U.S.-Russian Collaboration in Combating Radiological Terrorism

Committee on Opportunities for U.S.-Russian Collaboration in Combating Radiological Terrorism, Office for Central Europe and Eurasia, National Research Council

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

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Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Richard Meserve, Carnegie Institution of Washington and Chris Whipple, ENVIRON. Appointed by the National Academies, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

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SUMMARY

Packaging conventional explosives with radioactive material and detonating a radiological dispersal device (RDD) to kill and terrorize people—the "dirty bomb" scenario—is, unfortunately, readily within the means of some terrorist groups. The International Atomic Energy Agency (IAEA) reports that radioactive materials needed to build an RDD can be found in almost any country in the world, and more than 100 countries may have inadequate control and monitoring programs necessary to prevent or even detect the theft of these materials. The agency also reports numerous incidents of illicit trafficking in radioactive materials, including ionizing radiation sources (IRSs) used in medical, agricultural, and industrial applications. Potential links of such trafficking with international criminal organizations heighten the concern about these materials falling into the hands of terrorists, who could use them in RDDs or in other ways to threaten populations. These concerns are sufficiently serious that they have been a focus of several initiatives announced by the leaders of the G8 governments at recent summit meetings.

Given these developments, the U.S. Department of Energy (DOE) requested the National Research Council (NRC) to carry out an assessment of the threats posed by inadequately protected IRSs in Russia. The assessment was to lead to recommended steps that could enhance the effectiveness of DOE's current cooperative program with Russia to reduce the threat posed by inadequately secured IRSs in Russia. This program began in 2003 in recognition that after the United States, Russia has the world's largest inventory of IRSs and that a number of aspects of security of IRSs throughout the country should be promptly upgraded. This report presents the findings and recommendations of the committee of specialists assembled by the NRC in response to DOE's request.

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The challenges in preventing detonations of RDDs are immense, and they will persist for many years. Hundreds and perhaps thousands of inadequately protected IRSs that are considered dangerous by safety standards adopted by the IAEA are present in many countries. Some are in use, some are in storage, and some are awaiting permanent disposal. Also, some IRSs have been simply abandoned by their legal custodians since there were no financially affordable disposal pathways for those that had exceeded their useful lifetimes or were no longer needed. Poorly protected IRSs, and particularly those that have been abandoned, can become easy prey for terrorist groups.

Detonating an RDD cannot trigger a nuclear explosion with its familiar mushroom cloud. Unlike nuclear weapons, RDDs cannot instantly kill tens to hundreds of thousands of people and obliterate a city. However, the disruption attendant to an RDD detonation could be widespread, particularly if it occurs outdoors in a densely populated urban area and the RDD is well designed to maximize the dispersal of radionuclides. Although the number of victims resulting from the effects of radiation will most likely not be great, the psychological impact of a radiological attack may lead to widespread fear, serious social disruption, and potentially catastrophic economic consequences.

From the U.S. perspective, the primary concern is the prevention of detonations of RDDs within the United States or against U.S. interests abroad. A related concern is illicit spreading of radioactive material from IRSs or other sources in populated areas through water routes and other pathways. To guard against attacks in the United States, preventive measures are focused on securing inadequately controlled IRSs currently in the United States. Unfortunately, hundreds of unwanted IRSs have not been under adequate control; but DOE, with the assistance of other federal and state agencies, has mounted an aggressive program to find, collect, and secure these orphan sources, and many have been brought under much better control.

Terrorist groups might also try to smuggle IRSs or radioactive material in other forms into the United States. A variety of homeland security programs are in place to help prevent penetration of U.S. borders. However, this is a most difficult task, and the prevention of smuggling of nuclear materials across U.S. borders must receive continued vigilance.

The U.S. government is also concerned about the targeting of dirty bombs against U.S. assets abroad. Such assets include embassies, military bases, privately owned establishments, and other facilities of importance to the U.S. government or private sector. Disruption of activities at some of these facilities, particularly those that serve as governmental centers or as transportation or communication hubs, would have profound security implications.

The IAEA is leading international efforts to enhance security of IRSs. The agency has prepared the *Code of Conduct on the Safety and Security of Radioactive Sources*,[1] 2004, and supporting documents that provide guidance for ensuring both the safety and security of IRSs. It has developed recommended approaches for member states to control their imports and exports of IRSs.[2] Also, it has long had a technical assistance program to assist member states improve the security of IRSs. These efforts are a good beginning, but worldwide implementation remains a major challenge. DOE, in close cooperation with the IAEA, has undertaken a limited but important set of cooperative activities with a number of countries in enhancing security of IRSs in these countries. Programs in Russia have been an important component of this global effort.

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This report focuses on IRSs in Russia. Based on site visits by committee members, consultations with dozens of Russian and U.S. specialists, and reports prepared by our Russian collaborators, the committee concludes that shortcomings in the security and life-cycle management of IRSs in Russia present a serious problem.

Hence, the special attention directed to security of IRSs in Russia within DOE's global programs is very appropriate. The Soviet Union had many potent IRSs throughout the country, probably numbering in the tens of thousands. Most of them were located in the Russian Republic of the USSR and remain in the Russian Federation today.

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[1] IAEA. 2004. Code of Conduct on the Safety and Security of Radioactive Sources. Vienna: IAEA.
[2] IAEA. 2005. Guidance on the Import and Export of Radioactive Sources. Vienna: IAEA. Available online at http://www-pub.iaea.org/MTCD/publications/PDF/Imp-Exp_web.pdf. Accessed November 14, 2006.

Additional IRSs are being manufactured at the Mayak Production Association and elsewhere in Russia for use in the country and for export.

The task of adequately securing even the most dangerous IRSs in Russia is daunting. For example, hundreds of radioisotope thermal generators (RTGs) are located in northern reaches of the country, and the logistics to recover those that are no longer needed or could be replaced with other energy sources are formidable. Reports of criminals having stripped the metal off some of these RTGs indicate the vulnerability to theft of the radioactive components as well.

In addition to the problem of securing RTGs, the committee observed security deficiencies in protecting other types of IRSs of concern. IRSs that could provide material for RDDs are located in hundreds of institutes, enterprises, hospitals, and other locations, which are within easy reach of criminals or terrorists. Also, the committee heard reports from Russian officials in Yekaterinburg of unwanted IRSs being frequently discovered in abandoned facilities and in open fields.

If IRSs are stolen or diverted in Russia or any country, they might enter the international black market and possibly fall into the hands of terrorist groups that could target U.S. assets in the United States or abroad. Significant portions of the IRSs that have been intercepted at border crossing points and elsewhere have been of Russian origin. The likelihood of stolen Russian IRSs being smuggled into the United States seems relatively low since a terrorist group would probably try to obtain an IRS that is already located in the United States rather than risk detection at a point of entry into the country. However, the use of Russian-origin IRSs against U.S. assets in Russia itself (e.g., U.S. Embassy, facilities of U.S. companies), Central Asia (e.g., U.S. military bases), the Middle East (e.g., U.S. military or private facilities), or elsewhere could have a dramatic impact on U.S. national security interests.

Thus, a successful RDD detonation in Russia, or indeed in any country, poses serious problems for the United States. Such attacks could provide a "proof of principle" for terrorists who to date have not yet used radiological weapons, possibly encouraging copy-cat attacks by terrorists in the United States or against U.S. interests abroad. A major radiological attack in any major capital or financial hub would likely adversely affect the global economy, including the U.S. economy. It could have global repercussions as to the safety and public acceptance of nuclear technologies, just as the Chernobyl accident affected acceptance of nuclear power. An RDD attack in Russia or elsewhere could also undermine the credibility of the IAEA as an effective international organization for ensuring nuclear safety and security, just at a time when the United States is firmly committed to strengthening this organization to deal with nuclear security and nonproliferation issues worldwide. The United States has considerable interest in helping to ensure that the security of IRSs in Russia meets an international level of acceptability and that Russia improves the full life-cycle management of its IRSs.

