control and to include the inspection of companies, facilities, sites, and research establishments not possessing nuclear material but related to the nuclear fuel cycle and its technologies.

The new safeguards system aims at enabling the Agency to detect undeclared nuclear activities by generating a comprehensive database for the IAEA. This will only be possible if the NWS adopt the same obligations as the NNWS. Why?—Because Iraq was able to acquire proliferation-relevant equipment from both NNWS and NWS. As a matter of fact, commercial nuclear activities take place on a global scale due to the interrelationships between NWS and NNWS. It has to be emphasized that states not party to the NPT should also share the new obligations.

In addition, the NWS should consider separating their civilian nuclear fuel cycle from their military activities.

This global safeguards system has two advantages:

1. On the one hand, synergistic effects arise from a worldwide application of safeguards, possibly leading to a considerable reduction of control effects.
2. On the other hand, the standardized safeguards procedures, especially with SSAC, may also lead to an improvement in physical protection.

From the German side, the universal application of the '93+2' program was the major yardstick in the negotiations of this program.

Another problem will arise when the '93+2' program is implemented in Germany. It is still an open question whether EURATOM will be involved in the implementation of the '93+2' program. Germany must leave open an option to establish her own national system, which would be responsible for preparing the appropriate information, escorting access, and supporting environmental monitoring in Germany.

Summary

Physical protection, export controls, and the IAEA and EURATOM nuclear material safeguards form a substantial barrier to a possible misuse of nuclear material. Synergistic effects amongst the individual elements reinforce the overall system. Therefore a general reduction in the IAEA inspection effort should also be achieved by a global and universal application of Program '93+2'.

German experience with IAEA and EURATOM safeguards is positive and, in the future, special attention will be focused on concepts and measures to reduce the inspection effort. IAEA and EURATOM have already taken the first steps through the "new partnership approach."

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The Latin American Experience on Safeguards of Nuclear Materials

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10

The United States and the Brazilian Military

The United States has tried to enforce nonproliferation throughout the world. In doing so, the United States sold nuclear reactors under safeguards to many countries, including Brazil. On the one hand, to assure that nuclear materials from the imported reactors would not be diverted to nuclear weapons programs, the reactors were operated as if they were black boxes. On the other hand, the United States would grant enriched uranium to run the imported reactors. However, in 1972, the U.S. Atomic Energy Commission announced that it could not any longer grant enriched uranium to Brazil and other nations that had bought American nuclear reactors. Some Brazilian scientists and the military, who would prefer the development of an endogenous nuclear program (a thorium-based reactor is often mentioned as an example), strongly criticized the nuclear dependence of Brazil on the United States. The Brazilian government headed by General Ernesto Geisel made, in 1975, an agreement with Germany that covered in principle the whole nuclear fuel cycle. The United States started creating pressure on Brazil, prohibiting, for example, the transfer of any nuclear technology that could be of any use to the military. The Harkin amendment of 1976 was tentatively applied to Brazil. When, in 1977, at the beginning of the Carter administration, issues like human rights and nuclear proliferation (essentially the Germany-Brazil nuclear agreement) became entangled with military aid, Geisel canceled unilaterally the old military agreements with the United States.

The Need for National Nuclear Safeguards

The Germany-Brazil nuclear agreement made mandatory the application of the International Atomic Energy (IAEA) safeguards to every component imported from Germany. This created a need to train Brazilian personnel in safeguards techniques. A Code of Regulations for a national safeguards system was established in Brazil in 1982. The code was fairly well written, but seldom applied for many years. Argentina was also subject to nuclear safeguards because of nuclear cooperation with Canada, Switzerland, and France. However, Argentina did not have a code of regulations for national safeguards.

The SCCC and the Bilateral Agreement

The national nuclear safeguards code, established in Brazil in 1982, only started being enforced in the mid-1990s, when there was a change of attitude in the Brazilian Comissão Nacional de Energia Nuclea (CNEN). Soon after, the need for a bilateral (Brazil and Argentina) inspection system appeared, because of a speech given by the Brazilian President at the U. N. Assembly, and the forthcoming joint declaration in Foz do Iguacu. At the technical level, the negotiations were progressing quite well because there was a great deal of mutual confidence among the participants. The heads of the technical branches of the Brazilian CNEN and the Argentinean CNEA (Commission Nuclear de Energia Atomica) had known each other for decades, and in the past had been co-authors of a scientific paper. Such a level of mutual confidence facilitated the negotiations that allowed the creation of the Common System of Accounting and Control of Nuclear Materials (SCCC).

> “The SCCC is a full-scope safeguards system applied with the purpose of verifying that nuclear materials used in all nuclear activities in Argentina and Brazil are not diverted to the manufacture of nuclear weapons or other nuclear explosive devices, under the terms of the Agreement between the Republic of Argentina and the Federative Republic of Brazil on the Exclusively Peaceful Utilization of Nuclear Energy.” (Marzo, 1997).

The Agreement Between the Republic of Argentina and the Federative Republic of Brazil for the Exclusively Peaceful Use of Nuclear Energy (better known as the Bilateral Agreement) was signed on July 18, 1991. The text of this Agreement was published by the IAEA under code number IAEA lNFCIRC / 395 (Nov. 1991). In addition to the Bilateral Agreement, the SCCC encompasses the General Procedures and Implementation Manuals for each type of facility to be inspected. These General Procedures are consistent with INFCIRC / 153, and are analogous to Facility Attachments (Marzo, 1997).

The SCCC was the basis on which the Bilateral Agreement was negotiated. The Bilateral Agreement was the application of the principle *neighbors watching neighbors*, an idealistic approach to the nonproliferation regime, but should not be generalized.

The ABACC

The acceptable way to give international credibility to the Bilateral Agreement was to create the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC). This Agency is headquartered in Rio de Janeiro.

A four-member Commission, appointed by the States that are party to the agreement, constitutes the governing body of ABACC. The members of the ABACC Commission (Board Directorate) are the President of CNEN, a representative of the Brazilian Ministry of External Relations, the President of the Directory of the Argentine National Nuclear Regulatory Agency, and a representative of the Argentine Ministry of External Relations. Among the functions of the ABACC Commission are the following:

- Assure that the SCCC is correctly applied;
- Supervise the actions of ABACC’s Secretariat;
- Find and appoint the professional staff of the Secretariat;
- Maintain a list of qualified inspectors selected among those indicated by the Parties;
- Alert any of the two Parties of any anomalies in the implementation of the SCCC;
- Inform the Parties of any non-compliance with the Bilateral Agreement.

An interesting feature of the ABACC’s Commission is that decisions can only be made by an unanimous vote of the members.

Regular meetings of the Commission occur three times per year at ABACC's headquarters in Rio de Janeiro.

ABACC's Secretariat is composed of an Executive Secretary and a Deputy Secretary, one from each Party. The nationalities of the Executive Secretary and the Deputy Secretary alternate each year.

The staff of the Secretariat comprises six Senior Professional Technical Officials, forming two triplets from each Party. There are also two Professional Administrative Officials, four Auxiliaries, and about sixty Inspectors chosen half-and-half from each Party. The Inspectors are specialists from the National Nuclear Authorities in each Party or from another organization in either country. The inspectors are convened to ABACC whenever necessary. The Inspectors report directly to the Secretariat while performing their duties.

The functions of the Secretariat of ABACC are the following:

- To implement the directives and instructions issued by the Commission;
- To implement and administer the SCCC;
- To represent the ABACC in all necessary functions;
- To designate and instruct the Inspectors to carry out their duties properly;
- To receive and evaluate the reports made by the inspectors;
- To inform the Commission of any discrepancy in the records, concerning either Party, that may arise from the evaluation of the results of an inspection.

On July 1992, ABACC's Secretariat started operating in its headquarters in Rio de Janeiro. One of the first steps taken by both Parties was to declare their initial inventories. Since then, ABACC maintains all information concerning the inventories and keeps it up to date.

ABACC's budget was about U.S. $2.5 million in 1995, and it increased to $3.4 million in 1996. The Statements of Accounts for the annual budgets for 1995 and 1996 are presented in Table 1 for illustration purposes.

The budget deficit for 1995 was about 5%. However, the increase of contributions from the two countries plus a new influx of revenues, listed as other contributions, allowed a positive balance in 1996 of approximately 13%. This comparison reflects not only the financial health of ABACC, but also the credibility of the work done thus far. The governments of Brazil and Argentina would not increase their individual contributions or other contributions would not be added to ABACC's revenues if the technical activities were not satisfactory.

The Quadripartite Agreement

The Declaration of Foz do Iguacu, in November 1990, asked for IAEA participation in a joint nuclear safeguards agreement to supplement the Bilateral Agreement. Negotiations with the IAEA started in February 1991. One of the features of the agreement being negotiated at that time was the possibility of opening an avenue to facilitate the full adherence of Brazil and Argentina to the Tlatelolco Treaty. On December 13, 1991, the Quadripartite Agreement for the Application of Safeguards was signed in the IAEA Headquarters, in Vienna, Austria, involving the Republic of Argentina, the Federative Republic of Brazil, the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials, and the International Atomic Energy Agency.

The Argentine Congress approved the Agreement within six months of its signature; the Brazilian Congress, however, took about two years to approve it. The Brazilian Congress delayed their approval because there were political groups that saw the Quadripartite as an instrument to obstruct the technical development of the country. Notwithstanding, the Brazilian government was able to convince the majority of Congressmen that the Quadripartite Agreement would preserve technological and industrial secrets. Eventually, the Agreement was approved in March

Table 1. Summarized budget (revenues in dollars—expenses in percent) of ABACC for the years 1995 and 1996 (adapted from ABACC, 1995, 1996).

REVENUES (in dollars)	**1995**	**1996**
Brazilian government contribution	1,250,000.00	—
Argentine government contribution	1,250,000.00	—
Financial revenues	87,157.70	95,745.80
Other contributions	0.00	400,000.00
Total	$2,587,157.70	$3,422,137.83
EXPENSES (in percent)	**1995**	**1996**
Payroll	50.56	43.66
Temporary assistance	0.15	0.11
Travel and accommodation	28.86	19.49
Technical support	3.78	4.06
Office and vehicles	17.44	5.22
Financial expenses	0.51	0.19
General	0.70	1.07
Depreciation	3.07	3.96
Technical cooperation agreements	0.00	2.52
Public utility	0.00	2.01
Total	105.07	81.99
INVESTMENTS DURING THIS YEAR (in dollars)	**1995**	**1996**
Technical support	155,801.12	137.051.00
Office and vehicles	9,917.21	0.00
General	0.00	80,463.62
Total	165,718.33	217,514.62
LETTER OF CREDIT AND ADVANCES FOR PURCHASING EQUIPMENT	**1995**	**1996**
	27,081.00	123,884.66
YEAR-END BALANCE	$(131,142.06)	$452,610.90

1994. The full text of the Quadripartite Agreement is publicly available under the title IAEA INFCIRC/435, March 1994.

The Quadripartite allows the IAEA to apply full-scope safeguards in Argentina and Brazil to verify the findings of the SCCC. The ABACC and the IAEA have cooperative arrangements to implement the Quadripartite based on the following (Marzo, 1997):

1. The need to reach its own independent conclusions;
2. The need to coordinate to the extent possible their activities for the optimum implementation of the Agreement and in particular to avoid unnecessary duplication of ABACC's safeguards.

The IAEA and the Agency for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (better known by its Spanish acronym, OPANAL) both considered the Quadripartite Agreement as a valid instrument for complying with the requirements of the Tlatelolco Treaty and the Nuclear Nonproliferation Treaty (NPT), as far as Argentina and Brazil are concerned. This fact, of course, softened in the last few years the historical position of the Brazilian diplomacy against signing the NPT.

IAEA sent a first mission, under the Quadripartite Agreement, after the initial inventories had been previously verified by ABACC's inspectors. This IAEA mission visited Brazil in March and Argentina in June 1995. ABACC's Design Information Questionnaires covering all facilities were forwarded to IAEA in October 1995. A second IAEA mission was sent in February 1996 to Argentina, and in March 1996 to Brazil.

It is worth mentioning here that the Facility Attachments concerning the safeguards approach to the Pilcaniyeu Enrichment Plant, in Argentina, and the Isotopic Enrichment Laboratory, in Brazil, are still the object of negotiations between ABACC, the IAEA, and the two State Parties that signed the Quadripartite Agreement.

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China's Practice of Nuclear Materials Control

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11

Evolution of Nuclear Materials Control Structure

The State required the nuclear industry to adhere to the government policy "Safety First, Quality First" at the very beginning of its development. Naturally great attention was paid to the use, handling, transportation, and storage of nuclear materials; a set of rules were formulated for nuclear materials control. A few examples are given below.

Every manipulation and every experiment must be mastered with substitute materials before using real nuclear materials. Furthermore, when handling or transferring the actual nuclear materials, experimentalists were under parallel surveillance of the representatives from the relevant security, safety and environment protection divisions to ensure that nothing went wrong. Those divisions were set up when the facility was set up. Transportation of nuclear material beyond the facility is the responsibility of either local or national security and carrier departments, depending on where the materials are transported. Every major nuclear facility was equipped with a waste treatment shop. The person in charge of the facility is responsible for the surroundings, including atmosphere, water, and soil, which must meet national environmental standards supervised by the local environmental protection organization.

As a long time practice, the nuclear energy authority established a comprehensive system of rules and codes, and implemented them strictly. Everyone involved in nuclear materials realized quite well that to observe the "Safety First, Quality First" policy and the relevant rules were important not only to the industry but also to his own health.

During the period after the late seventies, the task of the nuclear industry switched from mainly military to both military and civilian. The management of nuclear materials became more complex both in extent and in variety. Not much later, in 1984, China joined the International Atomic Energy Agency (IAEA) and became a designated member state on the Board of Governors of IAEA. With the adoption of international standards, the control of nuclear materials in all areas has been further improved.

Taking into consideration the above developments, in 1987 the State Council promulgated the document, "Regulations on Nuclear Materials Control of the People's Republic of China." In 1990, a supplementary document, "Rules for Implementation of the Regulations on Nuclear Materials Control of the People's

Republic of China" was approved and issued by the National Nuclear Safety Administration and the Commission of Science, Technology, and Industry for National Defense (COSTIND). These two documents form the renewed legal basis for nuclear materials control.

Current Systems for Nuclear Materials Control

The main parts of the systems for nuclear materials control are described below.

The Legal System

The first document, "Regulations on Nuclear Materials Control," issued by the State Council stipulates that the present regulations are enacted to:

- Ensure the safety and lawful uses of nuclear materials;
- Prevent theft, sabotage, unlawful diversion, and unlawful use;
- Protect the security of the State and the public and facilitate the development of nuclear undertakings.

In the second document, "Rules for Implementation for Regulations on Nuclear Materials Control," concrete measures are formulated, including:

- Responsibility of the National Office for the Control of Nuclear Materials;
- Responsibility of the licensee; application, review, and assessment and issuing of license;
- Accounting management of nuclear materials;
- Nuclear materials balance and physical protection.

According to "the Regulations," the nuclear materials to be controlled include Pu, U, T, and Li-6. The specifications for the materials to be controlled are indicated in the document.

The Administrative System

The Ministry of Nuclear Industry is responsible for nuclear material management for the whole country. The National Office for the Control of Nuclear Materials under the Ministry of Nuclear Industry is responsible for the concrete implementation of the control function. In 1988, the China National Nuclear Corporation was established on the grounds of the Ministry of Nuclear Industry. The State Council charged the China National Nuclear Corporation with certain governmental functions involving nuclear issues; these functions were grouped under the name, China Atomic Energy Authority. The National Office for the Control of Nuclear Materials is now under the China Atomic Energy Authority.

The National Nuclear Safety Administration is responsible for the supervision of the safety of civilian use of nuclear materials. The main responsibilities of the National Office for the Control of Nuclear Materials are to:

- Elaborate the rules and regulations and specifications for the control of nuclear materials;
- Accept applications and issue licenses for nuclear materials;
- Exercise nuclear materials control of the whole country, establish an accounting system for nuclear materials for the whole country, and check accounting balance management, physical protection, and secrecy of the licensee;
- Submit quarterly reports of nuclear materials for civilian and military uses and an annual balance report to the National Nuclear Safety Administration and COSTIND, respectively.

The Licensing System

The State has adopted a licensing system for nuclear materials. An enterprise that owns nuclear materials up to certain quotas (specified in "Regulations on Nuclear Materials Control") must apply for licenses. The accumulated amount of allocation or production under the specified quotas may be exempted from applying for licenses, but nevertheless must be registered.

The National Office for the Control of Nuclear Materials accepts the application of license and the license is issued after being reviewed and approved either by the National Nuclear Safety Administration or by COSTIND. The license system helps protect nuclear materials from sabotage and unlawful use.

The required information to be submitted for application includes: the implementation plan for control of nuclear materials, accounting and balance, and plan for physical protection and secrecy of nuclear materials.

The period of validity for the license is specified in the license, and the license will automatically cease in force when it is overdue. If it is necessary to prolong the period of the validity of license, that applicant must submit the application within ninety days before the license expires.

During the period of validity of the license, if there are some changes related to the variety, quantity, the scope of application and the implementation plan of control, the licensee must submit the application for the change of license.

The Accounting System

The National Office of Nuclear Materials Control is responsible for establishing an accounting system of nuclear materials for the whole nation. It is required that the licensee must establish a specific organization or designate a specially assigned person to be responsible for nuclear materials, maintain strict handover procedures, set up accounting records and a materials status report system, and to ensure that the accounting records conform to the materials inventory.

The account forms used for nuclear materials management in nuclear facilities were revised in 1991 to conform with those used internationally.

Physical Protection of Nuclear Materials

The licensees shall establish a strict security and guarding system under the guidance of the local security organization for the site where production, use, and disposal of nuclear materials are done; adopt reliable security protection measures; and take strict precautions against theft, sabotage, accidental fire, and so forth.

The carriers for the shipment of nuclear materials shall be responsible for working out the transportation security plan with the relevant security office and making sure that the security precautionary measures are reliable. The transport organization, public security organization, and other relevant departments shall act in close coordination to ensure the safety of nuclear materials while in transit.

The level of protection requirements are divided into three categories for security control according to the type, quantity, and harmfulness of the nuclear materials.

Each nuclear facility has its own professional security organization which takes care of the physical protection of nuclear materials. Major nuclear facilities are guarded by the armed forces.

The measures of physical protection are under the guidance of the local security organization, and direct communication is established between the facility and the appropriate security organization.

Persons must be examined before they can be authorized for access to nuclear materials; those unqualified must be prohibited from access to nuclear materials.

Some Concluding Remarks

The Chinese Government pays great attention to the public health and security. A comprehensive system of nuclear materials control has been established and nuclear materials are now under effective control. The research and development programs that still need to be done to make further improvements include:

- Elaboration of norms and standards of materials control;
- Development of new techniques of measurements and improvements in the sensitivity and reliability of the equipment;
- Further implementation of statistical methods developed by the IAEA;
- Improvement of the reliability of instruments in the accounting system and physical protection of nuclear materials.

China's Regulations for Nuclear Materials Control

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Legal Basis and Delegation of Authority

On September 25, 1990, the National Nuclear Safety Administration, the Ministry of Energy, and the Commission of Science, Technology, and Industry for National Defense (COSTIND) approved and issued "Rules for the Implementation of Regulations on Nuclear Materials Control of the People's Republic of China." However, the present regulations are not applicable to the control of uranium ore and its primary products. And control measures for nuclear products transferred to the armed forces are laid down by the National Defense Department.

The Ministry of Energy delegated the responsibility for the control of nuclear materials for the whole country to the China National Nuclear Corporation, under which the National Office for the Control of Nuclear Materials ("the Office") was established. The Office is responsible for the detailed implementation of nuclear materials control. In particular, the duties of the Office include:

- Submitting quarterly reports for civilian and military uses of nuclear materials and yearly balance reports to the National Nuclear Safety Administration (NNSA) and COSTIND, respectively, including transfer, inventory, and accounting;
- Immediately taking appropriate measures and reporting theft, sabotage, loss, unlawful diversion, and unlawful use of nuclear materials to the NNSA, COSTIND, and the Ministry of Public Security.

Licensing Procedures

To ensure the lawful and safe use of nuclear materials, China adopted a licensing system for nuclear materials. In China, it is required that each licensee establish its own nuclear material physical inventory procedures. Licensees must: (1) conduct a complete and strict physical inventory at least once a year and (2) conduct physical inventories for such materials as Pu-239, U-233, and enriched uranium with U-235 abundance greater than 20% at least twice a year.

To ensure the accuracy and reliability of these inventories, licensees must ensure that:

- Nuclear materials are classified for inventory according to their varieties and physiochemical forms;
- While conducting inventories, the quantities of nuclear materials for all items must be the measured values;
- To ensure the quality of the inventory, strict measurements must be made of the physical inventory of nuclear materials in equipment and materials for reprocessing;
- Quantities of nuclear materials are measured during discharging or disposing of waste gas, waste liquid, and waste material.

A licensee must have a record keeping and reporting system, and send the required reports to the Office. The Office then submits quarterly reports of nuclear materials for civilian and military uses and the yearly balance, as described above, to the NNSA and COSTIND, and forwards any reports of theft, sabotage, loss, unlawful diversion, and unlawful use to the Ministry of Public Security.