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DOE has made a very good start in working with Russian organizations to upgrade security of IRSs. Even with the limited funds available to date, this program is improving the security of IRSs in Russia. Also, DOE has gained considerable experience in developing and carrying out significant on-the-ground activities in Russia.

Linkages have been made with key Russian organizations. Important problems were selected for initial program "quick fixes"—improved regional and ministry inventories of IRSs, accelerated timelines to reduce the number of vulnerable RTGs, collection and disposal of unwanted IRSs, and enhanced security at some of its storage and disposal facilities. Initial projects in each of these areas have been successfully completed.

Of particular importance, the modest U.S. financial contributions to the cooperative program to date have helped focus Russian attention on critical aspects of security of IRSs. The joint efforts have most likely stimulated Russian efforts in addition to those associated with the cooperative program. Continued encouragement of the Russian government to address the security of IRSs more aggressively in these areas is important. Also, new opportunities for collaboration that build on early successes have emerged (for example, involvement of more Russian ministries in the collaboration and demonstration of low cost approaches at model facilities).

Thus, the program of quick security fixes is very important and should be continued; and the DOE leadership should expedite its implementation. The committee encourages the DOE to continually evaluate the effectiveness of the quick fixes from a risk reduction point of view. Of particular concern to the committee is the end-of-life-cycle management of IRSs that are no longer wanted, including many that have been simply abandoned. Of course, counterpart Russian organizations should be involved in evaluation efforts as well as in planning and prioritizing future activities.

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The committee is deeply concerned over the continuing decline in the level of DOE resources being allocated to the cooperative program in Russia. However, the committee is not in a position to recommend expansion of current activities or initiation of new activities in the absence of an overall DOE Plan that clarifies how the cooperative program can be most effective in reducing risks attendant to inadequately protected IRSs. **Thus, a primary recommendation of the committee is that DOE develop a comprehensive plan to work with Russian counterparts to reduce the overall risk and consequences of radiological terrorism.** This Plan should become an important basis for budget requests to support the program.

The Plan for the cooperative program should be developed within the context of a comprehensive Russian program for ensuring adequate life-cycle management of IRSs throughout the country and should take into account activities of other external partners. However, because a comprehensive Russian program may take years to fully develop, the DOE should move forward promptly to work with Russian counterparts to address the most urgent problems and help them develop and implement their program. Of special relevance to development of a comprehensive Russian program for addressing the security of IRSs is the approach of the Federal Agency for Atomic Energy (Rosatom) in the area of "safety" of IRSs and radioactive waste. Rosatom has developed and regularly articulates a comprehensive overview of safety-related actions that are needed and are underway. According to Rosatom officials, this overview is very helpful in guiding the national effort. These officials informed the committee that a comparable program strategy to help guide the approach to "security" of IRSs has not been developed, although its importance appears to be recognized in the Russian government.

In summary, only the Russian government can strengthen the many weaknesses in the security system for IRSs and in dealing with the overall threat of radiological terrorism in Russia. However, the committee believes that technical cooperation by DOE and other external partners, along with carefully selected financial investments in such cooperation, will help the Russian government focus on developing a more comprehensive approach to ensure adequate life-cycle management of IRSs than currently exists. Such cooperation will lower the risk of radiological terrorism to both Russia and to the United States.

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The United States is not the only country vitally concerned with IRS-related developments in Russia. Other countries are also contributing financial resources and expertise for selected activities. The Scandinavian countries have long had interests in replacing the RTGs in the Far North of Russia. Japan carefully watches developments in the Far East. Ukraine is concerned about radionuclides of Russian origin being smuggled into its territory. As apprehensions about radiological terrorism increase in Europe, many G-8 governments recognize risks posed by inadequate security and control of radioactive materials, and particularly IRSs, in Russia.

Thus, the international community will probably embrace a number of program approaches advocated by the committee. They include development of financially affordable pathways for unwanted IRSs; upgrading security facilities that house highly active IRSs; plans for managing the consequences of IRS incidents; expanded risk analysis capabilities to help establish priorities; and, of course, a comprehensive Russian program which is crucial to long-term success in combating radiological terrorism.

In conclusion, the committee firmly believes that the United States has played and should continue to play an important leadership role in catalyzing this widespread interest in enhancing security of IRSs in Russia. Such leadership is highly significant in reducing the likelihood of radioactive materials in Russia finding their way into RDDs that are detonated in Russia or elsewhere.

Expeditious implementation of the current cooperative program of quick security fixes, strong encouragement of the Russian government to carry out a comprehensive program for enhancing the security of IRSs, and development and implementation of an overall plan for U.S.-Russian cooperation that supports critical aspects of a comprehensive Russian program should be the hallmarks of U.S leadership.

INTRODUCTION

During the past several years, and particularly since 9/11, international concern over the use by terrorists of radioactive material as a radiological weapon has increased considerably. The possibility of the detonation of a Radiological Dispersal Device (RDD), often referred to as a "dirty bomb," which has radioactive material packed in or around conventional explosives has been the focus of much of this apprehension. Press reports of illicit trafficking in radioactive material, web-chat attributed to terrorist groups, and discovery of primitive drawings of dirty bombs in the possession of international terrorist groups have heightened the concern.

International experts believe that crude devices could be easily constructed. Of course, depending on the technical skills of terrorists, the radioactivity and dispersion of particles could vary considerably. In any event, public statements of experts increasingly warn of a growing threat of radiological terrorism that needs urgent attention.

In response, the U. S. government has intensified its efforts to improve control over radioactive material in situations where the loss of control could constitute a threat to U.S. national security interests. U.S.-financed programs established during the past several years have been designed to improve security at facilities where radioactive material is located in a number of countries and to intercept radioactive material that has entered the international black market. At the same time, an international consensus—reflected at meetings of the International Atomic Energy Agency (IAEA) and in other national and international forums—has emerged that such efforts by the United States and by other governments are not adequate given the severity of the problem.

Against this background, in FY 2003 the U.S. Congress explicitly authorized the Department of Energy (DOE) to develop cooperative programs in Russia and other regions of the world to "protect, control, and account for radiological dispersal device materials." Information on the budgetary support for this initiative is set forth in Appendix E. The difficult transition from a tightly guarded and difficult-to-access Soviet nuclear complex to a Russian nuclear complex operating in a more open society has severely stressed security efforts to control fissile and radioactive material. In recent years, numerous reports of radioactive material of Russian origin falling into the hands of unauthorized individuals, such as those that are noted in this report, have raised international concern. Therefore, DOE has begun collaborative efforts with Russian organizations to upgrade the protection of radioactive material of concern, and specifically inadequately protected ionizing radiation sources (IRSs). IRSs are generally considered to be the most likely source of radioactive material that could be dispersed when dirty bombs are detonated.

In 2003, DOE commissioned the study that led to this report. The report addresses nuclear security issues in Russia where large quantities of radioactive material are located. The importance of helping to upgrade the security of IRSs in Russia was the primary theme during the negotiation of the contract between DOE and the National Research Council (NRC) that provided the basis for this report. The statement of task that was included in the contract, however, was somewhat broader in scope. At the time, both DOE and the NRC considered that a wide-ranging assessment of the radiological threat would be helpful in putting into context the issues associated with protecting IRSs in Russia. Appendix A provides the original task statement for this report.

As the study evolved, DOE's concern over the security of IRSs in Russia intensified. Therefore, the NRC committee responsible for this report, with the concurrence of DOE and Pacific Northwest National Laboratory, which served as the contract manager, decided to concentrate its efforts on the radiological terrorism threat posed by inadequately protected IRSs in Russia and on feasible approaches to upgrading the security of IRSs in Russia. The new statement of task is as follows:

> An ad hoc committee will be established by the National Academies to develop recommendations for priorities for U.S.-Russian cooperation to be considered by the Department of Energy (DOE) as it develops its program for countering the threats of radiological terrorism. The committee will consider threats posed by radiological dispersion devices (RDDs) which consist of radioactive material embedded with conventional explosives in configurations that enable the detonation of the explosives to disperse radioactivity over significant areas.
>
> The committee will concentrate its effort on activities that support Russian efforts to upgrade the security of ionizing radiation sources (IRSs) in Russia which could be used in RDDs. The committee will consider U.S.-Russian cooperation in the broader context of global efforts to improve the security of IRSs, and particularly efforts under the auspices of the International Atomic Energy Agency. In addition, it will identify the benefits to the United States in preventing radiological terrorism incidents in Russia.
>
> After reviewing ongoing cooperative efforts in consultation with American and Russian specialists, the committee will prepare a report concerning the extent of the problems associated with protection and control of IRSs, progress being made in addressing these problems, and additional steps that should be considered. Interim briefings will be provided to DOE at appropriate times during the project.

As to the timeline for this study, the initial 18-month projection for the study was extended by 18 months. Considerable time was required to resolve administrative difficulties in gaining access to facilities in Russia for first-hand observations, to consult with appropriate Russian officials and specialists given the dozens of government bodies and hundreds of important facilities involved in IRS-related activities, and to obtain authoritative documentation about security conditions in Russia in an area that is considered quite sensitive in Russia and elsewhere.

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In addition to misuse of radiological sources considered in this study, radiological terrorism could be carried out by sabotage of a nuclear facility, waste site, or transport container. Terrorists might attempt to detonate, set fire to, or otherwise cause serious dispersion of radioactive material that is located within the target area.

However, this report focuses primarily on dispersion of radioactive material. Terrorists might acquire by theft or other means non-fissile radioactive material and disperse such material with conventional explosives in a Radiological Dispersal Device (RDD) – the dirty bomb scenario noted previously. Other forms of radiological terrorism include the dispersion of radioactive material through public pathways, such as water supplies, roadways, or indoor heating or ventilation ducts. Another form of radiological terrorism is posed by Radiological Exposure Devices, which are radiation sources placed in public places and simply irradiate nearby persons rather than dispersing the radioactive material. Funding and time limitations led the committee to concentrate on RDDs, the main focus of the task statement. However, the Nuclear Safety Institute (IBRAE) report[1] commissioned for this study does discuss several scenarios for REDs.

The potential sabotage of nuclear facilities (especially nuclear power reactors) has received increased attention in the United States following 9/11 and in Russia since the Chernobyl accident. The cooperative efforts in this area have focused on enhancing the safety of power plants although there is clear overlap with security concerns. The committee did not address this area which is beyond the scope of this study.

As discussed in Chapter 1, international experts consider radiological dispersal from a dirty bomb as the most likely form of nuclear terrorism. Radioactive materials are ubiquitous around the globe – not only are they directly associated with civilian and military nuclear programs, but IRSs are also widely used in medicine (e.g., cancer therapy units), agriculture (e.g. food sterilization), and industry (e.g. oil well logging, gauging of metal thickness). Radioactive material from IRSs or other sources could be packed together with conventional explosives and detonated in public places. Depending on the characteristics of the material and the extent of the dispersion, radioactive material could threaten significant populations and might cause widespread fear and social disruption, along with potentially large economic damage.

As noted above, building effective cooperation between Russia and the United States to reduce the threat of radiological dispersal from IRSs is the principal focus of this report. Such sources often contain radionuclides with deeply penetrating radiation, they are *sealed* (encapsulated typically doubly in metal), and they are usually used with proper safety precautions during their useful lifetimes.

Unfortunately, few if any countries have given sufficient attention to the security of IRSs during their entire life cycle (from fabrication to final disposal), particularly after they have exceeded their useful lifetime or are no longer needed. In recognition of the security importance of ensuring that unwanted IRSs are not left unattended, in 2002, DOE moved its Orphan Source Recovery Program to its threat reduction organization. Similarly, the IAEA greatly expanded its *Code of Conduct on the Safety and Security of Radioactive Sources* and associated IRS programs to go beyond safety concerns and focus as well on security, including orphan source recovery.

The committee did not address other potentially dangerous radioactive material, such as spent reactor fuel or radioactive waste. However, some of the information presented in this report should be useful in dealing with such material that could be used in radiological dispersal devices.

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In surveying the work of many organizations concerned with IRSs, the committee gave special attention to the activities of the IAEA which has included IRS security on its agenda for a number of years. Much of the Agency's early work culminated in the *Code of Conduct on the Safety and Security of Radioactive Sources*, which was revised in January 2004.[2] Other highly relevant documents of the Agency are IAEA Safety Guide

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[1] IBRAE. 2005. Opportunities for U.S.-Russian Cooperation in Combating Radiological Terrorism. Prepared for the NRC Committee on Opportunities for U.S.-Russian Cooperation in Combating Radiological Terrorism.
[2] IAEA. 2004. Code of Conduct on the Safety and Security of Radioactive Sources. Vienna: IAEA.

RS-G-1.9, *Categorization of Radioactive Sources*, 2005, IAEA Vienna[3] and *Guidance on the Import and Export of Radioactive Sources*, 2005, IAEA Vienna. In addition, the IAEA maintains a database on illicit trafficking in radioactive material that includes many entries concerning IRSs that have been discovered. Of course, reports on some incidents are considered to be classified documents and are only available in closed databases of enforcement organizations such as Interpol. Finally, radiological terrorism is regularly discussed by government representatives at intergovernmental meetings of the IAEA and by specialists during agency-sponsored workshops and consultations on a variety of specialized topics. As this report underscores, the IAEA is not the only international organization interested in the topic of radiological terrorism; but it has been the focal point of most of the international attention devoted to IRSs in recent years and therefore was an excellent source of information in preparing this report.

Many other organizations and dozens of scholars and analysts in the United States and abroad have published hundreds of books, reports, and articles on radiological terrorism. A number of these writings have also been important in preparing this report. Three of the many examples of publications relevant to the observations in this report are:

- *Making the Nation Safer: The Role of Science and Technology in Countering Terrorism*, National Academy Press, 2002, pp 39-64[4]
- *Management of Terrorist Events Involving Radioactive Material*, National Council on Radiation Protection and Measurements, NCRP Report No. 138, October 24, 2001[5]
- Charles D. Ferguson and William C. Potter, *The Four Faces of Nuclear Terrorism*, Center for Nonproliferation Studies, Monterey Institute of International Studies, Rutledge, 2004, pp 259-317.[6]

Turning specifically to security of IRSs in Russia, the Federal Agency for Atomic Energy (Rosatom) published *Report on Safety* in March 2004,[7] which describes the government's policy and program framework for all aspects of nuclear safety, including safety in handling IRSs. The committee is unaware of a similarly comprehensive, publicly available report from Rosatom or other Russian organization on the closely related topic of *security* of IRSs which is the theme of this report.

Several Russian research organizations have been analyzing on a broad basis developments in Russia relevant to this study. For example, IBRAE of the Russian Academy of Sciences has published a number of articles on radiological terrorism

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[3] IAEA 2005. Categorization of Radioactive Sources. Safety Guide RS-G-1.9. IAEA Safety Standard Series. Vienna: IAEA. Available online at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1227_web.pdf. Accessed November 9, 2006.
[4] NRC Committee on Science and Technology for Countering Terrorism. 2002. Pp. 39-64 in Making the Nation Safer: The Role of Science and Technology in Countering Terrorism. Washington, D.C.: The National Academies Press.
[5] National Council on Radiation Protection and Measurements. 2001. Management of Terrorist Events Involving Radioactive Material. NCRP Report No. 138. Bethesda: National Council on Radiation Protection and Measurements.
[6] Ferguson, C. D., W. C. Potter, A. Sands, L. S. Spector, and F. L. Wehling. 2005. Pp. 259-317 in The Four Faces of Nuclear Terrorism. New York: Routledge/Taylor & Francis, LLC.
[7] Federal Agency for Atomic Energy. 2004. Report on Safety. Moscow: Komtekhprint.

concerns in Russia and other countries, including security of IRSs. The Institute of Chemical Technology of Rosatom, in cooperation with several other Russian institutes, has prepared a series of reports on distribution of radioactive material and radioactive contamination in Russia, under a broadly based program entitled *The Radiation Legacy of the Soviet Union*. Reports of this program are available through the International Science and Technology Center (ISTC)[8] in Moscow, an intergovernmental organization that supports projects to redirect former weapons scientiest to peaceful pursuits. Member governments of the ISTC have provided financial support for this assessment program for almost a decade. The Rosatom enterprise Izotop, which has for decades been a key facility in the distribution of IRSs, plays a special role in keeping track of IRSs and in assisting regulatory bodies in proscribing measures for appropriate handling of them.