Accounting for Nuclear Materials Balance

I would now like to elaborate a little bit further on several aspects of Dr. Zhang's paper ("China's Practice of Nuclear Materials Control"). First, I will comment on the Nuclear Materials Balance and add some detail about how this balance is calculated.

To go a little further with the formula for material balance (*given in the unabridged paper by Dr. Zhang*):

$$MUF = BI + A - EI - R - KL ,$$

where material unaccounted for (MUF) is calculated by subtracting the ending inventory (EI) plus removals (R) and plus known loss (KL) from beginning inventory (BI) plus additions to inventory (A). When MUF exceeds twice its standard error, it is considered that the closed material balance has not been reached, and may represent the loss, theft, or unlawful transfer of nuclear materials. In this case, the licensee must report to the "Office," which must find out the cause for the imbalance and the improvement measures that must be undertaken. The "Office" (National Office for the Control of Nuclear Material) has right to investigate and to deal with this matter depending on conditions.

We also set up a regulation about the Limit of Relative Standard Error of MUF of closed material balance for various types of installations. These relative standard error limits are:

Table 1. Relative standard error limits.

Installation Type	**sigma (MUF) (%)[a]**
Uranium enrichment	0.2
Uranium processing	0.3
Plutonium processing	0.5
Uranium reprocessing	0.8
Plutonium reprocessing	1.0

[a] Sigma (MUF) (%) means the relative standard error of MUF in the whole course of balance as a percent of the total amount.

Physical Protection of Nuclear Materials

Site Security

Now I want to add some detail about the different levels of Physical Protection. Protection requirements are divided into three categories for security control, as follows:

There are guards and defenses at the fixed sites for these protected nuclear materials, as follows:

Table 2. Categorization of Nuclear Material Physical Protection.

Material	Form	Category I	Category II	Category III
Plutonium[a]	Unirradiated	2 kg or more	10 g to 2 kg	10 g or less
Uranium[a]	Unirradiated U-235 enriched to 20% or more	5 kg or more	1 kg to 5 kg	10 g to 1 kg
	Unirradiated, U-235, enriched to 10–20%	20 kg or more	1 kg to 20 kg	—
	Unirradiated, U 235, enriched to less than 10% (not including natural uranium and depleted uranium)	300 kg or more	10 kg to 300 kg	—
Tritium	Unirradiated, counted by quantities of tritium	10 g or more	1 g to 10 g	0.1 g to 1 g
Lithium	Enriched lithium, counted by quantities of lithium	20 kg or more	1 kg to 20 kg	—

[a] The categorization of uranium and plutonium physical protection is counted by the quantities of the element but not by effective kilograms.

1. At Category I nuclear material sites, there are armed guards, and a special pass is required to access the site. Access by non-site personnel is strictly controlled. Personnel whose duties require that they have access must be approved by the competent authority of the unit. Non-site personnel must also go through the procedure of registration, and then be escorted by site personnel to access the nuclear materials. The vault system utilizes a "double man and double lock" regime.
2. At Category II nuclear material sites, there are armed guards or a person who is specially assigned to watch day and night. Personnel gaining access must use a special pass.
3. At Category III nuclear material sites, there is a person who is specially assigned to watch or see that the nuclear materials are put into safe conditions.

We also have physical barriers at these fixed sites, as described below:

1. At Category I nuclear material sites, there are at least two complete, reliable physical barriers. There is a vault or special security container for storing the category I nuclear material. There is also a technical protection system that includes alarms and monitoring stations.
2. At Category II nuclear material sites, there are two physical barriers, of which at least one is complete and reliable. The storage area for Category II nuclear material is of a "strong room" or "solid container" type. Alarms or surveillance protection equipment are provided for the vital area.
3. At Category III nuclear material sites, only one complete and reliable physical barrier is required.

Transportation Security

The consignor for shipment of nuclear materials is responsible for transport security and working out the transport security program jointly with the authorities concerned of transport, product management, safety protection, and public security. The transport security program for Category I and Category II nuclear materials is required to report in advance to the local security organization. The shipment of Category I nuclear materials is accompanied by armed escort. Information about the route, start time, travel time, arrival time, and destination of the shipment are required not to be disclosed to persons who have nothing to do with the job. A nuclear material code name is used in all versions of the transport plan and for filling in the waybills.

Korean Approaches to the Protection of Nuclear Materials

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Introduction

The Republic of Korea started its nuclear power industry in 1978 with the operation of the first nuclear power plant, Kori-1. Twelve nuclear power plants—ten Pressurized Water Reactors (PWRs) and two CANDUs—are now in operation and generate more than one-third of the country's electricity. Six more plants—four PWRs and two CANDUs—are under construction. With this active nuclear power program, Korea ranks tenth in the world in terms of nuclear power generation capacity. Korean capabilities in design, manufacturing, construction, operation and maintenance of commercial-scale Korean Standardized Nuclear Power Plants (KSNPs) have reached a level sufficient to carry out the LRW project at Sinpo, DPRK.

In addition to the nuclear power plants, there are two commercial nuclear fuel fabrication plants, two research reactors, and six facilities related to nuclear R&D. Considering the scale of investment and degree of success experienced by Korean nuclear power industries, a relatively small nuclear fuel cycle industry is in operation. The only segment that is localized is a commercial-scale, low-enriched and natural uranium fuel fabrication plant that supplies all domestic needs for PWR and CANDU fuels with uranium hexafluoride and uranium power imported from foreign countries.

Non-Proliferation Milestones

Since Korea became a Member State of the International Atomic Energy Agency (IAEA) in 1957, the first noteworthy encounter related to safeguards came in 1968, when Korea concluded the trilateral Korea-USA-IAEA safeguards agreement as TRIGA Mark II, the first research reactor in Korea, was introduced. After that, Korea ratified the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) on 23 April 1975. In connection with the NPT, the Safeguards Agreement between Korea and the IAEA has been in force since 14 November 1975. As a result of this full scope safeguards agreement, two research reactors, TRIGA Mark II and III, were the first nuclear facilities in Korea to which the IAEA safeguards were applied. Since then, Korea submits official reports to the IAEA and the IAEA performs the verification activities (i.e., safeguards inspection). Currently, because of the active nuclear power program in Korea, more than 25 nuclear facilities (ten PWR and two CANDU nuclear power plants, two nuclear fuel fabrication plants, four research reactors, six R&D facilities, and three others) are under the IAEA safeguards (Table 1). During 1996, the IAEA spent around 270 person-days of inspection (PDIs) for 23 nuclear facilities in Korea. The details are shown in Table 2. Because the nuclear facilities are predominantly power reactors, the major portion of

Table 1. Nuclear Facilities under IAEA Safeguards.

Name	Type	Code	Date of Facility Attachment
R&D, Others			
TRIGA II & III	Research Rx.	KOA-	1976-02-12
KyungHee Univ.	Educational Rx.	KOD-	1977-02-01
CFFP	CANDU Fuel Fab.	KOE-	1979-03-01
PIEF	R&D (hot cell)	KOL-	1988-11-09
HANARO	Research Rx.	KOS-	—
IMEF	R&D (hot cell)	KOV-	—
HFFL	R&D	KOW-	—
DUPIC	R&D	KOY-	—
KAERI LOF	R&D	KOZ-	—
KNFFP	PWR Fuel Fab.	KOR-	1988-12-15
	CANDU Fuel Fab.	?	—
Acrylonitrile Plant	Chemical Industry	KOB-	—
POSCO	Steel Industry	KOXA	—
KRISS	Research institute	KOXB	—
Power Reactors			
Kori 1	PWR	KOC1	1976-02-12
Kori 2	PWR	KOC2	1982-08-01
Kori 3	PWR	KOC3	1985-03-01
Kori 4	PWR	KOC4	1985-03-01
Wolsong 1	CANDU	KOF1	1982-09-22
Wolsong 2	CANDU	KOF2	—
Wolsong 3	CANDU	KOF3	—
Wolsong 4	CANDU	KOF4	—
Ulchin 1	PWR	KOO1	1988-11-09
Ulchin 2	PWR	KOO2	1988-11-09
Ulchin 3	PWR	KOO3	—
Ulchin 4	PWR	KOO4	—
Ulchin 5	PWR	KOO5	—
Ulchin 6	PWR	KOO6	—
Younggwang 1	PWR	KOM1	1985-05-30
Younggwang 2	PWR	KOM2	1985-05-30
Younggwang 3	PWR	KOM3	1995-10-11
Younggwang 4	PWR	KOM4	1995-10-11
Younggwang 5	PWR	KOM5	—
Younggwang 6	PWR	KOM6	—

Table 2. IAEA Safeguards Inspection Efforts in Korea.

Name	Code	Max.	1991	1992	1993	1994	1995	1996
TRIGA II & III	KOA-	4	2	2	2	2	2	1
KyungHee Univ.	KOD-	1	2	2	2	1	2	1
CFFP	KOE-	20	13	8	16	19	16	13
PIEF	KOL-	20	10	8	12	19	16	6
HANARO	KOS-	—	—	—	—	6	14	5
IMEF	KOV-	—	—	—	—	—	1	1
HFFL	KOW-	—	—	—	—	—	2	1
DUPIC	KOY-	—	—	—	—	—	—	—
KAERI LOF	KOZ-	—	—	—	—	—	—	2
KNFFP	KOR-	70	39	14	47	45	32	29
Acrylonitrile Plant	KOB-	—	—	—	—	—	—	2
POSCO	KOXA	—	—	—	—	—	—	—
KRISS	KOXB	—	—	—	—	—	—	—
Kori 1	KOC1	15	10	8	11	12	10	12
Kori 2	KOC2	15	9	12	10	13	8	12
Kori 3	KOC3	15	12	11	12	12	16	10
Kori 4	KOC4	15	10	10	10	10	9	10
Wolsong 1	KOF1	45	43	218	289	227	163	95
Wolsong 2	KOF2	—	—	—	—	—	—	8
Wolsong 3	KOF3	—	—	—	—	—	—	—
Wolsong 4	KOF4	—	—	—	—	—	—	—
Ulchin 1	KOO1	15	11	11	13	15	16	8
Ulchin 2	KOO2	15	13	9	12	13	13	8
Ulchin 3	KOO3	—	—	—	—	—	—	—
Ulchin 4	KOO4	—	—	—	—	—	—	—
Ulchin 5	KOO5	—	—	—	—	—	—	—
Ulchin 6	KOO6	—	—	—	—	—	—	—
Younggwang 1	KOM1	15	11	10	11	10	12	11
Younggwang 2	KOM2	15	15	12	8	12	11	9
Younggwang 3	KOM3	15	—	—	—	12	8	14
Younggwang 4	KOM4	15	—	—	—	—	10	10
Younggwang 5	KOM5	—	—	—	—	—	—	—
Younggwang 6	KOM6	—	—	—	—	—	—	—
Total Person-Days of Inspection			200	335	455	428	361	268

the IAEA inspection efforts are on power reactor inspections at four coastal sites, followed by fuel fabrication plants and research facilities at Taejon.

Note (Table 2) that in 1992, many PDIs were required at Wolsong-1, a CANDU-type reactor. Because of a shortage of spent fuel storage pool capacity, it was necessary to transfer spent fuel to the dry storage canister, and IAEA inspectors had to stay continuously during the transfer period. As nuclear facilities increase every year in Korea, the IAEA will spend more and more time there.

In 1991, both the North and South Korean governments proclaimed the so-called "Declaration of De-nuclearization in the Korean peninsula" as a self-binding principle. This started North/South mutual inspection initiatives as well as full scope IAEA safeguards on North Korea's declared nuclear facilities. The subsequent course of events finally led to the Agreed Framework between the United States and the DPRK in 1994 and the establishment of KEDO in 1995.

In the meantime, Korea pursued an Atomic Energy Act amendment that provides the way for a national inspection infrastructure. Due to expansion of the nuclear industry, nuclear material is continuously increasing and effective and efficient control measures are necessary. Nuclear control means state systems and relevant activities to prevent the misuse of nuclear material, equipment, facilities, and technologies for nuclear weapons or explosives. Basic systems for nuclear control are safeguards, physical protection, and export control. In Korea, the relevant laws for nuclear control, especially safeguards related, are the atomic energy laws. The Atomic Energy Act, the basic law for utilization and safety regulation of atomic energy, provides the legal basis for national inspection. Concerning physical protection and export control matters, Korea ratified the International Convention on the Physical Protection of Nuclear Material on 7 April 1982, and became a member of Nuclear Supplier Group and Zangger Committee in 1995.

Legal Basis of National Inspection

In Korea, safeguards and physical protection matters are provided by the Atomic Energy Act together with subsidiary legislation. The latest amendment to the Atomic Energy Act was made in December 1994 and went into effect on 5 January 1995. The amendment provides the legal basis for national inspections by the Ministry of Science and Technology. The Enforcement Decree of the Atomic Energy Act (Presidential Decree) and the Enforcement Regulation of the Atomic Energy Act (Prime Ministerial Ordinance) were revised during 1995–96. Four Notices of the Minister of Science and Technology, which are used to implement provisions of the atomic energy laws and provide detailed requirements and guidelines, went into effect on 23 July 1996.

Articles in the Atomic Energy Act relevant to national inspection are Article 15-2 and Article 16 given below. These two articles apply to owners of nuclear power reactors, installers of research reactors, nuclear fuel cycle enterprisers, nuclear fuel material users, and those disposing of radioactive waste:

Article 15-2 (Accounting and Control & Physical Protection Plan)

1. Any nuclear power reactor installer shall provide accounting and control and physical protection plans of nuclear material in internationally controlled material (hereinafter referred to as "special nuclear material") in accordance with the provisions of the Presidential Decree, and obtain the approval of the Minister of Science and Technology before the use of the special nuclear material is commenced. The same shall also apply in cases where any change is to be made.

Article 16 (Inspection)

1. The nuclear power reactor installer shall be inspected by the Minister of Science and Technology regarding installation of nuclear power reactors and related facilities, and accounting and control and physical protection of special nuclear material in accordance with the provisions of Presidential Decree.

In addition, reports and possible subsequent inspections are governed by Article 103:

Article 103 (Reports and Inspection, etc.)

1. In cases where the Minister of Science and Technology deems it necessary for the enforcement of this Act, he/she may order the nuclear-related enterpriser or the enterpriser who has engaged in the construction or the operation of a reactor and its related facilities, to report, or to submit documents relating to the enterprise, or to modify previously submitted documents.

2. In cases where the Minister of Science and Technology deems it necessary for the verification of submitted documents according to paragraph (1) or for performing inspection for enforcement of this Act, he / she may order that the public officials under his competence be given access to the office of business, factory, or ship in order to inspect books, documents, facilities, or other necessary matters and / or give questions to appropriate personnel and / or take the minimum samples for the inspection.
3. In cases where the Minister of Science and Technology find a violation of this Act and international agreement by the results of inspection, he may order corrective or complementary action.

The Enforcement Decree provides the particulars for implementation and enforcement of the Atomic Energy Act. The Enforcement Regulation of the Atomic Energy Act is a Prime Ministerial Ordinance that provides the particulars needed to carry out responsibilities delegated to it by the Atomic Energy Act and the Enforcement Decree of the Act, and is indispensable for the practical enforcement of the Act and the Decree. This Regulation provides the detailed specifications for the contents of various applications and the documents, including prescribed formats, that are required to be enclosed with applications.

However, for safeguards and physical protection matters, all detailed regulations are provided in a Notice of the Minister of Science and Technology. The Notices are designed with the flexibility to modify safeguards and physical protection regulations when necessary. These Notices of the Minister of Science and Technology are the actual means of implementing the provisions of the atomic energy laws. The four Notices below, which became effective on July 23, 1996, govern current safeguards and physical protection practices:

1. *Notice for Definition of Internationally Controlled Material (Notice of Science and Technology Minister No. 96-27)* : Defines internationally controlled material in accordance with international agreements and bilateral agreements.
2. *Notice for Preparation of Accounting and Control & Physical Protection Plan (No. 96-28):* Defines the contents and preparation methods of Accounting and Control & Physical Protection Plan.
3. *Notice for Verification(Inspection) of Accounting and Control & Physical Protection (No. 96-29):* Defines the method, frequency, and procedures for national (domestic) inspection.
4. *Notice for Reporting Internationally Controlled Material (No. 96-30):* Defines the contents, forms, frequency, and procedures for reporting internationally controlled material in accordance with international agreements and bilateral agreements.

According to the Notice, the scope of national inspection is (a) examination of the records coupled with nuclear material accountancy kept by the operator, (b) measurement of all nuclear material subject to safeguards, (c) verification of the functioning and calibration of instrument and other measuring and control equipment at the facility, (d) application and utilization of containment and surveillance measures, and (e) other necessary measures for safeguards implementation including the taking of destructive analysis samples.

The frequency of national inspection is dependent on the inspection type. The routine inspections serving timely detection purposes are carried out every 3 months normally. However, the period between two consecutive inspections may be changed depending upon the scale of the facilities, the type of nuclear material, or characteristics of the facility. The physical inventory verification (PIV) is performed once per each calendar year. The period between two consecutive PIVs does not exceed 14 months. *Ad-hoc* inspections and special inspections can be carried out anytime depending upon the purposes of their inspections. Design information verification is carried out before the facility startup and also is performed annually during the routine inspection.

Korean SSAC: Progress and Future Plans

Article 7 of the Safeguards Agreement between the Republic of Korea and the IAEA states that "the Government of the Republic of Korea shall establish and maintain a state system of accounting for and control of nuclear material (SSAC) subject to safeguards under this Agreement," and also, "the Agency, in its verification, shall take into account the technical effectiveness of the Republic of Korea's system." In order to meet these requirements, the Government of the Republic of Korea has been taking necessary measures. Korean SSAC was established at the Ministry of Science and Technology (MOST) immediately after the Safeguards Agreement became effective in 1975. The Nuclear Control Division at MOST was established in 1993 as an authoritative organization for safeguards implementation as well as an official government window for all international nuclear control matters. The Technology Center for Nuclear Control (TCNC) at the Korea Atomic Energy Research Institute (KAERI) was established in 1994 to develop safeguards technology and to provide technical assistance to the Government. On 16 November 1996, MOST authorized TCNC at KAERI as the technical assistance agency for the national safeguards implementation. Each nuclear facility or installation has its own designated independent safeguards officers, which was strongly recommended by the Government to strengthen the SSAC by utilizing a work force that specialized in safeguards area. Even though the Government is at the top and the center of the Korean SSAC in terms of hierarchy and national role, it is mutual cooperation with every organization and institution that has made safeguards work successfully in Korea. A schematic diagram of Korean SSAC is shown in Fig. 1.

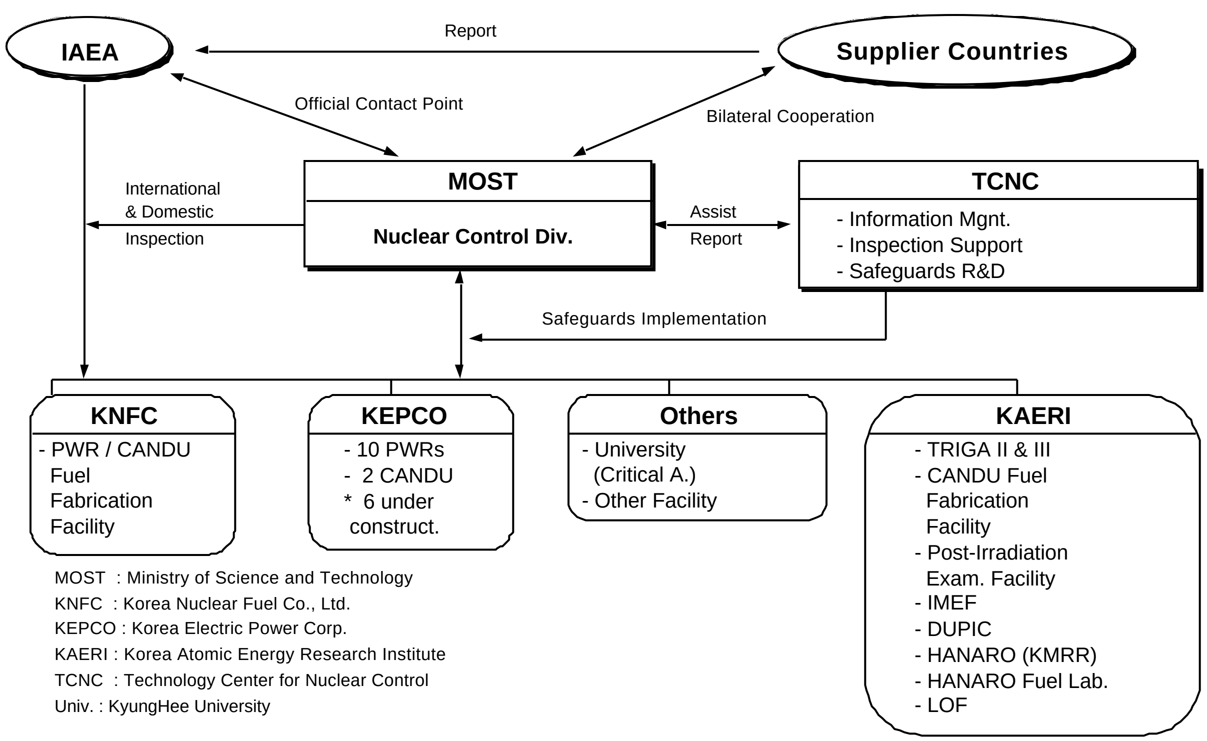

Figure 1. SSAC (State System of Accounting and Control) in Korea.