Three particularly important sets of documents for the preparation of the report were the following:

- Papers presented by officials and specialists from a number of Russian organizations at the Workshop on Safety and Security of Ionizing Radiation Sources hosted by the Russian Academy of Sciences and the National Academies in Moscow in 2005. Presentation material from this workshop can be obtained from the NRC.[9]
- A study commissioned by the NRC and carried out by IBRAE to provide a Russian perspective on many aspects of the topic of this report. Findings of the study are included in this report as appropriate.
- Background documents provided by the Office of Global Radiological Threat Reduction of DOE. Extracts from these documents are included in this report, and the complete documents are available in the NRC's public access file.[10]

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[8] See http://www.istc.ru. Accessed November 27, 2006.

[9] Please contact the National Academies Public Access Records Office for this information.

[10] See the following:

Tittemore, G. W. 2004. Nuclear and Radiological Threat Reduction Task Force. Presentation at the first meeting of the NRC Committee on Opportunities for U.S.-Russian Collaboration in Combating Radiological Terrorism, Washington, D.C., May 7, 2004.

For Task Force/RDD Threat Reduction Legislation, see:

National Defense Authorization Act for Fiscal Year 2003. Pub. L. No. 107-314, §3156. 2002. H.R. CONF. REP. NO. 107-772 at pp. 790-791 (2002).

Consolidated Appropriations Resolution, 2003. Pub. L. No. 108-7, 2003. H.R. CONF. REP. NO. 108-10 at p. 906 (2003).

Emergency Wartime Supplemental Appropriations Act, 2003. Pub. L. No. 108-11, 2003. H.R. CONF. REP. NO. 108-76 at p. 68 (2003).

Tittemore, G. W. 2004. Nuclear and Radiological Threat Reduction Task Force. Presentation at the second meeting of the NRC Committee on Opportunities for U.S.-Russian Collaboration in Combating Radiological Terrorism, Washington, D.C., August 24, 2004.

Sandia National Laboratories. 2004. A Basic Guide to Physical Protection of Radioactive Sources. SAND2004-2222P. Albuquerque: Sandia National Laboratories.

Sandia National Laboratories. 2004. A Basic Guide to RTR Radioactive Materials. Revision 3: 8 July 2004. Albuquerque: Sandia National Laboratories.

Tittemore, G. W., B. Waud, and P. D. Moskowitz. 2004. Nuclear Security Studies in Russia. Presentation at the second meeting of the NRC Committee on Opportunities for U.S.-Russian Collaboration in Combating Radiological Terrorism, Washington, D.C., August 24-25, 2004.

Soo Hoo, M. 2004. IAEA Documents on Source Security and Russia-Specific Activities. Presentation at the second meeting of the NRC Committee on Opportunities for U.S.-Russian Collaboration in Combating Radiological Terrorism, Washington, D.C., August 24-25, 2006.

Also of importance in preparing this report were briefings provided to the committee by specialists from DOE and other U.S. organizations and visits by committee members and staff to a number of Russian organizations and research facilities. A list of these briefings and visits is included in Appendix B.

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The report is structured as follows:

- Chapter 1 provides a global context of radiological terrorism as it is currently perceived and understood from the political and technical points of view in order to put the Russian situation in proper context.
- Chapter 2 describes the situation in Russia with regards to the presence of radioactive materials, security of these materials, the potential threat of terrorism posed by these materials, and the relevance of radiological threats emanating from Russia to U.S. national security interests.
- Chapter 3 describes and assesses past and current U.S.-Russian cooperative activities associated with managing and controlling radioactive materials and IRSs, and how these efforts affect the threat of radiological terrorism.
- Chapter 4 presents the conclusions and recommendations of the committee concerning steps that should be considered by DOE in supporting Russian efforts to combat radiological terrorism and secure IRSs in Russia.

Mustin, T. 2004. Office of Second Line of Defense Russia Program Overview. Presentation at the second meeting of the NRC Committee on Opportunities for U.S.-Russian Collaboration in Combating Radiological Terrorism, Washington, D.C., August 24-25, 2006.

Chapter 1

THE GLOBAL CONTEXT FOR PREVENTING RADIOLOGICAL TERRORISM

Packaging a conventional explosive with radioactive material and detonating the device to kill and terrorize people—the "dirty bomb" scenario—is, unfortunately, readily within the means of some terrorist groups.[1] As pointed out by the International Atomic Energy Agency (IAEA) in Box 1-1, the necessary radioactive material is readily available internationally and in many cases is poorly secured.

Box 1-1

"The radioactive materials needed to build a 'dirty bomb' can be found in almost any country in the world, and more than 100 countries may have inadequate control and monitoring programs necessary to prevent or even detect the theft of these materials... 'What is needed is cradle-to-grave control of powerful radioactive sources to protect them against...theft'."

SOURCE: IAEA. 2002. P. 1 is Inadequate Control of the World's Radioactive Sources. IAEA Press Release, September 2002. Vienna: IAEA. Available online at www.iaea.org/NewsCenter/Features/RadSources/rads_factsheet.pdf. Accessed November 27, 2006.

The IAEA report underscores the importance of governments actively "managing" the entire life cycles of many classes of radioactive material contained in ionizing radiation sources (IRSs). IRSs contain radioactive materials which are the most likely ingredients for dirty bombs, technically known as radiological dispersion devices (RDDs). Because IRSs have beneficial uses inextricably integrated into medicinal, agricultural, industrial, and research activities, and because their use will increase as the world becomes more industrialized, they cannot simply be locked up or eliminated. The challenge for governments is to expand their efforts to keep IRSs out of the hands of terrorists through life-cycle management while at the same time preparing to manage the consequences if dirty bomb events occur.

As underscored by the IAEA, the threat of detonation of a dirty bomb is global since the necessary radioactive material and conventional explosives can be found in many countries. This chapter provides a brief overview of the risks posed by RDDs and discusses global approaches to deal with these risks. The focus is on inadequately secured IRSs that could provide radioactive material. The discussion provides a context for subsequent consideration of developments in Russia and of U.S.-Russian cooperative

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[1] Cameron, G. 1999. Nuclear Terrorism: A Threat Assessment for the Twenty-First Century. New York: Palgrave Macmillan.

programs to reduce the threat of radiological terrorism with roots in Russia. Also, other publications that address important global issues in greater detail are identified.

The Radiological Risk

The committee concurs with the conclusions in the report *Making the Nation Safer: The Role of Science and Technology in Countering Terrorism*, published in 2002 by the National Research Council, that detonation of an RDD would most likely result in only a few deaths but could have the potential for causing substantial economic damage and/or social disruption.[2]

Of course RDDs cannot trigger a nuclear explosion with its familiar mushroom cloud. Unlike nuclear weapons, they cannot instantly kill tens to hundreds of thousands of people and obliterate a city. Thus, the concept of radiological terrorism is quite different from the possible use of nuclear weapons, and linking the two threats can hinder efforts to properly define the risks and to prevent events.

In principle, it is necessary for first responders to be prepared to deal effectively with each type of event. But first responders must be prepared to address so many types of events that it is likely that the procedures for responding to both RDD attacks and detonation of nuclear devices will be bundled within single guidelines. Should an event involving fissile or radioactive material occur, appropriately trained specialists that understand in detail the differences between nuclear and radiation attacks should promptly become involved in response and consequence management activities.

Radioactive material dispersed by an RDD may cause serious radiation health effects for a limited number of exposed people, and indeed may result in some deaths. But the gravest consequences of detonation of an RDD are more likely to be the spread of contamination requiring evacuation of large numbers of inhabitants of the affected area; short and long-term economic disruption that could extend well beyond the contaminated area by impacts on transportation, financial, and other sprawling infrastructure systems; incitement of psychological trauma among individuals and groups that are exposed to radiation or believe they have been exposed; and attendant social or political instability. Quite appropriately, RDDs have been called "weapons of mass disruption."[3]

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[2] NRC Committee on Science and Technology for Countering Terrorism. 2002. Pp. 49 in Making the Nation Safer: The Role of Science and Technology in Countering Terrorism. Washington, D.C.: The National Academies Press.

[3] Henry C. Kelly, president of the Federation of American Scientists, and Steven Koonin, a physics professor and provost of the California Institute of Technology, were among the first analysts after September 11, 2001 to draw attention to the massively disruptive effects of RDDs.
See: Kelly, H. C. 2002. Testimony before the U.S. Senate Foreign Relations Committee, March 6, 2002, available at http://www.fas.org/ssp/docs/kelly_testimony_030602.pdf. Accessed on April 23, 2004.
Koonin, S. E. 2002. Radiological Terrorism. Physics and Society 31(2):12-13. Available online at http://www.aps.org/units/fps/newsletters/2002/april/toc.cfm. Accessed on November 8, 2006.
Levi, M. A. and H. C. Kelly. 2002. Weapons of Mass Disruption. Scientific American (November):76-81.

Thus, an RDD may have considerable value as a terrorist weapon. The mere fact of an explosion being characterized as "nuclear" would almost certainly ensure that it had an impact on the public's apprehensions.

Returning to health risks, the radioactive material contained in various types and configurations of IRSs can pose very different risks, depending on the type of radiation emitted and on how effectively the material can be dispersed. Radionuclides such as cobalt-60, cesium-137, and iridium-192 used in many types of industrial irradiators and medical devices can result in acute health effects from penetrating radiation, including death when there are significant levels of exposure. At the other extreme, the amount of americium-241 used in domestic smoke detectors is benign. All of these radionuclides are used in commercial IRSs.

In addition to half-life (that is, the time it takes for one-half of the isotope to decay into its products), other characteristics of IRSs determine their relative security risk, namely the total amount of radioactivity, the portability of the IRS, and the chemical form that affects the ease of dispersibility. For example, Cs-137 in large IRSs is often in the form of powdered cesium chloride, which could be easily dispersed. In contrast, many IRSs contain Ir-192 or Co-60 in the form of solid metal pellets, which do not disperse easily. From a technical standpoint, the aerosolization potential depends on the material properties and the device geometry.

In short, when properly packaged, adequately shielded, and appropriately handled for their intended use, IRSs are safe, even when they contain the most lethal radionculides. However, if the shielding is removed and the containers breached either intentionally or unintentionally, the radioactive material in many IRSs can injure or perhaps even kill exposed persons and could seriously contaminate large areas. Such incidents have occurred as a result of accidents or theft.

"[E]ven without malevolent intent, the loss of control of radioactive sources has resulted in death or serious injury. The well known incident in Goiânia, Brazil, in 1987, is frequently cited as an example—a case in which the inadvertent dismantling of a radiotherapy source, and the dispersal of Cesium-137, resulted in a number of fatalities and significant social and economic disruption."[4] In this case, scavengers of scrap metal sold remnants of the source assembly to a junkyard owner who distributed material that glowed blue in the dark to relatives and friends. Soon twenty persons were hospitalized and four of them died. A total of 112,000 people were monitored for radiation and 249 had been contaminated either internally or externally. Approximately 6 months were required to clean up an area of about one square kilometer. As to the psychological impact, the IAEA reported as follows:

> The accident in Goiânia had a great psychological impact on the Brazilian population owing to its association with the accident at the Chernobyl nuclear power station in the USSR in 1986. Many

[4] ElBaradei, M. 2003. Statement to the International Conference on Security of Radioactive Sources. March 11, 2003. Vienna: IAEA. Available online at http://www.iaea.org/NewsCenter/Statements/2003/ebsp2003n007.shtml. Accessed on November 9, 2006.

> people feared contamination, irradiation, and damage to health; worse still, they feared incurable and fatal diseases. [5]

The wider the dispersion of radioactive material by explosive devices or by other means such as injection of material into ventilation systems or water ways, the larger the footprint of the contaminated area. But at the same time, spreading the material can result in dilution that lowers the immediate health risk. In the case of broad dispersion, the near-term deaths resulting from an RDD attack might be limited largely to the effects of the chemical explosion, not from radiation. However, there may also be long-term health effects due to increased risk of cancer within the population exposed to significant amounts of radiation. At the same time, estimates of long-term health effects due to exposure of low levels of ionizing radiation are difficult to make even if the radiation exposure is reasonably well known.[6] One analysis of some of the important dimensions of environmental releases of radiation is as follows:

> It is clear that even the major catastrophe of Chernobyl had a minor impact on the health of the average inhabitant of the northern hemisphere. But on the psychological and political level, it had an extraordinary effect, whose consequences on the economy, and even on public health, can be considerable. The problem is serious when people find themselves in a highly contaminated region where there is a severe short-term risk to their health or to their lives. It means little to them to know that epidemiologists consider that if the radioactivity with which they are afflicted were uniformly distributed, at very low dose, over the entire population of the globe, there would be the same number of victims in total, but the effect would be imperceptible because of other cancers, much more numerous.[7]

There are no publicly reported cases of RDDs being used or even fully constructed as terrorist weapons. Examples of intentional misuse of IRSs are noted later in this report. Thus, the possible consequences of an RDD incident can only be predicted from analysis of the impacts of major radiation accidents and other types of relevant events and from hypothetical scenarios. The IBRAE report noted in the Introduction can be helpful in this regard. It postulates several scenarios and discusses possible health, economic, and disruption impacts. Of particular concern are cleanup problems associated with different radionuclides.

Nevertheless, as already emphasized, it seems clear that the shock of the conventional explosive used in an RDD will most likely be the primary cause of any

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[5] International Atomic Energy Agency. 1988. P. 115 in The Radiological Accident in Goiania. Vienna: International Atomic Energy Agency. See http://www-pub.iaea.org/MTCD/publications/PDF/Pub815_web.pdf. Accessed on November 9, 2006.

[6] See, for example: NRC Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation. 2006. Health Risks from Exposure to Low Levels of Ionizing Radiation. BEIR VII Phase 2. Washington, D.C.: The National Academies Press. Available online at http://newton.nap.edu/catalog/11340.html. Accessed November 9, 2006.
Garwin, R. L. and G. Charpak. 2001. Megawatts and Megatons: A Turning Point in the Nuclear Age? New York: Alfred A. Knopf.
National Council on Radiation Protection and Measurements. 2001. Pp. 27-53 in Management of Terrorist Events Involving Radioactive Material. NCRP Report No. 138. Bethesda: National Council on Radiation Protection and Measurements.

[7] Garwin, R. L. and G. Charpak, op. cit. p. 192.

immediate deaths or serious injuries. While there is the potential for long-term radiation health effects, the most significant effect of radiation releases on individuals is likely to be the psychological impact on exposed populations. Of course the consequences of denial of access to important facilities and the need to relocate people due to contamination that could take weeks or months to clean up might be very large indeed.

In addition, persons not in the impacted area may believe that they might have been exposed to radiation or that they will be exposed in the future from such incidents. Many people recoil with great anxiety at the thought of encountering any level of nuclear radiation or any level of a toxic material that is invisible and cannot be felt. Even reassurances from government authorities or well-informed specialists that the risk to human health of radiation exposure is minimal, some residents in or near the path of radiation will surely seek to escape as quickly as possible from any level of exposure. Effective risk communication among government officials, recognized experts in radiation medicine, and the general public—while not always successful in quelling anxieties—is nevertheless a key element in reducing the likelihood of harmful psychological responses to an incident.[8]

In addition, even a reasonably minor RDD attack could serve as an effective multiplier to a conventional terrorist attack, such as a subway bombing, in the same geographical area. Access by first responders to contaminated areas might be denied by police, or contaminated emergency response centers might be closed during the crucial period of initial response.