The Korean national inspection system has some unique features. Under the Atomic Energy Act, each nuclear facility prepares its own Accounting and Control & Physical Protection (AC&PP) Plan and submits it to the Government for approval. The purpose of national inspection is to determine whether the nuclear facility is being operated according to the approved plan (Fig. 2). Since the Notices of the Minister of Science and Technology went into effect in mid-1996, each nuclear facility has prepared its AC&PP plan and submitted it to the Government for approval. By the end of September 1996, MOST evaluated a total of 17 AC&PP plans submitted by domestic nuclear operators, of which eight were from the Korea Electric Power Corporation (each nuclear power reactor office); six from KAERI (research reactors, CANDU fuel fabrication plant, and other research facilities); one from the Korea Nuclear Fuel Company (KNFC); and two from others. In the evaluation, MOST recommended the facilities modify their regulations and resubmit revised plans. The final approvals were made in January 7, 1997.

After the second half of 1997, the national inspection will be initiated at seven nuclear facilities in Korea, representing each nuclear facility type and location on a test basis. The seven facilities include: three PWRs and one CANDU nuclear power stations, one nuclear fuel fabrication plant, one research reactor, and one hot cell. The national inspection will be carried out by the officials from the MOST Nuclear Control Division utilizing MOST site-resident inspectors at nuclear power plant sites with technical assistance by the TCNC staff members. Inspection procedures, verification methods, and reporting procedures related to national inspection will be tested and reviewed during that period. After making necessary revisions to the procedures, national inspections will be expanded to all nuclear facilities in Korea during 1998.

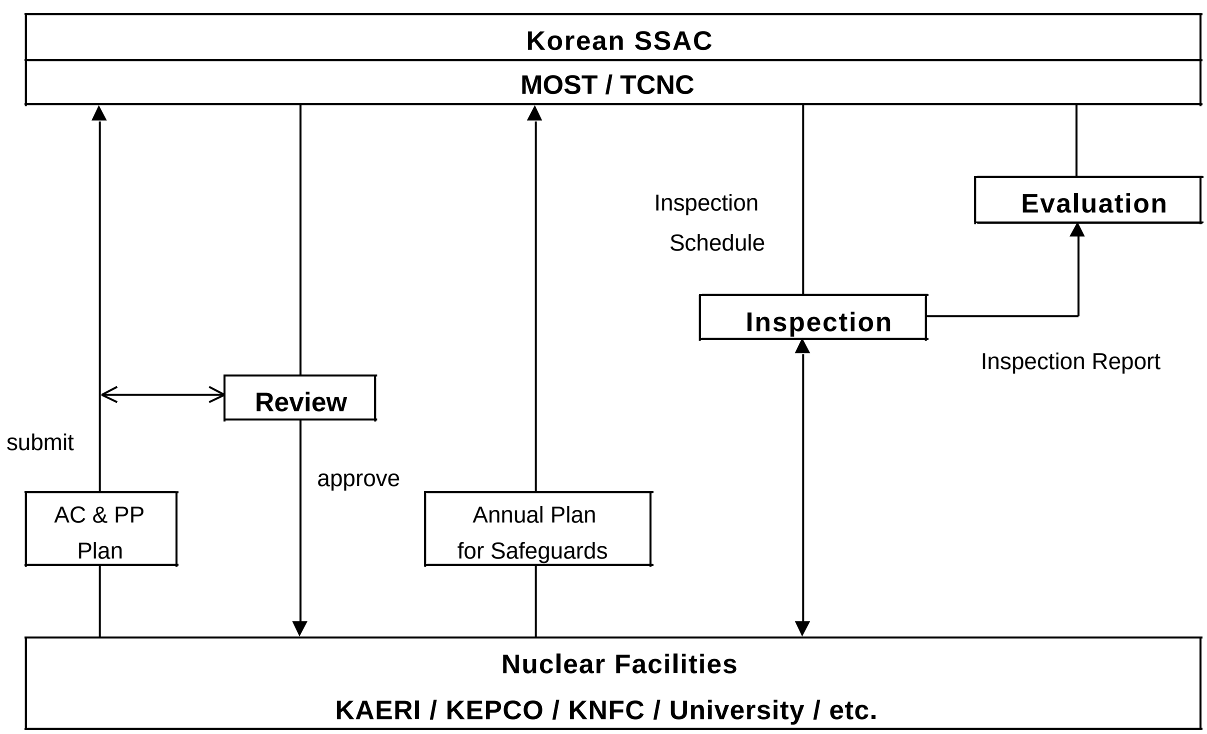

Figure 2. National Inspection System in Korea.

Cooperation with IAEA

In 1991, Korea and the IAEA started the first Joint Review Meeting on Safeguards Implementation in Korea. Since then, the Joint Review Meeting (JRM) has been held every year to discuss the result of safeguards implementation in Korea and the possible cooperation between both sides. The 6th JRM was held in Seoul during 5-9 July 1997, including working group meetings prior to the main meeting. Various topics were discussed during the JRM, such as safeguards implementation at individual facilities under the IAEA safeguards, strengthening of safeguards, and further cooperation between Korea and the IAEA. At the meeting, Korea and IAEA agreed to take steps for joint use of Non-Destructive Assay (NDA) equipment and seals by early 1998 and promote step-by-step cooperation in the joint use of other equipment for safeguards in Korea. Joint use of safeguards instruments will be extended to surveillance cameras for LWRs and to surveillance cameras and Core Discharge Monitors (CDM) for CANDU as experience is accumulated. This agreement is important for the future development of the Korean safeguards system.

The national inspection activities were programmed from the beginning with close cooperation with the IAEA in mind. All subsequent national inspections are scheduled to take place simultaneously with the IAEA routine inspections. Identical inspection and evaluation criteria will be applied. However, SSAC and IAEA will draw independent conclusions. This is analogous to the Level One Cooperation with SSAC as depicted in the Program 93+2 measures (Fig. 3). As the SSAC gains confidence and credibility in conducting the inspection activities on routine basis, the intent is to increase the sharing of safeguards research, equipment, and tasks as depicted in the Level Two Cooperation with SSAC. Level Two Cooperation may be broken into two parts, with sharing of equipment and technology at the first stage, and sharing of tasks and manpower at the second stage—such as the New Partnership Approach applied in EURATOM. The ultimate goal of a fully developed SSAC would be to conduct the routine inspection activities in lieu of the IAEA inspections, while the IAEA performs random verification of the SSAC results. This would be analogous to the Level Three Cooperation with SSAC. Currently, the Korean safeguards system seems to be at Level One. However, it is targeted to reach Level Three in the future.

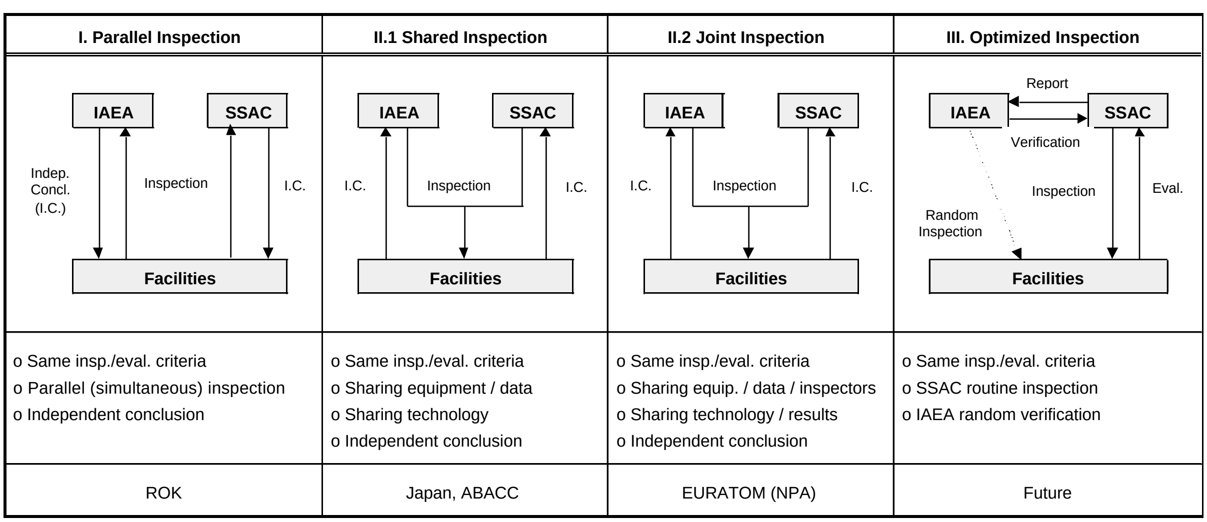

Figure 3. SSAC/IAEA Levels of Cooperation.

Future Considerations

In Korea, the national inspection system has just started and, for the time being, emphasis will be given to establishing concrete ground for the SSAC. Closer cooperation with the IAEA for improving the inspection goal attainment and sharing of equipment is also important for this.

Another issue, South and North Korean mutual inspection, which was raised several years ago, is unpredictable now. It may be raised again in the future after the successful completion of the Sinpo LWR project and normalization of the relationship between South and North Korea.

It is interesting to notice that there are many countries where safeguards inspections are conducted in parallel with the IAEA. However, most of those are performed under the scheme of the Regional System of Accounting and Control (RSAC), such as EURATOM and ABACC. Among the Non-Nuclear Weapon States (NNWS), only Korea and Japan have national inspection systems and are located in the same geographical region. So another issue, a regional collaboration scheme in the safeguards area, is an attractive idea. However, it is sensitive and interrelated with many other factors. It should be investigated in detail.

The Protection of Fissile Materials in Japan

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Introduction

In Japan, most nuclear facilities are oper ated by private industries or by semi-governmental organizations. The Japanese Government itself has no major nuclear facility. The major role of the government in this area is to establish policy, promulgate laws and regulations, and control compliance.

The main legal instrument for the protection of nuclear materials, including fissile material, is the Law for the Regulation of Nuclear Source Material, Nuclear Fuel Material, and Nuclear Reactors (the Regulation Law) enacted in 1956. Initially, the main objective in controlling nuclear material under this Law was the safety aspect. Since then, after subsequent amendments, the Regulation Law became the key regulation for administering national safeguards and physical protection for nuclear activities. We do not use the term "Material Protection, Control and Accounting (MPC&A)" in our legal system specifically, but the MPC&A system is in fact implemented in Japan.

Concepts Behind the Structures and Mechanisms for Japan's MPC&A

Japan has participated in several international treaties and governmental bilateral nuclear cooperation agreements. Japan is also a member of the Nuclear Suppliers Group. Such international / bilateral obligations affect the structure of Japanese MPC&A system. Both the physical protection system and the state system of accounting for and control of nuclear material (SSAC) of Japan take into account the obligations arising from international treaties / guidelines and bilateral agreements.

Although the Physical Protection Convention and the IAEA guidelines for physical protection (INFCIRC 225) can be applied universally, the level of physical protection measures are fairly dependent on the political and social situation of the country in question.

In the case of the SSAC, the basic structure, in principle, is less affected by the specific social / political situation than it is by the international commitments of the specific countries. However, the structure of the Japanese SSAC is an example of how the political situation at a specific time / place creates a unique system. To ratify the Nonproliferation Treaty (NPT), Japan had to solve several important political issues. How to ensure Japanese national security, while abandoning an option to go to nuclear (this was the 1970s, the time of the Cold War) was an important question. The other important question at that time was related to the IAEA's safeguards that were to be applied the Non-Nuclear Weapon States (NNWS) based on Article 3 of the Treaty. Japan was, and still is, an advanced country in nuclear energy development. Japan wishes that fair trade in the nuclear export business would prevail in the world. From the point of view of Japanese industry, the application of IAEA safeguards to their facilities would increase the cost of their products. Possible competitors with Japan would then be the United States, Canada, or the European states under EURATOM safeguards. If the IAEA safeguards relaxed its implementation for European states because they had accepted the EURATOM safeguards, Japan might be the sole country under stringent IAEA safeguards because the United States is a Nuclear Weapon State and does not need to use the IAEA safeguards based on Article 3 of the NPT.

So, the Japanese Government has decided that the national material accountancy system required by Article 7 of the model NPT Safeguards Agreement (INFCIRC 153) for Japan should have the same content as the EURATOM system. In this way, IAEA should treat these two systems the same. Using this reasoning, the SSAC in Japan has independent verification. The details of the SSAC are described below. However, briefly, the main points are that the SSAC requires the operators / facilities to establish and maintain a facility accountancy system, to report to the authority, and to request the operator to keep the inventory of its material accounts as required by the latest international standards (paragraph 55, INFCIRC 153). A Government inspectorate was established and safeguards inspectors verify the facility reports, etc., by independent verification techniques. Apart from the EURATOM case, an SSAC that has an independent verification capability is a very rare case in the world.

The guards do not carry firearms on duty at any nuclear facility in Japan. Countermeasures against an attack to the facility will be made by the reserve, back-up force (normally local police or self-defense forces). There are no specific measures taken against the "insider" problem in Japan. Personnel checks, normally made at the place of employment are deemed to be sufficient. Business people or workers are generally stationed together with many others in a large room rather than working in individual offices. Implicit mutual surveillance, in effect, exists in this system.

Japan's MPC&A

Legal Structure

The main legal basis for the implementation of MPC&A for Japanese facilities is the Law for the Regulation of Nuclear Source Material, Nuclear Fuel Material, and Nuclear Reactors ("Regulation Law") and associated Cabinet Orders, Prime Minister's Office Ordinances, Ministry of International Trade and Industry Ordinances and Ministry of Transport Ordinances. The implementing government organizations for this legal framework are the Science and Technology Agency (STA), Ministry of International Trade and Industry (MITI) and Ministry of Transport (MOT). The STA has the responsibility for overall coordination, implementation of the whole SSAC portion, and the physical protection portion of nuclear R&D facilities, nuclear fuel cycle facilities, and research reactors. The MITI is responsible for the physical protection portion of commercial power reactors, and the MOT is responsible for the physical protection associated with the transport of nuclear material.

According to the regulations, the holders of nuclear material have to establish and maintain a facility nuclear material accountancy system and facility physical protection system. The Government reserves the right to take measures to ascertain operator compliance with the regulation—chiefly by inspection and physical access, and such control measures as are actually called for.

Japan's Physical Protection System

Implementation

Facility operators handling nuclear materials are required by law to prepare and submit their physical protection rules to the state authorities. These rules require an approval from the state. The state authorities have issued technical standards of physical protection, which are essentially based on the IAEA's guidelines (INFCIRC 225). The facility operators also assign a protection manager for each facility and inform the authority of the name and title of the manager. As in the case of guidelines in INFCIRC 225, Japanese guidelines classify the facilities into three categories based on the quantity of nuclear materials in the facility. Technical standards for the physical protection measures to be allowed by the facility differ based on these categories.

Some of the technical standards for fixed sites are listed below:

1. A protected area should be established. In the case of a Category 1 facility, the area is doubly enclosed.
2. Boundaries of a protected area should be equipped with a barrier, alarm sensors, and other equipment.
3. Persons with access to the protected areas should be limited to those who need to have access, and to those who are determined to be reliable persons.
4. The articles carried into or taken out from the protected areas should be checked by metal detector, nuclear material detector, etc.
5. The inside and surrounding area of protected areas should be patrolled and constantly watched by guards.
6. Information on the physical protection plan and measures should be adequately controlled.
7. An emergency plan should be prepared.
8. Communications between the facility and back-up forces should be maintained, preferably by two different transmission methods.

Some technical standards in connection with transport of nuclear material are as follows:

1. A transport plan should be prepared for each individual shipment of nuclear material.
2. Shipments should be accompanied by one or more persons responsible for physical protection during transport as well as the necessary numbers of escorts.
3. Information on physical protection should be adequately controlled.
4. An emergency plan should be prepared.

Control of Compliance and Measures of Evaluating Effectiveness

State authorities (STA, MITI, and MOT) are authorized to check compliance by the facility operators and to evaluate the effectiveness of any specific physical protection system. In the case of the STA, which is responsible for nuclear fuel cycle facilities and research and development (R&D) facilities, STA officials visit the facilities from time to time and check the necessary information. The frequency of such visits depends upon the category; Category 1 facilities will receive more frequent visits, compared with other type of facilities. After site visits, the government officials report their findings and give their recommendations to the facility, if any. The actual statistics on the number of visits / recommendations are not disclosed yet.

Most nuclear material in Japan was transferred from the United States, originally under the terms and conditions of the Japan-U.S. Bilateral Governmental Cooperation Agreement. By the U.S. Non-Proliferation Act, U.S. officials have to ascertain that U.S.-origin nuclear materials are adequately protected. The U.S. Government sends a team of experts regularly to the recipient states to check the situation and to hold consultations; this team comes to Japan every 5 years. Although this is not a domestic procedure, it is a good time for the Japanese Government and the United States to check compliance at each facility and evaluate the effectiveness of each specific facility physical protection system.

Cost Considerations

The cost required to maintain the national physical protection system can be divided into the cost required by the Government to administer its responsibilities and the cost required by the holders of nuclear material to establish and maintain their facility physical protection system.

Government costs in Japan are difficult to identify. Human labor costs in the ministries are not charged to the project, so the personnel costs required to organize several advisory committees are minimal. Since the major role of the Government is to establish a policy, promulgate a set of regulations, and control the system, necessary expenditures are relatively small compared with the facilities' expenditures, apart from the R&D activities on physical protection. The R&D activities in Japan have been undertaken chiefly by the Nuclear Material Control Center (for the purpose of establishing policy, technical standards, etc.) and private industries (for commercial products to be applied in the nuclear facilities). Up to now, the Government expenditures for R&D activities are in the range of $1–10 million. Private industry's expenditures are not known.

Facility operators have to establish a physical protection system composed of hardware (barrier-like fence, hardened walls, doors, detection sensors, surveillance equipment, strong vault) and software (setting-up of the system, including computer system, employment of guards, escorts, education, and training). A larger facility requires much money. There is no data in Japan with which to analyze such expenditures. I guess a range of several million dollars to $10s of millions could be required in Japan for a large-scale commercial facility. Operational costs are relatively small, consisting of human labor costs (e.g., guards, workers for physical protection control room) and equipment maintenance. Operational costs are again proportional to the size of the facility.

Japan's System of Accounting for Nuclear Material (SSAC)

Implementation

The role played by the Government of Japan for the SSAC is more active than that for physical protection activities. STA has a Division solely devoted to the implementation of SSAC (including the jobs associated with the IAEA safeguards implementation). This Safeguards Division is responsible for establishment of policy, promulgation of domestic regulations, coordination of R&D activities on SSAC technology, implementation of safeguards inspections and so forth.

Facility operators must submit design information prior to the operation of their facility to the STA, and STA examines the design. During construction, the design information is examined by State inspectors. Before operation begins, the facility operator has to establish and maintain his nuclear material accountancy system in the form of "facility material accountancy regulations." This system must be explained to the STA and an approval sought prior to implementation. The operator also has to choose one or more nuclear material control managers for each facility. The name and title of such managers must be reported to the authority (STA). Regular reports (inventory change reports, material balance reports, and others), as well as *ad hoc* reports (export/import of nuclear material, special report) should be submitted to the STA. The facility operators account for nuclear material at an international standards level.

Control of Compliance and Measures of Evaluating Effectiveness

There are two ways to check the control of compliance and effectiveness of a facility material accountancy system. The major tool is the safeguards inspection; a check of "facility regulations" is the other.

Because Japan is a party to the NPT, the IAEA is implementing inspections at Japanese facilities. Government safeguards inspections are done concurrently with the IAEA inspections. At the facilities, national inspectors audit the facility records and reports, count the number of items such as fuel assemblies, check the identification of the material, measure nuclear material by non-destructive assay, take samples for chemical analysis, and apply and check surveillance devices.

The Japanese government has a safeguards analytical laboratory, and samples taken at the facilities are sent to be analyzed at this laboratory. During fiscal year 1996 (April 1996—March 1997), 152 uranium-bearing samples and 206 plutonium-bearing samples were analyzed. The number of non-destructive assay made at the nuclear facilities by national inspectors was 3,693 during fiscal year 1996.

There is no statistical data concerning the check of facility regulations. Since the same division in the STA is responsible for both of these activities, normally when national inspectors visit the facility for inspections, they check the facility regulations. In Japan, there are 166 small nuclear facilities. The amount of nuclear material contained in such facilities is so small that safeguards inspections are not done. Government officials check the facility regulations occasionally at such facilities.

Cost Considerations

Like physical protection system cost, the cost to maintain SSAC can be divided into two parts, Governmental cost and facility cost.

The Japanese Government has a Safeguards Division in the STA. The manpower in this Division would be used for SSAC operations. In addition, computer processing of accountancy reports and evaluation of accountancy data (about $3 million/y), maintenance of the analytical laboratory (about $4 million/y), and inspections (about 2,000 man days/y) are needed. At present about 30 persons belong to the Safeguards Division. The Government is also supporting R&D activities on safeguards and nuclear material accountancy technology. The expenditure for these varies year by year. In 1996, about $10 million per year was spent for the purpose.