Finally, with regard to developing methodologies for estimating the harm from dirty bombs, the Goiânia incident has been used as the basis for estimates that some types of radiological attacks could kill tens or hundreds of people and sicken hundreds to thousands and the economic impact could be great.[9] Expanded interdisciplinary research would help in providing a framework to extrapolate accident data to theoretical RDD events.

Coping with Millions of Sources

The committee is unaware of any authoritative estimates of the total number of IRSs that are in use or storage throughout the world. Worldwide inventories up to ten

[8] For a discussion of psychological impacts of a dirty bomb explosion and of risk communication, see National Council on Radiation Protection and Measurements, op. cit., pp. 54-73.
Fischhoff, B. 2006. Pp. 463-492 in The McGraw-Hill Homeland Security Handbook, D. G. Kamien, ed. New York: The McGraw-Hill Companies, Inc. In particular Fischhoff uses actual event examples to demonstrate that people react without panic in some cases of severe emergencies.
Also see Bennett, B., M. Repacholi, and Z. Carr, eds. 2006. Health Effects of the Chernobyl Accident and Special Care Programmes. Geneva: World Health Organization. Available online at http://www.who.int/ionizing_radiation/chernobyl/. Accessed on November 9, 2006.
[9] Zimmerman, P. D. and C. Loeb. 2004. Dirty Bombs: The Threat Revisited. Defense Horizons 38(January): 1-10.

million have been reported. The committee believes that the number is in the millions but cannot be more precise using available data.[10]

Concerns over terrorism focus primarily on IRSs of sufficient activity, either individually or when bundled, to create an RDD with considerable radioactivity potential. When considering radioactivity levels, half-life, portability, and dispersibility potential of IRSs known to be in use or in storage, only a small fraction of the millions of existing IRSs pose a high radiation risk. Still, there are estimates that tens of thousands of high-risk IRSs exist throughout the world; and as previously noted, even low-risk IRSs have the potential of frightening populations.[11]

A number of countries including the United States are beginning to develop comprehensive national IRS inventories. In Argentina, for example, maintaining a complete inventory has been a part of the established regulatory process, but this has been rare. Unfortunately, detailed inventories of existing IRSs are very difficult to compile in many countries because the licensing processes do not require complete reporting.

Countries which have produced and distributed IRSs should attempt to calculate the quantity of radionuclides produced and distributed to date to help establish an upper bound on an overall estimate of inventories. This information would assist in determining the level of resources that should be devoted by governments to combating radiological terrorism. Such work is currently being sponsored in the United States by the Department of Energy.[12]

As indicated in Box 1-2, the IAEA has developed the accepted international standard for categorizing IRSs with respect to the safety aspects of each type of IRS.

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[10] See for example U.S. General Accounting Office. 2003. P. 7 in Nuclear Nonproliferation: U.S. and International Assistance Efforts to Control Sealed Radioactive Sources Need Strengthening. GAO-03-638. Washington, D.C.: U.S. General Accounting Office.
[11] Ibid.
[12] Communication with DOE NNSA Office of Global Threat Reduction's U.S. Radiological Threat Reduction Program, October 2005.

Box 1-2
Categorization of Radioactive Sources

Category 1 sources, "if not safely managed or securely protected would be likely to cause permanent injury to a person who handled [them], or were otherwise in contact with [them], for more than a few minutes. It would probably be fatal to be close to this amount of unshielded material for a period of a few minutes to an hour." These sources are typically used in practices such as radioisotope thermoelectric generators, irradiators and radiation teletherapy.

Category 2 sources, "if not safely managed or securely protected, could cause permanent injury to a person who handled [them], or were otherwise in contact with [them], for a short time (minutes to hours). It could possibly be fatal to be close to this amount of unshielded radioactive material for a period of hours to days." These sources are typically used in practices such as industrial gamma radiography, high dose rate brachytherapy and medium dose rate brachytherapy.

Category 3 sources, "if not safely managed or securely protected, could cause permanent injury to a person who handled [them], or were otherwise in contact with [them], for some hours. It could possibly—although it is unlikely—be fatal to be close to this amount of unshielded radioactive material for a period of days to weeks." These sources are typically used in practices such as fixed industrial gauges involving high activity sources (for example, level gauges, dredger gauges, conveyor gauges, and spinning pipe gauges) and well logging.

Two additional categories, 4 and 5, are also described. These contain smaller quantities of radioactive material and are generally not considered dangerous in the context of an RDD. However, when large numbers of low activity IRSs are aggregated together and produce a total activity similar to the higher categories, a danger can exist.

SOURCE: IAEA. 2003. Pp. 27-29 in Categorization of Radioactive Sources. IAEA-TECDOC-1344. Vienna: IAEA. Available online at http://www-pub.iaea.org/MTCD/publications/pdf/te_1344_web.pdf. Accessed November 9, 2006.

Meanwhile, DOE has developed its own prioritization of radionuclides for IRSs based principally on the potential risk to life and the related health consequences of the radionuclides. The approach gives particular attention to the following general provision in the IAEA *Code of Conduct on the Safety and Security of Radioactive Sources* which is discussed in later sections of this chapter.

> In addition to the IAEA categories, states should give appropriate attention to radioactive sources considered by them to have the potential to cause unacceptable consequences if employed for malicious purposes, and to aggregations of lower activity sources...which require management under the principles of this Code.[13]

[13] IAEA. 2004. P. 15 in Code of Conduct on the Safety and Security of Radioactive Sources. Vienna: IAEA.

Table 1-1 identifies some of the most important applications of high-risk IRSs. Table 1-2 presents the Department of Energy's listing of the most important sources that it uses for establishing priorities for its international efforts to improve the security of IRSs.

TABLE 1-1 Applications of High-Risk Radioactive Sources

Practice or Application	[Radionuclide]	[Typical Activity] (Ci)*
Radioisotope thermoelectric generators (RTGs)	Strontium-90	20,000
	Plutonium-238	280
Sterilization and food irradiation	Cobalt-60	Up to 4,000,000
	Cesium-137	Up to 3,000,000
Self-contained and blood irradiators	Cobalt-60	2,400-25,000
	Cesium-137	7,000-15,000
Single-beam teletherapy	Cobalt-60	4,000
	Cesium-137	500
Multi-beam teletherapy	Cobalt-60	7,000
Industrial radiography	Cobalt-60	60
	Iridium-192	100
Calibration	Cobalt-60	20
	Cesium-137	60
	Americium-241	10
High-and medium-dose-rate brachytherapy	Cobalt-60	10
	Cesium-137	3
	Iridium-192	6
Well logging	Cesium-137	2
	Americium-241/beryllium	20
	Californium-252	0.03
Level and conveyor gauges	Cobalt-60	5
	Cesium-137	3-5

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* The curie (Ci) was based originally on the measurement of the activity of 1 gram of radium as 3.70×10^{10} disintegrations per second, but since the half-life of radium has been re-evaluated several times since then, the value of the curie has now been pegged at exactly 3.70×10^{10} disintegrations per second. This avoids changing the value to reflect new measurements or evaluations of the half-life of radium. The activity of a radioactive source can be expressed in terms of curies, which is a convenient unit, but the approved SI unit for activity is the becquerel (Bq), defined as one disintegration per second. Thus one curie=3.7×10^{10} Bq.

TABLE 1-2 Radionuclides of Primary Concern to DOE

	Action Level (Ci)*	Assessment Level (Ci)*
Americium-241	10	1
Californium-252	10	1
Cesium-137	1000	100
Cobalt-60	1000	100
Curium-244	N/A	N/A
Iradium-192	1000	100
Plutonium-238	10	1
Plutonium-239	N/A	N/A
Radium-226	100	10
Strontium-90	1000	100

* "Assessment level" means that a prompt evaluation of the security and safety aspects of a source with activity above the indicated level should be undertaken; and, if determined to be necessary, additional physical protection of the source should be provided. "Action level"` means that an appropriate level of protection is essential.
SOURCE: Sandia National Laboratories. 2004. A Basic Guide to RTR Radioactive Materials. SAND 2004-4155P. Revision 3: 8 July 2004. Albuquerque: Sandia National Laboratories.

The committee considers DOE's selection of radionuclides of particular concern to be a reasonable basis for considering the effectiveness of international cooperation. Originally these values differed slightly from IAEA values but have since been made consistent with the IAEA values when applied in DOE's international programs to upgrade security of IRSs. DOE's Guidelines also address many aspects of assessing the adequacy of security conditions at facilities where IRSs are located. The guidelines provide a good starting point for improving protection of IRSs, but DOE should remain flexible in its approach as new information is developed.

Other organizations, such as the DOE laboratories, have prepared lists with other radionuclides identified for priority as well as most of the DOE-identified radionuclides. While DOE should consider these alternative approaches, the committee did not consider them as leading to conclusions that are different from those presented in this report.

Shortly after 9/11, DOE developed an approach to prioritize its efforts for improving security of IRSs worldwide by calculating relative risk based on combining (a) the probability that an undesired event will occur, taking into account the threat and the vulnerability of the IRS of concern, and (b) the consequences if that event occurs. To this end, the threat is an estimate of the likelihood that a terrorist organization would target an IRS wherever it is located and attempt to acquire it illicitly. The vulnerability is an estimate of the likelihood that the IRS can be illicitly acquired by a terrorist organization directly or through middlemen without the knowledge of responsible authorities. The consequences are estimates of the impacts on U.S. interests arising from a successful attack by a terrorist group using an RDD. This is a very general approach that requires considerable sophistication in estimating the various components of the algorithm. Aggregating economic, social, and psychological factors, as well as health consequences, is obviously complicated. When the cleanup problems and mobility in the environment are considered, risk estimates become very uncertain. Also, it should be kept in mind that U.S. interests in protecting IRSs abroad are related to but are not identical to the interests of the countries where they are located.

Of course, any conceptual approach must be adjusted to accommodate practical considerations within specific countries. For example, important targets of opportunity for terrorists may not be in the highest risk categories. Data on the location of IRSs, let alone their possible vulnerabilities, may be inadequate to permit comparative risk analyses. Also, different local organizations that are responsible for the security of sources, and are potential partners for international efforts, may each have their own priorities that are not based on nation-wide comparative risk assessments or indeed on comparative risk assessments among the IRSs under the purview of the individual organization.

The consequences of an RDD attack that are described in IAEA and DOE guidance documents are measured in terms of radiation health effects, including death. The psychological effects and economic damage, which may be the most serious consequences of a radiological attack, do not emerge from their categorizations. These considerations are essential in a risk-based approach to assessing IRSs as potential components of RDDs.

Specifically, certain types of low-activity IRSs present little if any direct health hazard, but they nevertheless could provoke psychological and social responses depending on the terrorism scenario. For example, plutonium-239, an alpha-emitter that is dangerous only if inhaled or ingested, is usually not listed by the IAEA among the high health-risk radionuclides. Yet, plutonium dispersal will likely alarm the public because of its association with nuclear weapons. A research effort to determine the desirability and feasibility of expanding the current approaches of DOE and IAEA to more comprehensive risk models that would significantly improve regulatory efforts would be useful but should not delay addressing problems in Russia of obvious importance.

Keeping IRSs Out of the Hands of Terrorists

Terrorists could acquire IRSs in a variety of ways such as the following: deliberate transfer of an IRS by a national government working in collusion with a terrorist group, unauthorized diversion of an IRS by a government official who controls distribution of IRSs, theft of an IRS from a facility where IRSs are located with or without insider assistance, theft of IRSs while they are in transport with or without insider assistance, fraudulent license applications intended to protect illicit operations, and terrorist efforts to track down and take possession of abandoned IRSs. Reports of the interest of organized crime in such activities are cited later in this report and are particularly disturbing.

Orphan sources are IRSs that are considered by their legal custodians as no longer needed and have simply been abandoned. They are substantial problems in many countries including Russia. DOE has unclassified reports of over 775 cases of theft or loss of IRSs, including many orphan sources, during 2000-2004, with most of the cases reflecting losses in the United States.[14] DOE is aggressively working to gain control of the orphan source problem in the United States as discussed later in this chapter, but comparable efforts have not been initiated in Russia or in many other countries of the former Soviet Union and elsewhere.

Publicly available information concerning details of thefts of radioactive material is sparse. According to reports from the IAEA and other sources, however, efforts by thieves to scavenge the metal associated with radioactive material are commonplace. Occasional reports of more nefarious activities of radioactive thieves appear in the press around the world.

According to the IAEA, over 40 percent of the reported incidents of trafficking in IRSs during the past decade "involved...criminal activity, mostly theft. About one-fifth of [reported] incidents involved" border crossings. Three-quarters of these incidents were detected at international borders and the remainder after successful trafficking across borders had occurred. Cesium-137 was the most commonly encountered radionuclide.

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[14] Informal communication from DOE to project staff, January 13, 2006.

About 11 percent of the reported incidents involved dangerous IRSs, namely IAEA categories 1, 2, and 3. The number of such incidents was rising in 2004.[15]

About one-third of all recent discoveries of illicit trafficking have been made with the help of radiation detectors, with the percentage of such detections rising significantly since 1999. In 43 percent of the incidents, the IRSs were lost or stolen from the users' premises. In about 40 percent, they were lost or stolen during transport or pilfered from parked transportation vehicles. An additional four percent were stolen from remote sites or from urban construction sites.[16]

The IAEA database is incomplete since it depends on the willingness of states to report incidents. It nevertheless provides insights as to reported trends. Of particular interest is the large upsurge of reported incidents at border crossing points—an increase by a factor of three from 2003 to 2004**.**[17]

Examining information in other unclassified databases as well as information provided by the IAEA (e.g., the database maintained by the Nuclear Threat Initiative), the following observations concerning reported incidents of stolen, lost, or improperly discarded IRSs outside the United States emerge:

- IRSs are occasionally found in scrap metal.
- Most incidents involve IRSs of low activity.
- When IRSs can be traced back to their sites of origin, most are linked to non-nuclear facilities.
- Many sources are discovered in vehicles and transport containers where they have been stored.
- Theft is a common event.

The interests of international organized crime and international terrorist organizations could coincide in a number of ways, and this commonality of interests could result in IRSs that enter the international black market ending up in the possession of terrorist organizations. Of special concern is the use of narco-trafficking routes as pathways for illicitly obtained IRSs. A particularly troubling situation is in Tajikistan where lawlessness has become rampant. Heroin, opium, and hashish are omnipresent. There are occasional reports of smuggling of radioactive material from the states of the former Soviet Union through the country. There are also concerns over drug lords in Latin America being ready to pass radioactive material along their well-honed routes into the United States for an appropriate price.[18]

Given the interest expressed by some terrorist groups in radiological terrorism, how likely is a radiological attack in the near future? Many leading experts on

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[15] Hoskins, R. 2005. Illicit trafficking involving radioactive sources. Paper presented at International Conference on the Safety and Security of Radioactive Sources: Towards a Global System for the Continuous Control of Sources Throughout their Life Cycle, IAEA-CN-134. Bordeaux, France, June 27-July1, 2005.
[16] Ibid.
[17] Ibid.
[18] See for example, Spyer, J. 2004. The Al-Qa'ida Network and Weapons of Mass Destruction. Middle East Review of International Affairs Journal 8(3):29-45. Available online at http://meria.idc.ac.il/journal/2004/issue3/spyer.pdf. Accessed November 10, 2006.

nonproliferation and terrorism consider such an attack to be quite likely as indicated in Box 1-3. Dangerous IRSs are widely distributed, susceptible to diversion or theft, and often easy to transport. Moreover, as discussed previously, assembly and delivery of such devices require only modest enhancement of technical skills, related largely to radiation safety, that are currently widespread for carrying out conventional terrorist bombings.