For the facilities, again, it is difficult to find the data to determine the cost to maintain material accountancy systems. Some people indicate that the total cost for installation of the necessary material accountancy system, including computer software, measurement equipment, etc., would be less than a few percent of the total construction cost to build a nuclear facility. The annual operational cost of the system would depend upon the size of the facility as well as the mode of operation.

In Japan, significant expenditures are made by a facility for IAEA inspections. One PNC safeguards expert expressed the view that 600 man-days of inspections at his reprocessing facility cost the facility about 1,800 man days of effort to receive and prepare for the IAEA inspections. This cost stems from Japan's obligation to adhere to international treaties but it can not be separated from the cost for maintaining the facility accountancy system.

Further Strengthening of the System

Toward the end of this century, the world situation is drastically changing. The Japanese situation is not an exception. The social and cultural environments of Japan are changing. We are facing a wave of increased immigration, mostly from Asian countries. The traditional sense of safety and security is eroding. The employment style of Japanese industries is also gradually shifting. Lifelong employment is no longer secured. In spite of national control over the possession of firearms, the illegal import of guns is increasing.

So, I believe that now we might need to review our estimate of the possible threat, which is the basis for designing physical protection systems. Further, in Japanese regulations there is no description of the detailed criterion or standards which facility operators can use as references when they design their physical protection system. For evaluating licensing applications for nuclear facilities, the Government established the Nuclear Safety Evaluation Committee, composed of nuclear safety experts, to examine the safety aspects. In the case of physical protection, however, there is no such organization in Japan that reviews physical protection aspects. Licenses are examined by Government officials with no other assistance from the outside experts. In fact, we have difficulty identifying suitable experts on physical protection activities to consult in Japan. We need to strengthen the Governmental procedure for evaluating the adequacy of facility systems, as well as to make strong efforts to increase the number of physical protection experts in our country.

As far as the SSAC is concerned, Japanese SSAC is closely linked with the direction of the IAEA safeguards activity. Since IAEA safeguards are moving to a new direction (Programme 93 + 2), the Japanese SSAC will go the same way. The new IAEA safeguards system was approved by the Board of Governors on May, 1997. The Japanese Government, therefore, will go into the bilateral negotiations on the Protocol to be required to implement this new safeguards system in the future. According to the requirements incorporated in the Protocol, the SSAC has to be expanded to collect the information on nuclear-related facilities, in which nuclear material is not involved, and other information. Such changes will require an amendment to the Regulation Law.

In short, it is expected that the Japanese MCP&A system will require further strengthening of the SSAC portion, and may need reconsideration and strengthening of the physical protection part.

Roles of International Regimes

The roles of international regimes were very important in the past, and will become more important in the future. Many states who have significant amounts of sensitive nuclear materials have established their physical protection system with international guidelines (e.g., INFCIRC 225, Nuclear Suppliers Guidelines) as the basis for their system. As far as the SSAC is concerned, the changes to the IAEA safeguards system has a strong impact on the SSAC of the non-nuclear weapon states that are parties to the NPT. This trend will be the same in the future. Moreover, the power of the "nation state" might be weakened in the future, due to the fact that nongovernmental organizations and transnational industries seem to be growing stronger in the world of the future.

In the future, there is a possibility that various types of states could coexist in the world, namely, strong nation-states, chaotic states, and post-modern states. Some of the power presently held in the hand of the states might be transferred to the nongovernmental organizations or transnational industries. However, I do not believe the responsibility of MPC&A could be transferred to a nongovernmental body. There, the role of international entity must be strengthened. Some of my proposals that I would like to address at the International Conference on the Physical Protection to be held in Vienna in this autumn are briefly described below:

1. To widen the scope of the "International Convention on Physical Protection" so that the Convention can cover

not only international transfer but use or storage and domestic transport of nuclear material;

2. To strengthen international exchange on the experiences and technological knowledge about physical protection, e.g., regular scheduling of international meetings;
3. To strengthen the IAEA secretariat so that the secretariat can act as the best expert group in the world.

Conclusions

The Japanese system for the protection of nuclear material (i.e., MCP&A) was established, taking into account the international recommendations and guidelines. This system contains the measures to control the compliance at the facility operators' level. So far, the system has been working effectively, but due to recent changes in the environment, some strengthening of the present system is expected. The author recommends further improvement to the Japanese domestic physical protection system.

The international regime is very important to continue the effective application of worldwide protection of nuclear material. The author also recommends that the present international regime be improved.

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Review of the Indian Nuclear Experience

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India's Nuclear Power Program

India is an energy-starved country. In spite of the growth in India's power output from 1,400 MW at the time of national independence to 85,000 MW today, India still has enormous unmet energy needs. Symptomatic of this is the approximately 25% shortage of power at times of peak demand. Ambitious plans call for the addition in the next five years of 60,000 MW of increased capacity, requiring huge capital investments. This need for energy leads to a corresponding demand for nuclear power. Coal, gas, and oil are limited, so having secure energy sources demands the use of nuclear power.

India does not have sufficient quantities of uranium and therefore needs to use plutonium for the nuclear program to be successful. Using the uranium from domestic sources would only add a capacity of about 10,000 MW through Pressurized Heavy Water Reactors (PHWRs). The inadequacy of domestic uranium resources is compounded by India's not being able to buy natural uranium from any other country. This forces India to consider using its abundant thorium resources, which require the use of plutonium either as a burner or else in a fast breeder in conjunction with thorium. Using domestic thorium sources would increase power output capacity to 350,000 MW. Using plutonium is a proliferation risk, so India is trying to develop a proliferation-resistant thorium fuel cycle.

India has 10 nuclear reactors in operation. Two are boiling water reactors from the United States, two are PHWR reactors built with help from the Canadians. However, after India's 1974 "nuclear device" experiment, all collaboration came to a stop, so the remaining PHWRs are of indigenous design and construction. Total power output of India's nuclear reactors is about 2,000 MW. Progress toward the target of achieving a nuclear power capacity of 10,000 MW by the turn of the century has been slowed predominantly by inadequate funding and, to some extent, by the effort to develop an indigenous capability that is a consequence of certain foreign constraints.

Indian Material Protection, Control, and Accounting (MPC&A)

In 1948, India passed the Atomic Energy Act. Under this act, all nuclear minerals were brought under the ownership of the state to ensure security, control, and accountability. The Atomic Energy Commission was established, and placed under total civilian control.

Commission members are drawn from private enterprise, academic institutions, and top-level bureaucrats. This structure has not been altered since the Commission's inception. Civilian control is under the scrutiny of both the press and parliament. There is total transparency in all activities.

India generally follows the IAEA recommendations regarding physical protection. Although India has not signed the Convention on Physical Protection because it has doubts about the Convention's intrusiveness, it follows the convention in letter and spirit. Some recommendations have had to be modified because of site-specific issues and sociopolitical situations. Nuclear facilities are designed so the penetration time is longer than the countermeasures response time. When necessary (depending on the materials present), a double-barrier system is used, which is equipped with intrusion alarms and TV cameras under the control of security staff inside the facility. Internal security guards are not armed, but back-up is provided by special armed state police forces, which are in close proximity to the facility but keep a low profile. Commandos from the National Security Guard (NSG) are available if needed. Access to such facilities is controlled by monitors, magnetic cards, turnstiles, etc. India is currently developing a fingerprint access system. Reprocessing plants are co-located with power plants and R&D reactors to minimize transportation risks. Transport of nuclear materials over long distances is avoided.

An independent organization called Nuclear Material Control and Accounting (NUMAC) oversees MC&A; it is independent of the production and security agencies. Access to nuclear materials storage areas is key controlled and monitored by surveillance cameras and alarms. The transactions are carried out by the authorized personnel of the facility (dual control keys) in the presence of security and NUMAC representatives. NUMAC regularly audits the materials accounting, which is entirely computerized.

International safeguards apply to some of India's nuclear facilities. India has its experts in several IAEA activities. Matters dealing with safeguards are handled by a special committee in the Department of Atomic Energy.

Personnel training is considered very important. Facility operators are science and engineering graduates, undergo several years of training, and must be certified by the Atomic Energy Board before being authorized to work at the facilities.

India is proud that no instance of diversion, loss of material, or theft has occurred in Indian facilities.

The Experience in Pakistan

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There is no significant public concern in Pakistan about the protection of fissile material, partly due to the conspicuous absence of any reported case of theft, smuggling, or sabotage, and partly due to lack of public awareness about decision-making in this field. There has never been a report of an attempt to smuggle fissile material either out of Pakistan or theft from a nuclear facility or a terrorist attempt against nuclear installations. However, it does not mean that the concerned governmental agencies in Pakistan are oblivious of such possibilities. Pakistan Atomic Energy Commission (PAEC), is the premier national organization vested with regulatory authority to plan and implement Pakistan's nuclear program. It was first established in 1955 as a semi-government organization. Its administrative structure was reorganized in 1965 when it was made a statutory institution. The legal basis and framework for safety, control, and protection was provided through a Nuclear Safety and Radiation Protection Ordinance (IV) in 1984 under which PAEC was vested with powers to make necessary rules and regulations.[1] A Directorate of Nuclear Safety and Radiation Protection (DNSRP) was established in 1984 at the PAEC headquarters in Islamabad which was made responsible to formulate, supervise, and enforce nuclear safety and radiation protection measures.[2] The DNSRP examines the annual reports and carries out regular safety inspections of all the nuclear installations and establishments working under the executive authority of the PAEC.[3] Another body, the Pakistan Nuclear Safety Committee (PNSC), reviews safety reports and enforces guidelines on the safe transportation and application of nuclear materials.[4] There is an Advisory Committee on Fuel Cycle and Reactor Safety (ACFCRS) to assist the PAEC authorities and the DNSRP in the management, control, and protection of nuclear materials, and to maintain reactor safety.[5] Generally, the International Atomic Energy Agency (IAEA) guidelines on safety and protection of fissile material are followed.

PAEC seeks collaboration from the IAEA wherever possible under the terms of Pakistan's nuclear policy and from the Peoples Republic of China in personnel training and management skills.[6] According to the PAEC Annual Report 1991–92, DNSRP completed two Coordinated Research Projects awarded by IAEA on (1) Reference Studies on Probabilistic Modeling of Accident Sequences at Nuclear Power Plants in Pakistan [CRP-5560/RB] and (2) Modeling of PSA standard problems (benchmarks) to investigate uncertainties and sensitivities results to model assumptions and data [CRP-6045 / RB].[7] The PAEC also:

- Signed two agreements with China on the "Cooperation in the Field of Nuclear Safety and Assistance on the Nuclear Safety Review of CHASNUPP" (Chashma Nuclear Power Project) between National Nuclear Safety Administration (NNSA) and the PAEC.[8]
- Arranged two courses in collaboration with NNSA, China, on Accident Analysis and Safety Review of Pressurized Water Reactors (PWR) in which twenty engineers and scientists participated.[9]
- Provided advice and consultations on safeguards, materials control, and accounting procedures to various PAEC establishments.

There is an ongoing coordination between IAEA (Minister Technical, Atomic Energy Affairs) and DNSRP on matters related to the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in case of a Nuclear Emergency.[10]

Pakistan's main source of fissile material is the Uranium Enrichment Plant at Kahuta. This plant is probably the world's most protected nuclear facility. Its extremely tight and most secretive security procedures have been supplemented by the deployment of anti-aircraft missiles to ward off any acts of intrusion, sabotage, and aerial threats. The security procedures and structures for its protection were instituted in 1983–84 when Pakistan feared an Indian nuclear attack on Kahuta to preempt the development of its nuclear weapons capability. It was believed that India might have been encouraged by Israel's destruction of an Iraqi nuclear reactor in 1982. Pakistan's President at that time, General Zia-ul-Haq, declared that an Indian attack on Kahuta would lead to an all out India-Pakistan war. Despite the fact that India and Pakistan signed a "No-Nuclear Attack" (against each other's nuclear facilities) Agreement in December 1988, security procedures for Kahuta's protection continue to be in place. Since the Kahuta plant is the only main source of weapon-grade uranium (WGU), Pakistan cannot afford to relax its guard. The Kahuta Uranium Enrichment Plant does not figure in the Annual Reports of the PAEC. One can logically infer that the Kahuta Plant, being a dedicated nuclear facility, had not been placed under the control of PAEC. However, there has never been any official statement about the organizational hierarchy of Kahuta and its associated establishments at the Khan Research Labs, dedicated to the founder, Dr. A.Q. Khan. Pakistan has occasionally admitted the maintenance of a nuclear capability which has a security dimension. A former Foreign Secretary, Mr. Sheharyar Khan, admitted during an interview to *The Washington Post* in 1992 that Pakistan possessed a nuclear device and that it had frozen the production of "highly enriched uranium and weapons cores."[11]

Pakistan's operational nuclear power plant, KANUPP (Karachi Nuclear Power project), has a CANDU-type 125-MW natural uranium, heavy-water reactor. It was commissioned in 1972 with Canadian assistance, design, and development. It is under the Canadian-IAEA safeguards. After the withdrawal of Canadian nuclear assistance to Pakistan in 1976 in the aftermath of the Indian nuclear explosion of 1974, PAEC has been able to operate it through indigenous design and development of various spare parts and fuel fabrication. After the termination of the Canada-Pakistan Nuclear Assistance Agreement in 1976, Pakistan was under no obligation to continue to accept international safeguards from a purely legalistic standpoint. However, Pakistan never insisted on the removal of international safeguards. The nuclear waste material from KANUPP contains reactor-grade plutonium stored under water in the Karachi shore under the Canadian-IAEA-Pakistan safeguards and inspection system. The Pu output capacity of KANUPP is estimated at 30 kg per year. Pakistan does not possess a commercial-scale plutonium reprocessing plant and, therefore, there is no movement or transportation of reactor grade plutonium from the storage facility maintained under IAEA safeguards. Since operations began in 1972, there has been no report of material imbalances, theft, or attempted theft of nuclear material. However, there was a report of heavy-water leakage on April 18, 1989, at KANUPP. The DNSRP and IAEA prepared an evaluation report on the causes and environmental impact of the leakage.[12] Pakistan has recently installed a 40-MW research-cum-power reactor at Khushab near Sargodha. It is a natural uranium safeguards-free reactor with a Pu production capacity equivalent to India's CIRUS, between 9 to 12 kg. Since Pakistan does not possess and operate a commercial-scale reprocessing plant, there are no immediate weapons-oriented implications of the Khushab reactor. Pakistan's other nuclear facilities are small in scale and experimental in nature (e.g., two 5- to 10-MW research reactors, a pilot scale reprocessing plant, and another small-scale enrichment plant with negligible output capacity). A 300-MW nuclear power plant, CHASNUPP, which is being installed with assistance from China, is near completion. The plant is under the Chinese-IAEA safeguards.

There are varying estimates of Pakistan's stockpile of fissile material. Allbright et al., estimate Pakistan's stockpile of highly enriched uranium (HEU) as 130–220 kg, sufficient for 6 to 10 nuclear weapons.[13] Another source has suggested Pakistan's stockpile is 200 kg of 90 percent HEU.[14] This stockpile is appropriate for producing 8 to 10 nuclear weapons. As mentioned earlier, Pakistan's exclusive source of HEU is the Uranium Enrichment Plant at Kahuta. Nayyar, Toor, and Mian underline Pakistan's "checkered history" of uranium enrichment and point out that the production of HEU since the operation of the plant in the mid-1980s, which was first stopped in 1989, was restarted and capped again in 1990–91.[15] After that, the Kahuta Enrichment Plant is believed to be operating at the lightly enriched uranium (LEU) level, which indicates that there is another stockpile of LEU. These authors calculate that from 1991 to 1996, Pakistan could have produced between 6 and 22 tons of 3 to 5 percent LEU, which can then be enriched to a 90 percent level within a time frame of few months to one year, depending upon the nature of requirement or crisis.[16] For example, an understanding of a FMCT (Fissile Material Cut-Off Treaty) conclusion or the perception of an immediate threat from India.

Pakistan had accepted international safeguards on all its nuclear installations until 1974 when India exploded a nuclear device. All of its nuclear installations at that time, PARR-1 (Pakistan Atomic Research Reactor), KANUPP, and the controversial plutonium reprocessing plant stipulated in the France-Pakistan agreement in 1976, were under safeguards. It was only after the 1974 Indian nuclear explosion that Pakistan refused to unilaterally accept the full-scope safeguards.

To conclude, one can say that although Pakistan at present faces sectarian and ethnic violence in two of its major provinces, Punjab and Sind, there is no perception or fear of a terrorist attack on its nuclear facilities or any other form of sabotage. There is, of course, no guarantee that such an activity would not take place at all in the future. There is no long distance transportation of fissile material from one facility to another facility and therefore, no attendant transportation risks are involved.

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The First 50 Years—A Review of the Department of Energy Domestic Safeguards and Security Program

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The Early Years—Physical Security

In June 1947, the Atomic Energy Commission (AEC) established five separate field organizations with security offices and a small security staff in its Washington, DC, headquarters office. Security practices were instituted that centered around security investigations, inspections, protection of key facilities, and accurate inventorying and accountability of classified documents. By the end of 1948, the AEC security program consisted of four interdependent programs: personnel security, physical security, classified document control, and inspection. The AEC established divisions for security and intelligence to replace those of the Manhattan Engineer District and organized civilian guard forces to replace the military forces. The new security organization issued upgraded standards for the protection of Restricted Data in June 1947. Newly prepared AEC regulations were heavily compliance oriented. Other initial actions included:

- Conducting an independent audit and rating system of security operations and recommendations for revision of security policies;
- Formation of a security organization to transport classified materials, documents, and special nuclear material (SNM) within the United States;
- Establishment of AEC guard forces at Oak Ridge and Los Alamos.

AEC Bulletin No. 153, "Physical Security Standards for AEC Facilities," issued in 1949, provided for broad coverage of all phases of physical security required for the protection of AEC security interests. This bulletin was superseded in 1952 by "Physical Security Standards," and was itself replaced with AEC Manual Chapter (MC) 2401. MC 2401 included changes and additions that provided categories of material for determining required protection, authority to carry firearms and make arrests, descriptive requirements for various types of security areas, and, for the first time, definitions of terms. Later revisions to MC 2401 discussed lighting standards, delineation between classified and unclassified matter of strategic importance, posting no trespassing notices, and qualifications for guards. A complete revision of MC 2401 was issued in June 1969. Incorporated into this revision were standards for improving physical security programs, inspection of telephone equipment and masking of electronic emanations, and specifications for protective alarm systems. In the early 1970s, new firearms qualifications for guards and couriers were added. Changes were also incorporated to upgrade the in-storage and in-transit requirements for weapons, components, and SNM. Other security bulletins went through a series of revisions similar to those for MC 2401. As with other Manual Chapters, this document was complete with a detailed handbook of standards and guidance. For example, Manual Chapter 2406 (1970), "Protection of Government Property," established procedures for protecting unclassified AEC property and facilities. Beginning in 1949, while the AEC was formulating and improving physical protection, responsibility for security for the closed towns of Los Alamos, Oak Ridge, and Hanford was placed on local civic authorities. Secure buffer zones were abolished and the island concept, with its compressed security areas, was put in place. These areas held only those buildings containing classified material and replaced the much larger areas that had included all buildings at a given site. The open areas replaced some of the buffer zones around sensitive weapons areas such as the Y-12 Plant at Oak Ridge, TN, and Lawrence Livermore Laboratory in 1963.

Technical Security

In 1957, the AEC added staff electronics specialists to expand into technical security and testing. Closed-circuit televisions and interior and outdoor alarm systems were tested for acceptability. Detailed specifications for protective alarm systems were developed to standardize acceptable performance. Technical security inspections were conducted periodically and security personnel were trained in technical security countermeasures. Compromising emanations from areas that processed classified information were identified as a security concern by 1967. The AEC solution was to install electromagnetic shielding in each room. However, a white noise generation device developed by technical security personnel was soon in use to mask most radiated compromising emanations. A technical surveillance countermeasures committee was established in 1964 to counter technical security penetration attempts. In 1970, the Division of Security recognized that classified computer information required additional resources and development of security standards. Personnel were added to develop uniform security standards and, in 1971, the AEC published MC 2703, "Security of Automatic Data Processing Systems."

Vulnerability Studies

Since 1948, sabotage vulnerability surveys of vital equipment and process controls were conducted at major AEC facilities, and were later expanded to include support facilities. Potential or perceived threats to U.S. nuclear programs and activities had been documented as the "Basic [*security*] Assumptions" since the program's inception. By 1972, terrorist activities had increased worldwide to the point that the President established a Cabinet Committee to combat terrorism. The terrorist attack at the 1972 Munich Olympic Games increased public awareness of the potential threat of nuclear terrorism. Within the AEC, the Division of Security tightened physical security at the nuclear facilities, specifically measures to detect and prevent unauthorized entrance. The threat definition was updated in the mid-1970s to reflect the increasing dual concerns of proliferation and terrorism. Field managers were required to assess their protective arrangements and recommend appropriate changes. Internal assessments and external reviews provided the impetus in the early 1970s to improve and modernize the physical protection programs. For example, the Subgroup on Physical Protection and Surveillance of Special Nuclear Material, one of the five subgroups of the Task Force on Nuclear Materials Management, issued findings as part of the "Ryan Report" (named for its chairman, John G. Ryan, Executive Assistant to the AEC General Manager). The subgroup noted that the practices and procedures needed to be strengthened to assure that SNM was adequately protected: specifically, the nature of the threats should be redefined, the

AEC regulations were ambiguous in many instances and required rewriting, protection at licensee facilities was neither comprehensive nor definitive, and a stronger oversight program was needed to identify problems and initiate corrections.

Continuous Improvement

As early as 1948, the basic operating plan for the AEC Office of Security and Intelligence stressed that physical security programs should be supported by necessary research and studies on new materials, devices, techniques, and equipment to provide continuous security improvements for the protection of nuclear materials. Congressional hearings in 1973 addressed the concern that nuclear materials might not be adequately protected. The AEC and other federal agencies were directed to substantially increase research and development (R&D) for physical protection programs. Sandia National Laboratory was designated lead laboratory for physical security technology development because of its key role in the protection of nuclear weapons. Work focused on intrusion detection, hardened vehicles, personnel identification, penetration-resistant barriers, extended range communications, protective force training and equipment, and evaluation of methods to test commercial equipment and new proposals. An AEC-sponsored bilateral exchange was held between Sandia National Laboratories and other states to exchange methods, technologies, and new ideas for the physical protection of nuclear materials.

The Early Years—Safeguards

From 1947–54, all SNM was owned by the Government and generally held by the AEC and its contractors who operated government-owned facilities or government-controlled plants and laboratories. Material control procedures were prescribed by the AEC for its contractors to follow. Physical protection focused on nuclear secrecy rather than the prevention of theft or terrorism. A high level of accountability existed at these facilities due to the small scale of nuclear activities and materials. However, early safeguards consolidated the measurement data needed for plant operations with material control and accountability (safeguards). It was considered to be a matter of economics—SNM need be controlled only because of its intrinsic value—but there was no nuclear material control or physical security for privately owned SNM. Most SNM processed in the private sector was government-owned and/or classified in nature and was, therefore, subject to AEC classification and material control requirements. Many nuclear facilities were involved in commercial licensed operations as well as government contract operations. Some difficulties arose at these facilities, since identical nuclear materials could be in process under different lease or contract agreements and under varying degrees of financial responsibility. In April 1965, at the NUMEC facility in Apollo, PA, the AEC determined there was a discrepancy in the inventory of 61 kg of highly enriched uranium. A similar audit later that year at the Nuclear Fuel Services (NFS) Facility in Irwin, TN, found a discrepancy of 44 kg of highly enriched uranium. Beginning in May 1966, AEC regulations required that all licensees account for privately owned nuclear materials in their operations. Physical security continued to be required at the government facilities but not at private sector facilities that were not processing government owned or classified nuclear material. Nuclear materials accountability in the private sector was now upgraded to that required by AEC contractors entrusted with government nuclear materials. The problems brought to a head by the NUMEC/NFS discrepancies precipitated a broad review of the entire safeguards program. In 1966, the AEC established a safeguards advisory panel that raised the issue of safeguards against subnational threats posed by criminals and terrorists. Previously, materials accountability had been oriented toward international nuclear nonproliferation concerns. The panel set the stage, not for an increased emphasis on safeguards but for physical security in the private nuclear sector. However, during this period, the AEC supported development of equipment capable of measuring nuclear material as it moved through various processes in a facility and the term "materials control and accountability" was being used for the first time in the safeguards context.

The AEC materials-accountability system that was used for recording program inventories was primarily a manual record keeping system designed in 1948-50. In 1965, the Nuclear Materials Information Systems (NMIS) began its evolution into the government's automated information system of current and historic data on the processing and shipment of nuclear material. The Ryan Report recommended that NMIS be expanded to provide AEC-wide data necessary for what was to become the Nuclear Materials Management and Safeguards System (NMMSS). The report stressed greater care in assuring proper categorization of the material. One of the first facility computer-based accountability systems was developed and used at Los Alamos beginning in 1960. This punchcard-based system could provide inventory updates every two weeks.

The ERDA Years—Safeguards and Security

The Energy Research and Development Administration (ERDA) and the Nuclear Regulatory Commission (NRC) replaced the AEC in 1974. NRC took responsibility for the private sector of the nuclear industry while ERDA assumed responsibility for national security programs and R&D activities. Some facilities, such as NFS in Irwin, TN, were NRC-licensed, privately owned facilities performing work for ERDA. ERDA was short-lived and, like the AEC, was not a Cabinet-level agency. ERDA was replaced in 1977, but during its existence it supported an increased number of R&D activities to provide advanced techniques for modeling, assaying, assessing, and protecting nuclear materials. The governmental focus was changing from physical security to safeguards as the insider threat was being recognized and defined. Nonproliferation and international safeguards concerns were increasingly visible but would not yet impact domestic facilities with strategic-based missions. There was growing public concern that the nuclear threat would escalate. As a result, ERDA planned greatly increased expenditures in the late 1970s to expedite the development and installation of improved accountability and security systems.

Vulnerability Assessments

The historical evidence indicates that the period from 1974 to 1977 could be easily termed the "assessment years" for ERDA. The function of these assessments was to determine if any weaknesses or vulnerabilities existed and to upgrade the weak links. Some examples follow. The first aggressive attempts to increase safeguards and security program efficiencies and logically control costs occurred during this period. A joint ERDA-NRC Task Force on Safeguards produced a report in July 1976 that addressed the current status and future direction of physical security programs. Three representative ERDA (license-exempt) facilities were reviewed to assess their parity with NRC-licensed facilities of highly enriched uranium or plutonium. While generally in compliance, improvements were needed to assure these facilities could counter the defined threat levels. The most prevalent issues dealt with control of access to both stored and in-process special (strategic) nuclear materials, exit search procedures, and security force response capabilities. The report also noted that the facilities could not adequately protect against an external threat that had inside knowledge. One facility was identified as not being able to protect against theft of nuclear materials by an insider. ERDA and NRC were both tasked with identifying the required safeguards upgrades and with approving the necessary plans with funds. A rigorous assessment approach first used in 1976, Diversion Path Analysis (DPA), was a means for evaluating and improving internal control of safeguards and security. This method employed a systematic determination of all "diversion paths" in the process analyzed. As each diversion path was identified, the analyst suggested modifications to the current nuclear material operations to eliminate the path or decrease the detection time. DPA was a popular but labor-intensive assessment method used up through the mid-1980s when it was replaced by automated techniques. Brookhaven National Laboratory completed a physical protection simulation model for evaluating and comparing various physical protection plans under a variety of attacker configurations. The program assessed system effectiveness using tradeoffs of guards, barriers, alarms, procedures, and other components. Industrial sabotage could be analyzed through fault tree and decision tree analyses to evaluate safety systems and procedures designed to protect the public from accidents. In 1979, the NRC undertook the first comprehensive study of the potential insider threat to licensed nuclear facilities.

Computerized Accounting

Technological advances made the ERDA period a time of significant progress in computerized accounting systems. The Los Alamos Dynamic Materials Accounting and Control (DYMAC) concept was developed in 1973 to draw material balances around unit process areas as a more incisive approach to the problem of insider threat. This method incorporated the rapid measurement capability of new nondestructive assay technology, computerized data entry and retrieval, and a proven unit process system of accounting. DYMAC was the first "near-real-time" method and the first attempt at a complete operating safeguards system at Los Alamos. It demonstrated the importance of a systems approach to safeguards that combined the efforts of instrument developers, systems analysts, and materials-processing experts, and led to the formation of the Los Alamos Safeguards Systems Group in 1977. In 1976, the Savannah River Plant announced their Accountability Inventory Management System (AIMS), a computer inventory control system for nuclear materials at their plant. It was designed to produce reports for ERDA and the plant and to maintain timely records of nuclear material by location.

Nondestructive Assay

During the mid-1970s, the wet chemistry techniques and by-difference estimates that had supported accountability needs were being augmented by nondestructive assay. These new assay methods permitted reasonable accountability values to be determined for materials that were previously unmeasurable. During this period, the Los Alamos nondestructive assay program was actively developing new techniques for safeguards use, including delayed-neutron and gamma-ray counting, passive neutron coincidence counting, passive gamma-ray spectrometry with transmission correction, enrichment meter, and K- and L-edge densitometry. A main concern was to correct for macroscopic effects due to physical characteristics of the assay material.

Systems Integration

During the 1970s, the security and response forces were still a mix of federal and contractor employees. Physical security activities focused on integrating existing technologies into comprehensive systems and refining existing programs. The "Nuclear Security Enclosure" was one such system that combined personnel access and control, special materials detection, metal detection, and explosive-detection units. Hand-held radiation monitors were developed in 1975 to permit security inspectors to scan vehicles and personnel for nuclear materials during normal search procedures and during emergency conditions. Computer-based systems were being incorporated into alarm display systems to enhance security console communication and interaction. These systems replaced the more expensive annunciator panels, which used indicator lights and push buttons to signal alarms, and the cathode ray tube systems, which were not capable of simultaneously displaying the status of all the security zones. A method was developed for automatically detecting duress in security personnel. This technique recorded the heart rate of the security officer and used computer analysis to determine the reliability of an alarm triggered under duress. The most vulnerable link in the overall SNM handling system involved transportation of strategic quantities of nuclear material. In 1976, new transportation procedures had been implemented for 95% of the strategic quantities of government-owned SNM shipped between, to, and from licensee facilities and between ERDA and military sites. A computerized conflict simulation model, SABRE, was introduced for the analysis of transportation safeguards systems undergoing an armed attack.

Emergency Response

Two ERDA elements for timely and effective response to mitigate potential diversion attempts or other nuclear emergencies were: (1) the Emergency Action Coordinating Team, which coordinated government reaction to a nuclear emergency, and (2) the Nuclear Emergency Search Team (NEST), which provided detection and recovery of nuclear materials using specially designed portable sensors for material detection.

The Department of Energy

ERDA was replaced by the Department of Energy (DOE) in August 1977. Public Law 95-11 (42 USC 71 31) established the DOE at the Cabinet level to effectively manage the energy function of the Federal Government, transferring the ERDA functions related to nuclear weapons and national security (42 USC 71 1 12). The Atomic Energy Act of l954, as amended, remained the foundation and legal basis for SNM safeguards and security programs in the DOE.

During the first years under DOE direction, R&D activities in safeguards and security flourished. In 1979, the Office of Safeguards and Security was established to develop policy and support safeguards and security applications to assure the nuclear materials inventory at the contractor facilities. In the late 1980s, safeguards and security operational costs and technology development funding declined as production and process lines were closed and SNM inventories were consolidated. But significant improvements had been made for both safeguards and security. Physical protection benefited from commercially available, advanced systems technology. Safeguard advancements benefited from the tremendous strides in computing in near artificial intelligence applications and nonintrusive measurement systems. Although most significant changes in safeguards and security occurred during the mid-1980s, these changes had their basis in the early days of the AEC. The technological impetus initiated in the 1960s ultimately allowed technology to replace many costly, labor-intensive operations. Security forces personnel were increasingly replaced by automated monitoring and alarm systems; complex wet chemistry analyses for nuclear material accountability measurements were replaced with automated destructive and nondestructive assay systems. In the late 1980s, mandatory compliance to specific requirements was being replaced with performance-based requirements, which specify the conditions to be met without prescribing the methods to use. The concept of graded protection gave the different DOE sites the freedom to adjust their safeguards and security according to their site needs. Graded protection and risk management principles necessitate that safeguards and security programs be applied where the loss, theft, compromise, or unauthorized use of materials or information would have serious impact upon national security, the public, the environment, or other DOE programs. In the 1990s, DOE nuclear facility requirements became a mixture of regulatory orders and Federal statutes that changed the penalties for noncompliance to a civil nature.

Physical Security Today

Beginning in 1977 and extending through the budget cycle in 1987, security upgrades were completed to install state-of-the art detection and assessment capabilities at the DOE nuclear facilities. Physical protection was deemed the most critical to complete, with safeguards improvements to occur later in the process; several billion dollars were spent on improvements to safeguards and security programs during this period. Security forces that transitioned from AEC to DOE as government employees were fully privatized in the 1980s in an attempt to reduce costs and to put in place physical condition requirements for security personnel. Immediately after the protective force contractors took the place of the DOE guards, the size of the security force increased dramatically due to new requirements put in place by DOE. Helicopters, explosives detection, patrol canines, and, in 1982, special response and tactics teams were added to the response options for threats to government materials at the nuclear facilities. Increased emphasis was placed on training the security forces. In the mid-1980s, laser-based training gear (Miles) allowed force-on-force security response training exercises with laser-equipped rifles and personnel wearing sensors. The modern, DOE Central Training Academy in Albuquerque, NM, was established in 1984 and was later expanded to all aspects of safeguards and security. A human reliability program, initially implemented in 1985 to reduce the potential insider threat, required everyone with potential access to significant quantities of SNM to undergo a medical review and drug testing. Technology was put in place at facility boundaries to detect intrusion and to close possible diversion paths.

DOE issued a modern-era '"Generic Threat Statement" in 1982 that established the content and format for future revisions. Terminology was changed in a 1991 update to reflect its current status as a "Design Basis Threat." Later revisions in the early 1990s reflected events in the United States and abroad that could have an impact on DOE safeguards and security programs (e.g., the terrorist use of sarin in the Tokyo subway incident in 1995 and the terrorist bombing of the World Trade Center in New York City in 1993). The Design Basis Threat currently provides the foundation for DOE safeguards and security policy, establishes a national baseline for the new facility design and current facility reconfiguration, and serves as the norm against which system effectiveness is assessed.

Assessment of a facility's safeguards and security system performance and identification of system vulnerabilities became more inclusive. Computerized programs determined where a facility should employ its resources to achieve the greatest benefit when mitigating any vulnerabilities in the safeguards and security system. The software program EASI used early hand-held calculators to analyze one pathway and give the probability for interruption of an outsider's attempt to acquire nuclear materials. With greater computing power, more complex programs to support safeguards and security activities were developed beginning in the mid-1980s. BATL was a neutralization program that considered facility protective force engagements with small outsider forces. SAVL was a program that considered multiple paths for an outsider attempting to break into a facility to acquire nuclear materials. The program ET considered the insider or knowledgeable worker's potential for acquiring control of nuclear material. The original BATL, SAVL, and ET programs have been improved for current use and added as modules to the program ASSESS, which is a mathematical computational program that identifies the 10 most vulnerable pathways that could be used by an adversary to acquire nuclear material. The results provided are the probability of neutralization of the adversary's attempt to acquire access to a security area regardless of motivation (theft, sabotage, etc.). ASSESS considered the facility's safeguards, security, and operational issues to give the overall probability of the safeguards and security system's success. The latest software for a desktop computer is Joint Technical Simulation (JTS), a simulation program that uses the 10 most vulnerable pathways determined by ASSESS as well as any expert option pathways in the determination of the probability of neutralization. The results from these assessments are documented in a Site Safeguards and Security Plan (SSSP) with a detailed description of the safeguards and security system, facility operations, and any unique facility conditions. Independent reviews and assessments are compared against the information provided in the SSSP to validate acceptable system performance.

Previously, security personnel manning a central alarm station (CAS) watched either a series of lights that would flash to indicate an alarm condition or watch a series of cathode ray tubes to identify an alarm activity. By the late 1980s, technological improvements provided the security personnel at the CAS with the automated capability to identify, assess, and direct a rapid response to an alarm. For example, in an alarm condition, a computer automatically activates a camera monitoring the alarmed area, places the picture on the monitor screen, and records a historical video of the alarmed area. Alarms in any part of the plant can now be inspected and assessed by individual location using a touch screen monitor.

Safeguards Today

One of the most advanced monitoring systems was the result of a plant upset condition that led to a nuclear criticality. This accident at the Idaho National Engineering Laboratory at the Chemical Processing Plant resulted, by the mid-1980s, in a process monitoring and control system that monitored the status of valves, pumps, solution densities, and tank volumes for both processing and chemical makeup areas. Data acquisition devices transmitted process data to a computer for data processing and storage. While the system was used by safeguards, operations, and support functions, it allowed safeguards to monitor and track SNM as it moved through the process. Monitoring programs provided for an alarm when atypical processing data were received. Another part of this system automatically tied in data to the process monitoring system from the analytical laboratory to provide technical specifications limits and statistical testing used for safety and operational control of the process.

From a safeguards viewpoint, the most pronounced impact upon any domestic program in DOE for safeguards and security is due to the improved capabilities of nondestructive assay systems. Advancements in electronics and computing capabilities allow nondestructive assay systems to perform nonintrusive measurements for a greater variety of materials. The thermal neutron coincidence counter that was first installed at the Los Alamos plutonium facility in 1972 has been improved to produce results that are more accurate and much more precise. The segmented-gamma-scan instruments have greater capabilities and improved software to perform measures that account for lumps and other inhomogeneities in the material. Instead of having a single type of coincidence counter, instruments can be constructed that are insensitive to or correct for a material's physical and chemical characteristics with improved measurement results. Calorimeters measure the heat output from nuclear materials, which is directly related to the quantity of material present. Tied with gamma isotopic instrumentation, the calorimeter produces timely, high-quality assay results without opening the material container. Nondestructive assay instruments not only produce results comparable with destructive analytical analysis but also provide assay information on materials that previously could only be given an estimated value. However, as with any assay method, the best results are obtained when the calibration standards used are representative of the material being assayed.

Nuclear material accounting systems have advanced to become local area networks with work stations wherever nuclear materials are handled or stored. Information is entered before the actual transfer operations begin to provide nearly immediate transfer approval and updating of the location and inventory of all nuclear materials throughout the facility.

Summary

From the early days of the AEC through the ERDA to the DOE, the key to success was building on past knowledge to produce safeguards and security programs that are responsive to changing threats in protecting and accounting for U.S. nuclear materials. The principal support for this process is the technology development program that identifies new technology, modifies existing capabilities to fit new needs, and learns lessons from past activities.

We have improved detection, delay, and response capabilities. Remote monitoring technology can maintain continuity of knowledge on a canister of material. Central alarm stations incorporate many advanced features that rely less upon human interactions for detection and response. Our safeguards and security personnel are better trained, equipped, and knowledgeable in the performance of protecting and accounting for nuclear materials. DOE has also learned that rigid compliance with general, national regulations is not sufficient. Allowing sites to design and implement equipment and systems that best suit their needs results in the best performance against both insider and outsider threats on a site and facility-specific basis. The Design Basis Threat and the concept of graded protection allow facilities to manage their nuclear material risks and apply resources where they're most needed. We also have the capability to performance-test our systems by simulation and actual force-on-force and insider exercises to demonstrate that the systems do perform to address the safeguards and security concerns. In contrast, in the initial DOE years, such a demonstration would most likely have included only a nuclear material inventory to indicate that no materials were missing and to verify that the book inventory matched the actual nuclear materials inventory. Materials accountability was recognized as an acceptable performance test for the physical security systems.

Safeguards and security systems require constant attention and improvement to be effective and reduce costs. It is essential that we remain alert and continually improve our system to assure continued protection of nuclear materials. Nevertheless, we are confident that our implemented safeguards and security programs are capable of protecting U.S. interests against a variety of threats and can serve as a worldwide example for the establishment of similar systems elsewhere. The DOE continues to fulfill its mandate that began with the nuclear programs of the pre-World War II years for protecting and accounting for SNM and weapons information.

International Cooperation to Combat Illicit Nuclear Trafficking

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Scope of the Problem

Early in the nuclear age, it was recognized that tight security had to be provided for nuclear materials. Although countries took different approaches, the potentially disastrous consequences of nuclear theft were recognized by authorities everywhere, as well as in countless movies and novels. The United States developed a system that emphasized both physical security on facilities holding nuclear materials and procedures to ensure accurate accounting for such materials. The Soviet Union relied more on a pervasive security apparatus that prevented access by outsiders to the locations where nuclear materials were handled.

With the collapse of the Soviet Union, the Soviet security system can no longer be sustained, giving rise to fear that the large inventories of nuclear materials remaining in the newly emerging states—particularly Russia—would be at risk. These concerns were heightened by reports of numerous smuggling incidents allegedly involving fissile materials. While most of these cases turned out to be frauds, two incidents in 1994 that involved more significant quantities of material galvanized awareness of the problem. The attack on the Tokyo subway with chemical weapons demonstrated the potential for the use of weapons of mass destruction by terrorist groups.

These concerns drove governments to respond. Presidents discussed illicit nuclear trafficking at summit meetings. Substantial programs of assistance on nuclear materials security have been put in place. Additional efforts have been made to strengthen domestic law enforcement capabilities to deal with nuclear smuggling and terrorism, and to increase international cooperation among law enforcement, customs, and intelligence agencies.

Where Do Things Stand?

The news is not all bad. Political leaders have spoken out strongly about the dangers of illicit nuclear trafficking, and coordination mechanisms have been established among the international community and among agencies within individual governments. Significant improvements have been made in security and accounting for weapons-usable nuclear material in the Newly Independent States (NIS), helped by sizable assistance from the United States and others. Although it is impossible to perform a rigorous statistical analysis, the frequency of cases of illegal trafficking appears to have evened out in 1995–96, after increasing significantly in 1993–94. At the same time, the number of seizures and arrests have been rising since 1995. Again, most cases appear to be scams, or opportunistic thefts of radioactive sources, low enriched uranium (LEU), or other materials lacking weapons usability. There is no direct evidence that known terrorist groups or their state sponsors are contemplating attacks using nuclear devices, nor are there indications that these groups are actively seeking to procure nuclear materials. Nor have we seen substantiated evidence of the involvement of organized crime in nuclear smuggling.

That said, we cannot be complacent. The leakage even of small amounts of LEU points to a deficiency in the system of control that could be exploited. Certainly, the likely involvement of "insiders" at nuclear facilities is disquieting. And the acquisition of hundreds of kilograms of LEU would make it much easier for Sadaam Hussein to conceal an enrichment facility, even if this material could not itself directly be used in a bomb.

We should not assume that the illicit trafficking problem is exclusively related to Russia or Eastern / Central Europe. We need to be concerned both about other geographical routes for transit from Russia and the NIS, but also about the potential for the theft of nuclear materials from other countries. There have, for example, been thefts of uranium residue in South Africa and seizures of other nuclear materials in countries far removed from the former Soviet Union.

U.S. Policy

The U.S. approach to nuclear materials security in Russia and the NIS, and reduction of risk of illicit transfer of nuclear materials, is codified in a September 1995 Presidential Decision Directive. Its key elements are:

- A full range of U.S. capabilities—intelligence, technical, diplomatic, law enforcement, military—incorporated in U.S. strategy.
- International cooperation against smuggling, both bilaterally and in multilateral forums.
- Efforts to secure material at its source to attain the highest probability of success.
- A layered defense that includes strengthened laws and national control systems, tools to detect and retrieve smuggled materials, international cooperation to apprehend traffickers, and a coordinated response capability to smuggling incidents.

In implementing this policy, we recognize the importance of maintaining close coordination of efforts to counter illicit trafficking with counter-terrorism cooperation, export control assistance, and other similar activities. To avoid duplication and confusion, we are committed to work through existing channels where possible.

Bilateral Cooperation Efforts

Since 1994, the U. S. Department of Energy (DOE) and its national laboratories have been working directly with their counterparts in Russia, Ukraine, Kazakhstan, Belarus, Latvia, Georgia, Uzbekistan, and Lithuania to improve nuclear material security. Cooperation is underway at over 50 sites. The emphasis of this program is on weapons-usable nuclear material in these countries—some 650 metric tons—in non-weapons forms. Work focuses on installing comprehensive, technology-based Material Protection, Control, and Accounting (MPC&A) systems comparable to those in use in the United States that are effective against both insider and outsider threats.

In addition to facility upgrades, the DOE program encourages the development of a safeguards and security culture, and seeks to strengthen national-level systems for MPC&A, including ongoing training, technical support, and independent regulatory agencies. Cooperation extends beyond Russia and the Minatom laboratories— the Russian Federal Nuclear and Radiation Safety

Authority (GAN), other NIS countries, and the Russian Navy are also included.

The U.S. export control assistance program also contributes to combating illicit nuclear trafficking. U.S. assistance programs aim at improving the legal and regulatory foundation for export controls—including controls on nuclear material exports. They also work to develop professionalism in law enforcement and customs organizations and to provide equipment for border controls and for information management and communications among officials.

In addition to work in Russia, Kazakhstan, Ukraine, and Belarus, these programs are giving increased emphasis to the Caucuses, Central Asia, the Baltics and other transit points, including some at a distance from the former Soviet Union. For example, these programs have provided x-ray vans to facilitate customs inspections and similar equipment to facilitate enforcement.

New efforts between the Department of Defense and the Federal Bureau of Investigation (FBI) and Customs Bureau are similarly targeted toward training law enforcement personnel, border guards, and customs officers. Particular emphasis is being given to assisting Kazakhstan, Uzbekistan, and Kyrgyzstan as well as the states of Eastern and South Central Europe.

Finally, we continue to cooperate with, and help fund, the International Science and Technology Center in Moscow and the Science and Technology Center in Kiev, providing opportunities for peaceful research to over 19,000 scientists formerly engaged in research on weapons of mass destruction. The program now includes projects developed and funded by private industry partners under the Science Centers umbrella. A related initiative, DOE's Initiatives for Proliferation Prevention (IPP) program, teams U.S. weapons labs with their NIS counterparts to identify and validate technologies with commercial potential, thereby reducing the incentive of NIS weapons scientists to emigrate to countries of proliferation concern.

Multilateral Cooperation

Beyond its own bilateral programs, the U.S. recognizes the importance of building broad international cooperation to combat nuclear smuggling. One early effort was adherence to the Convention on the Physical Protection of Nuclear Material. Recently, the P-8 summit process has been the primary vehicle for developing a political framework for cooperation against nuclear smuggling. This group is manageable in size, includes the major nuclear material holders, and the informal and confidential nature of its meetings has been useful in encouraging active Russian participation. Recent actions include:

- At the April 1996 Nuclear Safety and Security Summit in Moscow, the leaders of the Eight adopted a "Programme to Combat Illicit Trafficking in Nuclear Materials." They committed themselves to strengthen collective action against nuclear smuggling, and agreed to establish an information-exchange mechanism among themselves.
- Subsequently, the Eight's Nonproliferation Experts Group (NPEG) has worked out ground rules for operation of an illicit trafficking Point of Contact system to facilitate information exchange among the Eight and coordinated action in the event of a rapidly breaking smuggling incident. We have had a recent instance in which this coordination mechanism was successfully invoked.
- The Eight have also called for strengthened cooperation against nuclear smuggling among their intelligence and law enforcement agencies, and have defined specific categories of information whose exchange is to be encouraged. This gives a political mandate to domestic agencies to provide such information.
- A progress report on actions against illicit nuclear trafficking was included in the Foreign Ministers' report issued

at this year's Denver Summit of the Eight.

- Expansion of participation in information sharing and crisis response activities is clearly desirable. The Eight have indicated their desire to have additional countries associate themselves with the objectives and political commitments of the 1996 Programme. A number of countries, particularly in Western and Central Europe, have indicated their willingness to do so. We expect there to be a meeting of interested countries in the fall of 1997.
- Finally, the Eight have endorsed cooperation among their laboratories to strengthen forensic analysis of materials seized in nuclear smuggling cases. This is one of the most promising areas for practical international cooperation.

The International Atomic Energy Agency (IAEA) also has an important role to play in coordinating the international response to illicit trafficking. It already manages a database of reported trafficking incidents, and through its technical cooperation programs has assisted member states to improve physical protection measures at their nuclear facilities. Potentially, the Agency could also provide a clearinghouse for information on assistance programs and help with outreach to additional countries. The IAEA is keeping in close touch with the NPEG as it develops its own thinking about where it can make the greatest contribution to combating illicit trafficking.

Results So Far

To summarize, some key results from international cooperation against illicit trafficking are.

- Through the P-8 process, we've secured a high-level political mandate for further cooperation to prevent smuggling. It's particularly welcome that Russia has been willing to associate itself with this effort, and has indeed played an active role in discussions of this issue among the Eight.
- Multilateral discussion of the issue and the creation of a Point-of-Contact system has forced each of the participating governments to address its own internal coordination mechanism for responding to nuclear smuggling cases and for exchanging information.
- Not surprisingly, we've all found that illicit trafficking crosses many departmental jurisdictions and has implications for a wide range of bureaucratic interests.
- In the United States, we've been able to improve interagency coordination by creating a Response Group chaired by the National Security Council that includes the State Department, DOE, FBI, the Intelligence Community, and others. This has greatly facilitated communication among agencies and improved the coherence and speed of responses to requests for help from foreign governments.
- Practical cooperation and assistance programs are also having an affect, most notably on MPC&A, but also in training law enforcement and customs personnel.

Next Steps

It's fair to say that we don't foresee the need for additional high-level political declarations. Implementation is now the most important priority. We need to maintain an effective Point-of-Contact system and sustain support for MPC&A and other assistance efforts.

An increased role for the IAEA may be appropriate, and interested member states need to begin consultations among themselves and with the Secretariat. At the same time, there will probably always be a need for an informal communication mechanism among the G-7, as long as Russian sensitivities remain.

Finally, we should expand Programme participation as agreed, and begin looking at the dangers of illicit trafficking in areas of the world other than the former Soviet Union. Certainly, a more active dialogue with China, India, and other countries with stocks of fissile materials would be useful.

How to Strengthen International Norms Against Stealing or Smuggling Nuclear Material?

George Bunn
IIS Consulting Professor
Center for International Security and Arms Control
Stanford University

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Existing MPC&A Treaty Norms Relating to Illicit Trafficking

The nonproliferation treaty (NPT) provides international norms prohibiting illicit transfers by state parties. It also requires non-nuclear-weapon states to agree with the International Atomic Energy Agency (IAEA) on safeguards for all nuclear materials (NM) in peaceful nuclear activities. Each of the five avowed nuclear-weapon states have voluntarily accepted IAEA safeguards on some peaceful nuclear activities.

But, the NPT does not require non-weapon or weapon parties to adopt domestic statutes or regulations prohibiting illicit trafficking by individuals or providing physical protection of NM. Had I known when the NPT was being negotiated what I know now, I would have urged provisions for adoption of domestic legislation to establish national systems of physical protection and control over nuclear material and to make illicit trafficking in such material a national crime.

The Convention on Physical Protection of Nuclear Material requires parties (both nuclear-weapon and non-weapon states) to adopt domestic standards for physical protection and statutes prohibiting illicit trafficking by individuals. But it applies only to nuclear material "for peaceful purposes in international transport" or during storage "incidental" to international transport.

Before the treaty review conference in 1992, some parties discussed eliminating all or part of this broad exception by amending the Physical Protection Convention (PPC). A number of parties were opposed, and no such amendment was approved. Since then, fears of the consequences of illicit trafficking have risen greatly, increasing the likelihood of such an amendment.

Possible New Provisions on MPC&A

Physical Protection Proposal

One possible new requirement is that parties provide physical protection to all nuclear material under their control, and that IAEA inspectors be permitted to check physical protection during inspection. Even now, IAEA inspectors sometimes comment unofficially on obvious inadequacies in physical protection during their safeguards inspection. Under 93+2 safeguards, inspectors will be visiting more sites than they do under INFCIRC 153 safeguards. It may be appropriate to give them specific authority to comment on physical protection. The PPC does not currently provide for inspections to verify its fairly limited requirements for physical protection.

This proposal, as stated above, would make physical protection requirements applicable to material whether or not it is in international transport. That should not be an onerous new burden to most states that are already parties to the Convention—approximately 60 states, most of whom have relevant nuclear activities. Perhaps the fact that the five avowed nuclear-weapon states are parties suggests that the Convention has not required any significant intrusion into the nuclear activities of parties.

Some will contend that physical protection is directly related to sovereignty and therefore not of concern to other states. However, to say that IAEA inspectors can enter a nuclear facility for safeguards inspections that are of international concern but not enter the same building to check physical protection because that is only of domestic concern is absurd. Nuclear terrorism and smuggling are clearly international concerns, and physical protection is an important barrier to them.

Another objection to inspection may pose a greater barrier. This proposal would make physical protection inspections applicable to nuclear-weapon states' weapons materials, not just their civilian ones. However, IAEA inspectors would verify only that physical protection measures complied with the PPC. Weapons themselves would not be inspected even if the Conventions' Category 1 nuclear material protection standards were applicable (i.e., if weapons or weapons material in significant quantities were being guarded). However, any inspection of weapons facilities, even to assure that their perimeters had fences and guards, would probably be objected to by the avowed nuclear-weapons states and the threshold states. And the IAEA might take the position that its statute would not permit it to inspect a weapons facility to check the adequacy of physical protection. For example, Director General Blix recently took the position that IAEA inspectors could not safeguard the Russian warhead-pit storage facility being built at Mayak unless the pits there were irrevocably dedicated to peaceful purposes.

An alternative to inspection might be reports to the IAEA on the protection the states provide pursuant to the Convention and, perhaps, pursuant to INFCIRC 225—the IAEA recommendations that go beyond Convention requirements. As things stand now, there is no easy way for any state to find out what physical protection is provided by other states. Suppose the IAEA Board called upon the Secretariat to prepare a form to be filled out by states showing what physical protection they gave to all their nuclear activities in various classes, and the Board called upon members of the Convention to fill out that form every year? This would not be as good as inspections, but it might at least provide data for comparisons and point to problems needing solution.

Adoption of National or Regional MPC&A Standards

Another possible new requirement would be that all states adopt national or regional-organization (EURATOM and ABACC) MPC&A standards and apply them to all nuclear material present within their territory or under their control. The NPT requires nonnuclear weapon parties to adopt IAEA safeguards requirements (either individually or together with other states as with EURATOM and ABACC) on their civilian nuclear material. But it does not require them to adopt a national (or regional) system. Moreover, unlike this proposal, it applies only to non-nuclear-weapon states. This proposal could be applied to nuclear-weapon states and to nuclear-weapon material if the verification requirement were only to disclose the language of the regulation or decree adopting the national system.

Export, Import, and Border Controls

A third possible requirement would be that the parties adopt export, import, and border controls over NM. The NPT has the effect of requiring adoption of export controls because it prohibits exports of nuclear material unless subject to IAEA safeguards. The PPC prohibits its parties from exporting nuclear material unless it will receive physical protection at least during transport. Participants in the Nuclear Suppliers' Guidelines must also adopt some export controls for NM as well as dual-use items.

To deal with smuggling and other forms of illicit trafficking, more is required. Import/border controls with devices to monitor transport of NM could be a significant addition.

Possible Provisions to Make Illicit Trafficking a Domestic-Law Crime

The PPC requires parties to make the following acts criminal offenses:

- Theft or robbery of nuclear material;
- Embezzlement or fraudulent obtaining of nuclear material;
- Receipt, possession, use, transfer, or disposal of nuclear material "without lawful authority" when this is "likely to cause death or serious injury" to persons or property. Many believe this "death or serious injury" requirement is too limiting.

There is no requirement that states report on the statutes they have adopted pursuant to these requirements. Perhaps this would be a useful new request to make to parties to the Convention.

Another possible requirement suggested by the Nuclear Suppliers' Guidelines is that states adopt legislation making it a crime to use imported nuclear material for purposes other than those authorized by the exporting state.

International Cooperation to Deal with Criminal Activities by National Authorities

There is already considerable cooperation between national police; intelligence, export control, and customs officials; and between them and Interpol. Strengthened cooperation among G-8 countries was called for by the "Programme for Preventing and Combating Illicit Trafficking in Nuclear Material" adopted at the Moscow Summit on April 20, 1996.

The CPP contains useful provisions requiring cooperation including exchanges of information, help in recovering stolen nuclear material, detaining suspects, and supplying evidence for criminal prosecutions.

Extradite or Prosecute

The Convention on Physical Protection:

- Requires a party to take jurisdiction of any illicit trafficking offense (described above) that is committed on its territory or aboard a ship or aircraft registered to it, or when the alleged offender is its national.
- Requires a party that apprehends a suspect to extradite him or her if the suspect is not its own national if the offense was committed elsewhere and if the party does not intend to prosecute the suspect itself.
- Contains provisions to avoid the "political" offense exception in some extradition treaties.
- Authorizes (but does not require) extradition even between parties that do not have extradition treaties with each other.

These are all useful provisions for use in apprehending and prosecuting suspected nuclear smugglers.

Options to Establish or Strengthen International Norms Against Illicit Trafficking in Nuclear Material

There are many possible forms for joint or individual action to establish or strengthen norms, ranging from voluntary action reporting on compliance with the PPC to amending the Convention itself. A list of some possibilities follows:

- Voluntary reports on compliance pursuant to forms prepared by the IAEA Secretariat and recommended by the IAEA Board of Governors.
- Adoption of norms that are not legally binding such as G-7 or G-8 communiqués, IAEA INFCIRC 225 Rev. 3, Nuclear Suppliers Group Guidelines, OECD announcements, IAEA Board declarations calling upon members to take certain actions, UN General Assembly or Security Council resolutions, NPT Review Conference or PPC Review Conference reports.
- Party consensus interpretation of the language of the PPC, for example, to limit the effect of the "serious-injury-to person-or-property" requirement to the unauthorized transfer prohibition. Another possibility might be to interpret the "international transport" limitation in a way to reduce its impact. For example, the parties might agree at the next Review Conference that any nuclear material that was imported or might at some future date be exported must be protected at least to the degree required by the PPC for material during storage "incidental" to international transport.
- Amendment to the PPC.
- A new treaty dealing more effectively with illicit trafficking.

Command and Control: On The Protection of Fissile Materials

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Is it possible to restore, and in some in stances, even strengthen the command and control structure erected to protect fissile materials? Or do we have to resign ourselves to the inevitability of these materials diffusing into the terrorist bazaar as did materials for chemical weapons? What should be the guidelines for protecting these materials? Would international agreements and control regimes work as effective barriers against proliferation of fissile materials? This is the problem we propose to address in this paper. We shall also consider India as an example of countries that are not parties to international agreements (on nonproliferation and banning of nuclear weapon tests), but which have accepted the responsibility to protect fissile materials produced outside international safeguard regimes.

Protocols for Protection

Before we discuss protection, it is important to identify the materials that need be protected. The list must include highly enriched uranium, polonium, and irradiated nuclear fuel. While one may argue that this list must also include the tritium and plutonium that provide the neutron trigger for the bomb, or isotopes of lithium used in hydrogen weapons, we believe that these are of only secondary importance. Without an appropriate heavy nuclear core of uranium or plutonium, these materials are of no importance in the manufacture of nuclear weapons. Even without neutron triggers or lithium, it is still possible to make nuclear weapons, though of doubtful performance.

Uranium (by this, we mean only very highly U-235 enriched uranium) and plutonium are stored in fuel production and reprocessing centers and in fuel fabrication shops. Irradiated fuels containing sizable amounts of plutonium are stored in cooling tanks to allow radiation to decay. Nuclear weapon countries would also have these materials at centers where they make warheads or dismantle them. Fissile materials, fortunately, are not so widely spread as materials for chemical weapons are, and this should come as relief to those concerned with erecting access controls.

There are two major components in the hierarchy of fissile materials protection. The first is the physical barrier that controls access to fissile materials, and second, personnel with access and knowledge. Both these components are vital for protection. A weak chain of human command is open to abuse, and a fragile physical security system could be easily broken into. The radio-toxicity of these materials in itself offers no protection, as both uranium and plutonium are alpha active and are thus easily shielded. In the past, high activity does not seem to have deterred those desperate to get hold of such materials.

Security systems are now becoming more and more sophisticated, and are more robust and efficient. Some decades back, it was a punch card and a guard who could identify the worker before permitting entry into the security zone. Today, the electronics system is more sophisticated; it can match finger prints and the hierarchy is built so it is impossible for the machine to be over-ruled except by two or more senior security officials. The problem is therefore not with the structure of the system but with the people who have access or entry control responsibilities for restricted areas.

Command and Control Systems

1. The command chain should be long, well structured, and robust. It must also include a large number of people in the decision making at appropriate levels.
2. Depending on the nature of decision making (from transferring a few milligrams of plutonium to another laboratory to transporting large quantities of plutonium for fuel fabrication), the command system should be appropriately structured with few options for delegation or abdication of control. Every link in the designated chain should perform, and each area of responsibility should be clearly delineated, documented, and verified.
3. Major decisions involving fissile materials will have to be approved by political leadership after a detailed assessment of options and procedures.
4. A long chain of command, in spite of being empowered in an area of responsibility, does not automatically provide every link with unfettered access to information. This should be structured by the erection of fire-walls with a well defined hierarchy for need-to-know.
5. Fissile materials are not nuclear weapons, and it is therefore not necessary for the military to be involved in decision making. While in mature democracies, the relationship between military and civilian systems is well established, and the supremacy of civilian political leadership accepted, this may not be the case in fledging democracies or in various forms of government where military leadership is intimately involved in choosing leaders of the government. The military sees fissile materials as the route to ultimate weapons. Involvement of the military on issues of fissile materials protection is therefore wrong and should be discouraged.

Russian Lessons

There are lessons to be learnt from the difficulties faced by the Russian nuclear establishments following the collapse of the Soviet Union. The command chain in the former Soviet Union was relatively short with only a few links totally empowered. When the chain broke, a few found themselves powerful and with minimum accountability. The absence of proper documentation only made the situation worse.

The second lesson concerns the people working in these establishments. In the Soviet Union, workers at these establishments were chosen only after a careful selection process and were continuously monitored. Relocation at 'closed' towns and cities also shielded them from the outside world. It was very difficult for them to change jobs or move to other parts of the country. The virtual exile was sweetened by the ready availability of good apartments and goods that were not easily available elsewhere. Often, the salaries were also better. All this has changed now.

Russia is relatively poor, unable to afford all the laboratories and nuclear establishments. The workers are not paid their wages regularly. Some establishments are now totally dependent on foreign hand-outs. Specialization in narrow areas, isolation, and an umbilical-cord dependence on the state have made the workers unresponsive to opportunities in other areas of the economy. Some years back, there was talk of migrating to other countries with opportunities. This has now died down. Excepting the highly qualified, others don't seem to get jobs. As Pasternak once observed, emigration is anathema to Russians. In spite of a general reluctance to leave, some Russians continue to believe that a few countries or groups would be interested in their specialization and the materials they may be able to smuggle out. One has only to talk to Russians working in these establishments to realize how wide-spread such beliefs are and how some cash-strapped establishments tacitly encourage such overtures. These are the vulnerable sectors and they should be protected from becoming easy targets for terrorist and smuggling gangs.

How do we prevent this from happening in other countries that may also be subject to such radical political and economic changes? Unfortunately, we can do very little. It is difficult to imagine how a single sector of national technology could remain immune to revolutionary changes sweeping across the entire country. But we can minimize the disruption by encouraging all countries to establish the robust command links we discussed earlier in this paper. Employees working in these areas should be given opportunities similar to those in other areas of the economy. While one may complain of the possibility of losing trained and talented human-power to other sectors, we have to weigh this against the advantage of preventing the build-up of interest groups solely dependent on nuclear establishments and technologies for their livelihood. It is difficult to take or implement far-reaching policy decisions in the presence of such powerful interest groups. Our concerns about involving the military also arise from similar considerations.

The International Atomic Energy Agency (IAEA) has defined guidelines and established monitoring devices to ensure that materials under IAEA safeguards are not removed from scrutiny. This has provided a semblance of security although there are instances where these systems were made inoperative. There is a need for the IAEA to take the major initiative in developing guidelines on command-control systems for consideration by member states. As there will be a general reluctance for countries to share information with others on their national command control systems, IAEA can only play an advisory role with the hope that its suggestions and examples are considered while building or reviewing security systems for fissile materials protection. There is a growing feeling in developing economies that IAEA has become more a monitoring and control agency than an international organization established to diffuse information and provide expertise on peaceful uses of nuclear energy. IAEA's involvement in areas such as command and control would help remove such a feeling of neglect and also help many countries to develop their own structures.

India: An Outsider, Insider

A few countries have not signed nuclear non-proliferation and comprehensive test ban treaties, and India is one of them. India's case is really a special one as it is the only country that had also tested a nuclear device and is self-sufficient in all areas of nuclear technology. In India, only a few power reactors are under IAEA safeguards, and others, including a number of research and power reactors, lie outside international scrutiny. In spite of this, India has maintained excellent control over its fissile material stocks. All reactors, fuel processing, and fabrication centers are under a single government department control (Department of Atomic Energy) and the Prime Minister is in charge of the department. Thus the Atomic Energy Establishment has been able to resist various political pulls and pressures and has not faced any ups and downs with changes in the government. In addition to establishing a reasonably lengthy command and control system with appropriate documentation and authority, India has been able to resist outside pressures to share its fissile materials and technologies. The only offers India made to other countries were either under the auspices of IAEA or with its safeguards. There have been no reports of smuggling materials or technologies from India.

In spite of this, India is now subject to nuclear embargoes and controls and is unable to acquire nuclear technologies or materials from other countries. This has slowed the Indian nuclear power program, especially at a time when the country is clamoring for more power. For the past few years, peak power shortages have grown to about 30% with black-outs and brown-outs becoming routine. This may well be the time for the nuclear supplier groups to recognize India's mature handling of its large stock of nuclear materials by providing access to nuclear materials and technology to Indian nuclear power reactors. For this initiative, rules and regulations in a few countries have to be modified or reinterpreted, and India may have to place its power reactors under safeguards. Without such initiatives, Indian nuclear power programs will continue to be slowed down, and India's growing stock of fissile materials will remain outside safeguards. Criticism is growing in India that the country has not gained anything by its restrained handling of sensitive issues related to nuclear technology. And suggests India should consider emulating its giant Asian neighbor that seems to have no qualms about selling its technology to all those who crave it. It is likely that the Indian attitude in the coming years, in the midst of its rapidly changing political scenario, may be shaped more by such considerations than by its past policies.

Countering the Threat: DOE's Nuclear Smuggling Program Plan

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The threats of nuclear proliferation and terrorism are undeniable in the post-Cold War world. One pathway to these dangers is the theft and illicit trafficking of special nuclear materials, generally plutonium and uranium. The U.S. government meets these threats through several of its agencies and organizations, civilian and military. The Department of Energy's Nuclear Smuggling Program was created to integrate major DOE strategies to

- Protect sources of special nuclear materials from theft;
- Work with other U.S. agencies to identify and track national and subnational groups seeking special nuclear materials, through either theft or purchase;
- Support governments' need for technology to detect and intercept illicitly trafficked special nuclear materials;
- Support law-enforcement operations and diplomatic undertakings (including technical assessments and training);
- Plan, prepare, and exercise the capabilities needed to stop end-users of smuggled special nuclear materials.

DOE's Program Plan focuses on better countering the smuggling of special nuclear materials. Our role in the overall problem of nuclear theft, trafficking, and terrorism is bracketed on either end by very strong, existing programs for Materials Protection, Control, and Accountability (MPC&A) and for responding to threats of nuclear terrorism (Communicated Threat Credibility Assessment, or CTCA and the Nuclear Emergency Search Team, or NEST). The nuclear Black Market Sales Assessment capability has been instrumental in evaluating the hundreds of nuclear smuggling scams that have occurred during the last few years and in rapidly concentrating on those few that actually involved special nuclear material.

Program elements, such as intelligence work on foreign weapons programs and export controls of nuclear and nuclear-related, dual-use technology, are part of DOE's nonproliferation program and complement what is presented here. DOE conducts basic research and development to support all of the strategies—nuclear technology is the foundation of our role in countering nuclear smuggling and enhancing nonproliferation.

Activities specifically tailored to counter nuclear smuggling total $10 million in FY97 (in DOE's Office of Nonproliferation and National Security). Experience over the past two years has shown that gaps exist in DOE's overall program and its support to other agencies. To close these gaps, we outline here a new initiative to appreciably increase the funding by $9 million to counter nuclear smuggling—for a total of $19 million in FY98. Funding for complementary efforts in NEST (in DOE's Defense Programs) is also increased in FY98.

The national effort to counter nuclear smuggling is a large one involving many agencies, including the intelligence community, law-enforcement agencies, disaster-management agencies, as well as the Departments of Defense, State, and Energy. DOE's Nuclear Smuggling Program Plan was developed by DOE program managers in collaboration with the national laboratories and advisors from other government agencies. We intend this report to contribute to understanding the importance and scope of the threat posed by the smuggling of special nuclear materials and to help establish a clearer national vision and increased commitment.

Defining the Challenge

Nations determined to acquire nuclear weapons can produce the necessary nuclear materials indigenously in covert production facilities or they can divert these materials from legitimate civilian programs. Less advanced states and sub-national groups are limited to a third route—theft. This more unconventional proliferation path is harder to pursue, but we have already seen it at work: cases of nuclear-material trafficking in Europe following the breakup of the Soviet Union.

DOE's role in combating theft, trafficking, and terrorism involving special nuclear materials—plutonium and enriched uranium—is part of a systematic effort to contain the post-Cold War dangers from weapons of mass destruction. We visualize these dangers as different pathways from source to target and appropriately countered by a layered defense. Nuclear smuggling is one of these pathways.

Integrated into each of the following layers of defense is the technology base and the technical and analytical expertise amassed by DOE and its national laboratories over many years. In many of these steps, this expertise can be as important a contribution as the technology itself. These layers are further described below as DOE's five nuclear smuggling strategies:

1. Protect sources of special nuclear materials from theft—

The greatest security against theft begins at the sources of special nuclear materials: production, processing, and storage facilities. Technologies transferred from a major DOE-led program— MPC&A—have significantly contributed to the security against theft at Russian and Newly Independent States' key nuclear sites. Similar efforts have long been elements of DOE's programs to safeguard our own nuclear materials and to ensure physical protection of U.S. material provided to other nations on a bilateral basis. DOE also supports the International Atomic Energy Agency (IAEA) programs to safeguard and monitor nuclear material and the new International Physical Protection Advisory Service.

2. Work with other U.S. agencies to identify and track national and subnational groups seeking special nuclear materials, through either theft or purchase—

Tracking potential smugglers and end-users can provide intelligence analysts and response forces with valuable information, not only to intercept nuclear materials but also to prevent their theft in the first place. Without such information, recovering stolen materials can be impossible. DOE contributes technical support and analyses to the U.S. government.

3. Support governments' need for technology to detect and intercept illicitly trafficked special nuclear materials—

Once nuclear material is stolen, the next opportunity to intercept it usually occurs during its transport. A wide variety of radiation-monitoring devices can detect nuclear materials during transport. DOE technologies developed for nuclear facilities are being adapted to border crossings. Outfitting major airports and shipping ports with these detectors can alert officers to the presence of nuclear materials in the same way magnetic detectors now identify guns and weapons at airports. An added public health benefit is the detection of careless movements of legal radioactive materials. Technical measures by themselves are far from absolute and may not deter determined, sophisticated smugglers, but they raise the risks and the uncertainties of success by the smugglers.

4. Support law-enforcement operations and diplomatic undertakings—

DOE's rapid assessment of purported transactions of illicitly trafficked nuclear material permits law enforcement agencies to more effectively and efficiently use their limited assets in response to such incidents. This is accomplished by weeding out criminal scams and other spurious occurrences. Law enforcement agencies and diplomatic customers depend on DOE's technical experts and resources, permitting them to carry out their responsibilities with full confidence. Such assistance now includes subject-matter experts from our national laboratories assisting on-scene personnel and preparing formal assessments for criminal investigators and policy makers on alleged special nuclear material transactions. With detectors more widely deployed, both in the United States and at foreign borders, we expect new demands for this assistance.

5. Plan, prepare, and exercise the capabilities needed to stop end-users of smuggled special nuclear materials—

Key assets that might be targets for smuggled materials or weapons can be protected by both perimeter monitoring systems and local, trained response elements that in some ways mirror those at the source to protect against theft. Finally, should stolen materials reach end-users who build some sort of nuclear weapon or radiation-dispersal device, NEST and other emergency response capabilities can be called on to neutralize the threat posed by these devices. Encouraging and exercising with similar teams in other nations, as well as preparing our own assets for overseas deployment, are essential to a complete international response to nuclear theft and terrorism.

DOE's Contribution

In summary, countering theft, trafficking, and terrorism involving special nuclear materials is a complex problem being met by broad, interagency cooperation within the U.S. government. The involvement of different countries adds to this complexity. DOE is a key player in addressing this challenge. Our capabilities have grown over 50 years of experience, not only in the science and technology of nuclear weapons and materials but also in analytical support, safeguards, and emergency operations.

Appendix

Workshop Agenda A-1

Monday, July 28, 1997

9:00 a.m. *Welcoming Remarks*
MICHAEL MAY, Co-Director, Center for International Security and Arms Control, Stanford University

9:10 a.m. *Purposes and Goals of the Workshop, Brief Definition of Issues, and Outline of the Policy Context*
RON LEHMAN, Director, Center for Global Security Research, LLNL
WILLIAM POTTER, Director, Center for Nonproliferation Studies, Monterey Institute
JAMES E. GOODBY, Payne Lecturer, Stanford University, and Former U.S. chief negotiator for nuclear security

9:50 a.m. *Review of Recent Experience in the Former Soviet Union*
Moderator: James E. Goodby
YURI VOLODIN, Head, Department of Safeguards, Gosatomnadzor, Moscow
GENNADY PSHAKIN, Director, MPC&A, Institute of Physics and Power Engineering (IPPE), Obninsk
WILLIAM POTTER, Monterey Institute

11:15 a.m. *Session Discussion*

12:00 p.m. *Working Luncheon*

2:00 p.m. *Review of Experience in URATOM countries*
Moderator: Ron Lehman
ROGER HOWSLEY, Head, Security & International Safeguards, British Nuclear Fuels (BNFL)
G. STEIN, Head, Programgroup, Technology Assessment, Research Centre Juelich, Germany

3:00 p.m. *Session Discussion*

3:45 p.m. *Review of Experience in Latin America*
Moderator: Ron Lehman
ANSELMO S. PASCHOA, Professor of Radiation Physics, Department of Physics, PUC-Rio, Brasil

4:20 p.m. *Discussion and Wrap-up od Day's Events*
Ron Lehman
(Reception and Dinner will take place at COOKSEY HOUSE, San Juan Street, Stanford University)

6:30 p.m. *Reception*

7:00 p.m. *Dinner* (Speaker: JAMES E. GOODBY, Payne Lecturer, Stanford University, and Former U.S. chief negotiator for nuclear security)

Tuesday, July 29

9:00 a.m. *Review of Experience in Asia: China, Korea, and Japan*
Moderator: William Potter
PRC: ZHANG XINGQIAN, Standing Member, Science & Technology Committee, CAEP
ROK: KUN JAI LEE, Korea Atomic Energy Commissioner, Department of Nuclear Energy, Korea Advanced Institute of Science and Technology (KAIST)
JAPAN: HIROYOSHI KURIHARA, Senior Executive Director, Nuclear Material Control Center, Tokyo

10:45 a.m. *Session Discussion*

12:00 noon *Working Luncheon*

2:00 p.m. *Review of Experience in Asia: India and Pakistan*
Moderator: Jeff Richardson, LLNL
INDIA: S. RAJAGOPAL, Visiting Professor, National Institute of Advanced Studies, India
PAKISTAN: ZAFAR IQBAL CHEEMA, Chairman, Department of Defense & Strategic Studies, Quaid-i-Azam University, Pakistan

3:00 p.m. *Break*

3:15 p.m. *Review of United States Experience*
Moderator: Ron Lehman
BILL DESMOND, Program Manager, Office of Safeguards and Security, DOE

3:45 p.m. *Discussion and Wrap-up of Day's Events*
William Potter

6:00 p.m. *Reception and Dinner*
Fontana's Restaurant, 1850 El Camino Real, Menlo Park
(Speaker: BRUNO PELLAUD, Deputy Director General for Safeguards, IAEA)

Wednesday, July 30

9:30 a.m. *Review of United States Experience (cont'd from Tuesday)*
Moderator: Ron Lehman
KEN SHEELY, Deputy Director of the Russia / NIS Nuclear Materials Task Force, Office of Arms Control and Nonproliferation, DOE
LAURA HOLGATE, Cooperative Threat Reduction Program, DOD

10:00 a.m. *Session Discussion*

10:30 a.m. *Break*

10:45 a.m. *International Cooperation in Combatting Illicit Trafficking in Nuclear Materials*
Moderator: David Elliott
LOTHAR KOCH, Head of Department of Nuclear Chemistry, European Institute for Transuranium Elements, Joint Research Centre
STEVE AOKI, U.S. Director, Office of Regional Nonproliferation, Department of State
GEORGE BUNN, Nonproliferation expert and Former NPT negotiator, CISAC

12:00 p.m. *Session Discussion*

12:30 p.m. *Working Luncheon*
Speaker: V.S. ARUNACHALAM, Senior Visiting Professor, Carnegie Mellon University

2:00 p.m. *Report by Rapporteur*
MATTHEW BUNN, Assistant Director, Program in Science, Technology & Public Policy, Harvard University

2:30 p.m. *Roundtable Discussion on Lessons Learned from the Proceedings*
Moderator: David Holloway, Co-Director, CISAC
JOHN IMMELE, Special Assistant, Office of Nonproliferation and National Security, DOE / NN
M. GRANGER MORGAN, Head, Department of Engineering & Public Policy, Carnegie Mellon University
VLADIMIR SUKHORUCHKIN, Kurchatov Institute
Others to be announced

3:30 p.m. *Session Discussion*

4:00 p.m. *Conclusion of Conference/Wrap-up*
Final Remarks by James Goodby, Ron Lehman, William Potter, and David Holloway

IAEA Safeguards Implementation and Verification of the Initial Inventory Declarations in the NIS

K. Murakami. S.-S. Yim, I. Beguier, N. Islam
C. Charlier, and M. Zendel
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A-2

Abstract

An area that has posed quite a chal lenge to the IAEA has been the emergence of a number of new States, known as the Newly Independent States (NIS), many with substantial nuclear programmes, resulting from the disintegration of the former Soviet Union. The IAEA has been conducting the verification of the initial inventory declaration of these States. The status of the Safeguards Agreements and IAEA safeguards implementation in each State of the NIS will be reviewed. The implementation of IAEA safeguards in this area is a totally new experience to the NIS as well as a new challenge to the IAEA. The Agency, while experiencing good co-operation from the state authorities, experiences problems in logistics and communications between the IAEA, State, and the operators. Improvements are needed at both State and Facility levels for an effective SSAC and continued assistance should be focused more on these problem areas. It is expected that the initial verification will be completed in 1997 for a majority of the NIS. The focus will then be shifted to the completeness assessment of the state nuclear fuel cycle and to the start of the inspection activities on a routine basis as soon as possible.

Activities of the Department of Safeguards in the NIS

The department of Safeguards has carried out activities in the NIS in the following fields:

- Safeguards implementation under the Safeguards Agreements;
- Assistance and monitoring of Coordinated Technical Support Programme;
- International cooperation and communication against illicit trafficking;
- International Seminar and training on physical protection.

In this paper only the activities of the department of Safeguards in the area of safeguards implementation will be described.

Status of NPT and Safeguards Agreements

Once a country has deposited the instrument of accession to the Treaty on the Non-proliferation of Nuclear Weapons (NPT), it is required to negotiate with the Agency the conclusion of a Safeguards Agreement similar to INFCIRC 153 (corrected). The Safeguards

Agreement should enter into force not later than eighteen months after initiation of negotiations (article III, para 4 of NPT). The current status of NPT and Safeguards Agreement with the NIS countries is listed in Table 1.

There are seven countries where the Safeguards Agreement is in force: Armenia, Belarus, Kazakstan, Latvia, Lithuania, Ukraine, and Uzbekistan. Moldova has signed the Agreement which is pending its ratification.

Once a country signs the NPT and the Safeguards Agreement, the IAEA has the "right and obligation to ensure that safeguards will be applied, in accordance with the terms of the Agreement, on all source or special fissionable material in all peaceful nuclear activities within the territory of the state,..." (para 2 of INFCIRC 153 (corrected)).

Long before the individual NIS States ratified the NPT and signed the Safeguards Agreements, the IAEA experts and Safeguards staff went on technical visits to all locations reported by the States to have nuclear material. The main purpose of these visits were to collect data in order to prepare the Agency's safeguards approach for each facility, explain these approaches to facility and State representatives, and demonstrate safeguards equipment that would be used thereby preparing the facility for eventual inspections. A variety of nuclear facilities (uranium mining, fuel fabrication plant, commercial nuclear power plants, research reactors, and storage facilities) was found in the NIS.

Nuclear Facilities and Materials in the NIS—Status of Safeguards Implementation

Countries with Safeguards Agreement in Force

Armenia

The country has one nuclear power plant with two WER-440 type reactors units. Unit 1 started up in 1979 and unit 2 in 1980. Both the reactors were shut down since 1989 on seismic considerations following the earthquake of 1988. In August 1995, loading of the reactor unit 2 was initiated and has been in operation since 27 October 1995. It is operating again following refueling and maintenance during August-September 1996. The main material type in these reactors are low enriched uranium (LEU) and plutonium (Pu).

Table 1. Status of NPT and Safeguards Agreements.

State	NPT	Safeguards Agreement	—
Armenia	93-07-15	93-09-30	94-05-05
Azerbaijan	92-09-22	—	—
Belarus	93-07-22	95-04-14	95-07-31
Estonia	92-01-31	—	—
Georgia	94-03 07	—	—
Kazakstan	94-02-14	94-07-26	95-08-11
Kyrgyzstan	94-07-05	—	—
Latvia	92-01-31	93-12-21	93-12-21
Lithuania	91-09-23	92-10-15	92-10-15
Moldova	94-10-11	96-06-14	—
Tajikistan	—	—	—
Turkmenistan	94 09-29	—	—
Ukraine	94-12-05	94-09-28	95-01-13
Uzbekistan	92-05-07	94-10-08	94-10-08

On 23 August 1994, the Agency received the Initial Report which was confirmed in September 1994 to cover the entire nuclear material inventory of the country. Initial inventory verification was started in February 1995 and completed in January 1997 with regard to all nuclear material in the facility including unit no. l core fuel.

The Agency has installed necessary containment and surveillance in the Armenian nuclear power plant. The facility is under *ad hoc* inspection mode as the facility attachment has not yet been negotiated.

Belarus

Most of the nuclear materials and nuclear facilities in the Republic of Belarus are concentrated within the industrial zone of "Sosny" Science and Technology Complex (SOSNY STC). These facilities are:

- Critical assemblies "ROSA" and "CRISTAL"
- Fresh fuel storage "LANDYSH"
- Spent fuel storage "ISKRA."

All nuclear material from the critical assemblies have been removed and are stored in the fresh fuel storage. Another location, where a small amount of nuclear material (HEW) is present, is a waste storage close to the SOSNY center. The main material type in the Belarus facilities are high enriched uranium (HEW) and low and natural enriched uranium (LNEU).

The Initial Report on nuclear material of Belarus was received by the Agency on 19 October 1995. Initial verification is not yet complete as the Agency is trying to create NDA standards for verifying certain non-standard materials. Otherwise the SOSNY facility is under regular *ad hoc* inspection regime.

Kazakstan

The safeguards relevant facilities of Kazakstan and their main material types are:

- Fast Breeder Reactor at Aktau (HEW, LEU, DU, PU);
- LEU Fuel Pellet Fabrication Plant at Ulba (LEU);
- A thorium storage at Ulba (TH);
- Three research reactors of the Institute of Atomic Energy of the National Nuclear Center in Kurchatov (Semipalatinsk area) (HEW, LEU);
- A research reactor at Alatau, near Almaty (HEW, LEU).

The Initial Report on nuclear materials subject to safeguards in Kazakstan was officially received by the Agency on 4 September 1995. The initial verification is complete at the Ulba Fuel Pellet Fabrication Plant and at the research reactor near Almaty; it is in progress at the Fast Breeder Reactor and at the research reactors at Kurchatov.

In view of the complexity of the facilities in Kazakstan, it has received much assistance from donor countries, particularly in the field of physical protection and nuclear material control and accountancy.

As part of implementation of Programme 93+2, Part I measures, the following steps have been taken so far:

1. Agency inspectors are granted one-year multiple entry visas by Kazakstan.
2. Environmental sampling of hot-cells have been started to establish baseline signatures.
3. The SSAC have provided additional information about nuclear facilities in the country.

Latvia

Latvia has one IRT research reactor (5 MW(th)), located 20 km from Riga, a radioactive waste disposal and different enterprises all over Latvia using small Pu-sources. The reactor uses Highly Enriched Uranium (HEU), but its load factor is very low. Operation is anticipated for another year using the remaining fresh fuel. A plan has been drafted for the decommissioning of the reactor. The operator is concerned about the future storage of spent fuel.

The Agency received the initial report on nuclear material inventory on 22 February 1994 and verified the initial inventory in June

1996, which included mainly the verification of all high enriched uranium materials and spent fuels. Since then *ad hoc* inspections have been carried out on a routine basis twice per year.

In implementing Part I measures of the 93+2 Programme during 1997, the State authorities have provided the Agency with the required additional information and the Agency collected environmental samples with a view to establishing base line signatures of hot cells.

Lithuania

Safeguards relevant facilities of Lithuania are the Ignalina Nuclear Power Plant (INPP) with two on-load RBMK reactor units and miscellaneous locations (insignificant quantities).

The Ignalina NPP contains two RBMK-1500 reactors, which are located in separate buildings and are identical in design but operate completely independently of each other. The RBMK reactor is a light-water-cooled, graphite-moderated, boiling-water reactor with on-load refueling of about 1600 vertical fuel channels. Unit #1 was started up in 1983 and unit #2 followed in 1987. They are the largest units currently operating in the world and provide over 80% of Lithuania's electricity needs.

The initial report was provided to the Agency as early as 31 October 1992. Several technical visits were carried out to prepare for the Safeguards implementation. The implementation started with the installation of C/S equipment in December 1992 to freeze the inventory of the spent fuel ponds and to provide surveillance for the cores. Quarterly inspections have been carried out routinely at the INPP since August 1993. The first PIV was carried out in February 1994. Recently unattended mode operated neutron/gamma NDA instrumentation was introduced to enhance the safeguards capabilities.

It should be noted that the Agency experienced a dramatic change of the operator's accountancy system from a hard copy system to a fully computerized accountancy system during the time of safeguards implementation.

Ukraine

On 2 March 1995, the Agency received the initial report on all nuclear material in Ukraine subject to the Safeguards Agreement. Upon receipt of the State Initial Inventory Report, the initial verification of the nuclear material started in April 1995 and *ad hoc* inspections are now carried out at facilities declared by the State. These include 15 nuclear power station units (1 twin WER 440 unit, 11 WER 1000 units, 3 RBMK 1000 units), 1 research reactor, 1 naval nuclear reactor training facility, 1 subcritical facility, and 1 research centre. The initial inventory verification is about to be completed. Surveillance installations are ongoing and should be completed by mid-1997.

Two unattended monitoring systems were installed at Chernobyl (one at the operating reactor unit 3 and one at the separate spent fuel storage) in September 1996 by France under the French Support Program to the Agency.

Under the Co-ordinated Technical Support Plan from the donor countries to Ukraine, assistance is being provided in the areas of nuclear regulation, provision of communication equipment, material accountancy, hardware/software, training in basic SSAC, import/export control, and physical protection of nuclear material.

The Agency has also made significant efforts in improving the safeguards implementation in the State, such as:

- Installing satellite communication systems at the main facilities, including the State office;
- Purchasing two cars for the transportation of Agency inspectors;
- Opening an office within the UNDP compound in Kiev and hiring the service of one full-time staff member to assist the inspectors in resolving logistical problems (customs clearance,

transportation, storage of Agency equipment, car maintenance, and as a driver for the inspectors, etc.).

Uzbekistan

Uzbekistan has a 10-MW(t) water-cooled and moderated research reactor, a pulse reactor "Photon" used for testing the effect of radiation on space equipment, and four uranium mining and milling facilities producing U_3O_8 as the final product. The main material types in Uzbekistan are HEU and LEU.

The initial report of Uzbekistan was received by the Agency on 18 November 1996. Initial verification was started in December 1996 and is still continuing with *ad hoc* inspections being carried out every three months.

Countries with Safeguards Agreement Not in Force

Estonia

The safeguard relevant facilities in Estonia are a former training site (Paldiski Russian naval base) with two decommissioned nuclear reactors, a metallurgical conversion plant with former uranium recovery activities (Sillamae Plant), and waste disposal sites. Because there is no safeguards agreement, no safeguards activities are currently carried out in Estonia.

The Agency carried out a fact-finding mission to Estonia in April 1993 concluding that the scope of safeguards to be applied by the Agency in Estonia at this stage would be rather limited due to the lack of a functioning SSAC and the existing uncertainties in the decommissioning of the reactors by the Russian Federation. In April 1996, that means three years later, a second technical visit was carried out, confirming that the facilities, which previously handled nuclear materials in Estonia, are not operating anymore.

Estonia acceded to the NPT on 31 January 1992. The Safeguards Agreement between the Agency and Estonia, which was approved by the IAEA Board of Governors at its session of February 1992, has not yet been signed.

Georgia

Because of civil war and unrest in this country, the Agency has not carried out a technical visit to Georgia so far. A trip to Georgia by the IAEA Director General is now expected in July, 1997.

According to information available, Georgia's nuclear facilities / activities consist of:

- An 8-MW(th) pool-type research reactor near Tbilisi which was started up in 1959 and has been shut down since 1990;
- The Institute of Stable Isotopes for R & D activities in Sukhumi (currently under rebel control).

Georgia acceded to the NPT on 7 March 1994, but has not yet signed the Safeguards Agreement.

Improvements Made in the NIS

Some of the positive developments made over the last five years are enumerated below:

- Knowledge of safeguards relevant facilities gained through numerous fact-finding missions, technical visits, and inspections.
- Development of nuclear material control and accountancy practice at both facility and state level. Some of these facilities were processing nuclear material without clear concept of profit or loss or MUF. Dramatic changes have taken place in accountancy systems when operators switched from hard copy system to fully computerized accountancy systems.
- Physical protection of nuclear material particularly of HEU and Pu have been dramatically improved with state-of-art sensors and techniques being employed.
- Training in relevant fields given to local personnel through numerous workshops, seminars or training courses organized by the donor countries in which IAEA staff sometimes

took part as instructors. Local staff have quickly adopted the modern practices.

All these developments were possible in part due to the dedicated work of State and facility operators in the NIS. The Agency would like to record its appreciation on the exemplary cooperation it received from the majority of the State and facility operators.

Improvements Still Needed

In spite of the improvements recorded above, work is still required to be carried out to improve the following areas:

- Problems still exist in logistics and communication.
- State and facility level accountancy need to be improved for effective SSAC in some of the NIS countries.
- The general economic condition of the people of the NIS requires drastic improvement. The dedication of the local staff to continue producing high-level work in spite of their poor economic condition is amazing and deserves special mention. As such there is a need for continued donor support to the problem areas.

Conclusion

Significant work has been carried out in introducing safeguards in the NIS over the last five years. However there is still work to be done. The international community and well-wishers of the NIS should continue to provide the necessary support for advancing the goal of proper accounting and safekeeping of nuclear material in the NIS.

The IAEA plans to conclude initial verification in most NIS states by the end of 1997. Thereafter the Agency will focus attention on checking the completeness of the initial declarations and assessment of States' nuclear fuel cycles. Other aspects of the Strengthened Safeguards System (Programme 93+2) will also be implemented in due time.

IAEA Co-ordinated Technical Support Programme to the NIS

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Abstract

With most Newly Independent States (NIS) of the former Soviet Union becoming parties to the Non-Proliferation Treaty as Non-Nuclear Weapon States, there has been an acute need in these states for considerable assistance for the establish-ment of the necessary structure and resources to ensure that their commitments to non-proliferation are implemented in a full and a timely manner. A number of IAEA Member States have offered and are now providing assistance to the NIS at a bilateral level to set up in each state an appropriate State System of Accounting anal Control (SSAC), Import/Export Control, and Physical Protection of Nuclear Material. The IAEA and several Member States established the Co-ordinated Technical Support Programme (CTSP) to ensure that the support given to the NIS was done in a co-ordinated and transparent manner and to avoid duplication of effort. The IAEA has played a co-ordinating role for the past 5 years by helping to identify detailed needs in individual States, by providing a platform for Member States to identify areas where they could provide the optimum support, and in preparing an outline of the Co-ordinated Technical Support Plan. The IAEA organises a meeting in Vienna annually, attended by all donor and recipient countries, to review the focus and implementation status of the co-ordinated technical support activities. A position statement is made by each donor and recipient country and views and experiences are exchanged.

Introduction

The disintegration of the former Soviet Union has resulted in the emergence of a number of newly independent States. These States inherited a number of nuclear facilities and programmes; however, the infrastructure to support and maintain these facilities was no longer in place. All of these States declared their intent to stay or become Non-Nuclear Weapon States. In these States the nuclear facilities and the nuclear material concerned are complex and cover a wide variety of different types of facilities (i.e., nuclear research centres for various purposes, different reactor types including WOOER, RBMK, and FBR, and different types of bulk handling facilities). In 1992, the Agency, having a direct involvement in international safeguards and non-proliferation in this area, embarked on a number of activities to support NIS Non-Nuclear Weapon States to meet national and international obligations. In safeguards agreements pursuant to the NPT, the State is required to establish and maintain a State System of Accounting and Control (SSAC). In most States, the SSACs were set up to also be responsible for ensuring adequate Physical Protection, Export/Import Control, and other regulatory matters.

The IAEA conducted a number of fact-finding missions in most of the NIS countries during the period 1992-94. The purpose of these fact-finding missions was to identify the needs for the establishment of an SSAC; to contact the individual State authorities as well as facility operators in order to obtain information about the State infrastructures and the personnel involved, facility conditions and operational status, nuclear material inventories and flows; to identify safeguards equipment needs; and to identify additional requirements covering Physical Protection, Export/Import Control, and communication systems.

Through these fact-finding missions, the needs for support associated with the IAEA safeguards implementation were identified. It was also noted that some NIS States were already receiving some donor support on a bilateral basis.

On the basis of suggestions from a number of countries, a meeting of potential donor States was organized in Vienna on 27–28 May, 1993. The participants at that meeting expressed their desire to help the NIS improve their SSACs in a co-ordinated manner in order to increase efficiency and to avoid duplication of efforts. As a result, a number of countries made funding available and became actively involved in providing support to the NIS. Today the active donor States include: Australia, Finland, France, Hungary, Japan, Norway, Sweden, the UK, and the USA. Additional countries have indicated an interest in joining the technical support programme.

Content and Principles of the CTSPs

The Co-ordinated Technical Support Plan is a detailed description of the support activities to be provided to each recipient NIS. The Plans were developed to provide adequate support at both the facility level and State level. The support encompasses the following: nuclear legislation; SSAC at State and Facility levels; Physical Protection (PP); Export/Import Control, and other areas. The agreed Plan represents the consensus of the donor State, recipient State, and the IAEA. The objectives of each Plan are to: 1) define the needs to be addressed, 2) define the time-scale over which activities need to be undertaken, and 3) assign a preliminary allocation of responsibilities between donor countries. Continuing discussions, cooperation, and co-ordination among the donor countries, the recipient country, and the IAEA, including the periodic exchange of detailed information, are recognized as conditions for successfully obtaining the Plan's goals. The Plan emphasizes the linkage of activities and provides preliminary estimates for the required resources. The resources needed for a specific task depend upon several factors (e.g., contributing country and the extent to which experience and technical resources are readily available). The Plan comprises the following three phases:

- Phase I addresses immediate requirements which would provide the legislative infrastructure; nuclear material accounting and control, Physical Protection, and Export/Import Control at the facility and State level; and preparation for implementation of safeguards.
- Phase II addresses the near-term requirements which would provide for the completion of the legal infrastructure, improving the operator's nuclear material accountancy and control systems, and upgrading Physical Protec-

tion and Export/Import systems. Training is recognized as an important element in the plan and is connected with each technical activity.

- Phase III addresses future needs for advanced information systems, inspection support measurement equipment, and improved operator measurement systems.

The plans have been subdivided into tasks that can be completed by one or more donor countries. This has resulted in a large number of tasks in States that have several nuclear facilities. Phase I activities are mostly covered and many tasks have been completed. Work is on-going in Phase II and Phase III.

To date CTSPs are active in the following countries: Armenia, Belarus, Georgia, Kazakstan, Latvia, Lithuania, Ukraine, and Uzbekistan. Plans are pending in Azerbaijan, Estonia, Kyrgyzstan, Moldova, and Turkmenistan.

The IAEA's Role in the CTSPs

The Agency has played a key role in defining the CTSPs for each country by working with the individual recipient country and donor country to identify the elements of support to be provided for each task. The Agency has prepared and updated the CTSPs for each recipient country. The progress on each task is periodically reported to the Agency by the recipient and donor countries. This progress is monitored using a computerized Monitoring System that provides the latest status on each task. These data have been recently made available to the donor and recipient countries on CDROM and can be used by the individual donor and recipient countries to assess the progress of the tasks and to identify open areas for support. The Agency also updates and distributes two data bases: 1) a Calendar of Events announcing relevant donors/recipient meetings and visits and 2) a data base containing the training profiles of the NIS safeguards personnel.

From the beginning the IAEA recognized that voluntary funding and expertise from its Member States was imperative to successfully address the magnitude of the task ahead. Thus, the Agency contacted various Member States to organize their support. The Agency is continuing to contact Member States for their support and to identify new potential donor countries.

The Agency has organized several Annual Review Meetings. The objectives of the meetings were to review the accomplishment of the agreed CTSPs, to discuss the coordination and exchange of information, and to identify new needs, new resources/interested donors, and future plans. The most recent meeting was held in Vienna on 6–7 November, 1996, and was attended by 14 NIS countries, 9 donor countries, and 4 observer countries. At this meeting IAEA senior staff made presentations on the status of all activities within the framework of the CTSPs. This was supplemented by brief accounts of related Agency activities in the NIS in the fields of Legal Assistance, Physical Protection and Illicit Trafficking, and Technical Cooperation. The meeting gave the opportunity for many bilateral contacts among donor and recipient countries.

Progress of the Support Activities

In general, significant progress has been made in implementing the support programme tasks. Table 1 indicates the implementation status broken down by recipient country. On average, 24% of the tasks are completed, 54% are on-going, and 22% are open (that is no donor country has been identified). It should be noted that a majority of the open tasks occur in recipient countries with small nuclear programmes.

A significant amount of time and effort has been spent by the donor countries in support to the NIS. Most recipient States now have basic SSACs in place. Training courses on the basic requirements for an SSAC have been presented in the NIS and at donor countries.

Nuclear material accountancy and control is now carried out in a better and more organized way. Procedures for recording and reporting inventories and inventory changes are in place in the State office and in most facilities. Computer equipment and programmes have been supplied to most facilities to perform the recording and reporting of inventories and inventory changes. Significant changes have taken place in accountancy systems when operators switched from a hard copy system to fully computerized accountancy systems. The supply of advanced computer programmes for nuclear material control and accountancy at the facility level is on-going.

Physical protection of nuclear material, particularly of HEU and Pu, has been dramatically improved with the installation of advanced electronic sensors. This has been done through site assessments, the development of the design and specifications for the upgrade of the facilities, and the supply and installation of the equipment.

The Agency has been able to implement Safeguards under the Agreements that have entered into force. Initial inventory verifications have been completed or are in progress in most of the facilities. They are expected to be completed in all States by the end of 1997. However, improvements are still needed at the State and facility levels for effective SSACs.

Future Directions

As noted in Table 1 and as discussed during the Annual Review meeting, there remains a number of open tasks. Support resources from donor countries are still being pursued to meet these needs. Initial efforts were directed to those recipient countries that had large nuclear programmes and had nuclear material of strategic significance (e.g., unirradiated direct use material such as high enriched uranium and plutonium). Clearly the first priority of the donor countries and the IAEA was placed on safeguarding and protecting this type of material. However, now that a majority of the needs have been met in this area, efforts should be focused on other types of nuclear material (e.g., LEU, NU, and thorium). Physical protection improvements are needed at nuclear power plants. Efforts should also be expanded to other areas (e.g., Export/Import Control and trafficking). In addition, efforts should be initiated in the remaining NIS countries that have small or negligible nuclear activities. These countries need support to develop the legal framework and infrastructure for an SSAC and Export/Import Control.

Table 1. CTSP Implementation Status as of Spring 1997.

Recipient country	Total tasks	Completed tasks	On-going tasks	Open tasks
Armenia	25	1	6	18
Belarus	26	4	18	4
Georgia	25	6	3	16
Kazakstan	62	14	48	0
Latvia	19	8	11	0
Lithuania	22	3	12	7
Ukraine	112	32	65	15
Uzbekistan	25	9	7	9
TOTAL	316	77 (24%)	170 (54%)	69 (22%)

The Agency is committed to continue its support in the implementation and monitoring of the progress of the CTSP. The Agency will continue to organize an Annual Review meeting to review the status of the CTSP. In such a meeting the presence of both the donor and recipient countries is essential. The provision of financial support by donor countries to enable the participation of recipient countries is vital. Several donor countries provided such financial support in the past, and it is hoped that they will continue in the future.

Referring to the previous Annual Review Meeting, several donor countries noted that the progress of the CTSP would have been better if the recipient countries on their side had made a stronger commitment to facilitating the implementation of the tasks. It was felt that in order to ensure smooth implementation of the CTSP, a strong support particularly by high government offices and facility management is essential. In this context there is a need for an integrated approach to nuclear nonproliferation to include: SSAC, Export/Import Control, and Physical Protection. The establishment of an appropriate system of nuclear laws and regulations in each recipient country is basic to such a process.

Training has proved to be extremely valuable to all recipient countries. In the past, a large number of NIS personnel have participated in training courses organized and conducted by the Agency and various donor countries. More effort should be directed towards developing the capability of the individual recipient countries to organize and conduct suitable training courses for their State and facility staff members.

Significant work has been carried out in introducing safeguards in the NIS over the last five years. However, in spite of the improvements, work is still required to be carried out to improve the state and facility level accountancy for effective SSAC in some of the NIS countries. Basic computer programmes have been provided; however, advanced computer programmes at the facility level are needed. Problems still exist in logistics and communications. The international community should continue to provide focused support for advancing the goal of adequate accounting and physical security of nuclear material in the NIS.

Attendees A-4

Mohammed Afzal, Pakistan
Obie Amacker, PNNL
George Anzelon, LLNL
Steven Aoki, DOE
V.S. Arunachalam, Carnegie Mellon University
Ken Baker, DOE / NN
Deanna Behring, OSTP
Adam Bernstein, CNS / Monterey
George Bunn, CISAC
Matthew Bunn, Harvard University
Jack Caravelli, NSC
Zafar Iqbal Cheema, Pakistan
Ron Cherry, DOE / NN
Steve Cohen, Univ. of Illinois
Floyd Culler
William Desmond, DOE
Bill Dircks, Atlantic Council
Sid Drell, SLAC
Katya Drozdova, CISAC
David Elliott, CISAC
Charles Emigh, NRC
Emily Ewell, CNS / Monterey
Michel Ferrier, France
Cheryl Fitzgerald, DOE
James E. Goodby, CISAC
Jean-Claude Guais, Cogema, Inc.
Vipin Gupta, Sandia
Rosemary Hamerton-Kelly
Kevin John Harrington, CISAC
Larry Himmelsbach, DOE / NN
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Roger Howsley, UK
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Susan Koch, DOD
Hiroyoshi Kurihara, Japan
Peter Lavoy, Naval Post Graduate School
Kun Jai Lee, Korea
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John Lepingwell, CNA / Monterey
Milton Levenson
Yesha Li, PRC
George Look, DOD
Bruce MacDonald, OSTP
Michael May, CISAC
Scott McAllister, LLNL
Dennis Mangan, Sandia
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Mark Mullen, LANL
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Ken Sheely, DOE
Theodore Sher, NRC
John Sopko, US Senate staff
David Speedie, Carnegie Corporation
Chauncey Starr, EPRI
Jeff Starr, DOD
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Yuri Volodin, Russia
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Ken Ystesund, Sandia
Zou Yunhua, CISAC
Xingqian Zhang, China