Box 1-3

"[R]espondents [to a poll] judged the probability of a major radiological attack over the next five years to be greater than the probability of a biological, chemical, or nuclear attack," with 68 of 83 respondents saying "there was...a 10 percent chance of [an] attack that affects a major portion of a city." When the timeline is extended to ten years, "40 of 82 respondents judged the risk of such an attack as 50 percent or greater."

SOURCE: Lugar, R. G. 2005. Pp. 22-23 in The Lugar Survey on Proliferation Threats and Responses. June 2005. Washington, D.C. Available online at http://lugar.senate.gov/reports/NPSurvey.pdf. Accessed November 10, 2006.

Given the relative ease of acquiring dangerous material from poorly secured IRSs and the relatively simple skills needed to assemble an RDD, why has there not been a detonation to date? Although the committee has no clear answers, it offers some opinions. Perhaps terrorists have more confidence in using simpler and proven conventional devices—and they have been able to achieve many goals to date using this approach. Perhaps they are concerned that use of dirty bombs would trigger more aggressive retribution aimed at them and their causes. Perhaps they share to some extent the same fears of radiation that the general public does. They may realize that a radiation hazard to them exists during the time that IRSs are in their possession. Even a terrorist willing to sacrifice his or her life in a suicide mission may be concerned about dying from the effects of radiation sickness while in transit to a target.

Whatever the reason that a successful detonation of an RDD has not occurred to date, the tragic events of 9/11 and the string of major international terrorism attacks since then underscore the need to address the RDD threat with a greater sense of urgency and commitment. It is time to provide significantly stronger backing to the IAEA in helping to secure IRSs around the world. Good safety standards for using IRSs have been widely accepted for decades.

As discussed in the Introduction, security differs from safety, although there are clear overlaps. At times, safety and security concerns may even be in conflict as exemplified by placing safety warning signs that highlight the presence of radioactive material in security-sensitive areas. Also, security measures may require researchers to modify their research approaches to accommodate new time-consuming security requirements. Safety measures are designed to avoid accidents. Security measures must be designed to prevent intentional malevolent use. For the most part, security measures applied to IRSs in use and IRSs in storage are a more recent concern. More robust physical protection and more complete accounting and life-cycle management of IRSs should now be the order of the day. A particularly worrisome security vulnerability results when IRSs are no longer needed and a clear and affordable disposition path does not exist.

Regulation of IRSs in the United States

An important starting point for a discussion of protection of IRSs worldwide is a review of protection of IRSs in the United States. Many lessons have been learned that are relevant to controlling IRSs in Russia and other countries from the U.S. experience during the past several decades. While a detailed discussion of the U.S. approach is beyond the scope of this report, several important aspects are noted with pointers to more details for interested readers.

Three major types of licenses are issued by the Nuclear Regulatory Commission (NRC), or by Agreement States which have delegated authority to issue licenses, as follows.

- A *General License* may be automatically granted when an individual or organization purchases a product containing low-level radioactive material from a supplier which has an NRC license to manufacture or distribute the product. Such products are seldom of sufficiently high activity to cause concern over their possible use in RDDs. The NRC does not inspect recipients of General Licenses, and most IRSs that are distributed with General Licenses have not been individually tracked by the NRC during the past several decades.
- A *Specific License* is issued to an organization possessing a significant amount of radioactive material, typically IRSs in IAEA categories 1, 2, 3, and 4 as discussed in a previous section. There are currently about 22,000 specific licenses in effect in the United States. Less than ten percent of these licensees have Category 1 or 2 IRSs. Inspections have historically concentrated on safety concerns, with security issues only recently coming into prominence. The NRC conducts about 2000 inspections of nuclear material licenses each year, and the agreement states about 8000. These inspections cover areas such as training of personnel who use materials, radiation protections programs, radiation patient does records, transportation, and security of radioactive materials. Due to the interim source database, since 2005, the NRC has a good estimate of the total number of Category 1 and 2 sources in use, transport, and storage in the United States.
- A *Storage Only License* is provided for organizations that seek to dispose of unwanted IRSs, but do not have a disposal path and therefore are required to maintain their licenses.[19]

The details of these and related activities are available on the web site of the NRC (www.nrc.gov).

[19] U.S. Nuclear Regulatory Commission. 2005. Information Digest. NUREG-1350, Volume 17. July 2005. Washington, D.C.: U.S. Nuclear Regulatory Commission.

Import/Export of Sources

On July 1, 2005, the NRC published new regulations that require specific licenses for the export or import of radioactive materials that could possibly be used in weapons, making the United States the first country to implement comprehensive export controls on these materials in compliance with the IAEA's *Code of Conduct on the Safety and Security of Radioactive Sources.* The regulations went into effect on December 28, 2005.

The rule's list of nuclear materials and activity levels of concern are essentially identical to those in the IAEA's Category 1 and Category 2. Before approving an export license, the NRC determines that the proposed export is not inimical to the defense and security of the United States. In making this determination, the NRC considers whether the importing country has the technical and administrative capability and the resources and regulatory structure to manage the material in a safe and secure manner, and has authorized the recipient to receive and possess the material.

Import licenses will be granted only after NRC determines the import would not be inimical to the defense and security of the United States or pose a threat to public health and safety. Importers must verify to the exporting country that they are authorized to receive the material, provide prior notification of shipments to the NRC, and verify to the NRC that each recipient is authorized to possess the material. The NRC has the discretion to grant broad specific licenses covering multiple shipments over several years or limit a license to a single shipment.[20] Again the reader is referred to the NRC web site for additional information.

Securing Orphan Sources in the United States

An important concern in the United States is the possible malevolent use of unaccounted for IRSs, a problem that began to gain increased attention well before 9/11.

As noted above, the United States has long had a relatively well-developed system of regulatory control involving the licensing, possession, and use of IRSs in comparison with systems in most countries. However, the lack of available disposal pathways for some IRSs leaves licensees limited viable options when IRSs are no longer needed. The regulatory framework is not well prepared to deal with this problem, and large numbers of excess and unwanted IRSs have accumulated in storage with no routes for permanent disposal.

By 2000, both DOE and NRC had become well aware of this problem. DOE became actively engaged in a cooperative program with the NRC and many regulators in Agreement States to aggressively recover and secure IRSs that had no disposal pathways. The recovery sites were at DOE installations where high security was assured

By 9/11, this program was well underway with a solid infrastructure in place. It only needed increased scope. As its activities expanded, the program became an active force in the nation's homeland security effort. Thus, the recovery effort was given a

[20] National Archives and Records Administration. 2005. Rules and Regulations. Federal Register 70(126):37985-37994. Available online at http://www.nrc.gov/reading-rm/doc-collections/cfr/fr/2005/20050701.pdf. Accessed on November 14, 2006.

sharper national security focus. In the two-year period following 9/11, approximately 6,000 sources were recovered. The accomplishments as of the end of 2005 are summarized in Box 1-4. In 2006, the target is to recover and secure an additional 2,000 sources. These efforts clearly lower the probability that radiological material will fall into the hands of terrorists within the United States, and this experience should be instructive in helping to address security weaknesses in Russia and other countries.

Box 1-4

Achievements within the United States of DOE's Global Threat Reduction Initiative (GTRI) and its predecessor programs since 1997 have included recovery of over 12,000 high-risk radiological sources, including four large strontium-90 sources (four RTGs containing a total of about 60,000 Ci) just prior to the Super Bowl in Houston in 2004, about 500 sources in a complex single operation, and a number of plutonium-239 and cesium-137 sources.

SOURCE: DOE presentation at the first meeting of the NRC Committee on International Efforts to Counter Radiological Terrorism, Washington, D.C., January 4-5, 2006; DOE communication via e-mail, August 16, 2006.)

Role of the International Atomic Energy Agency

The IAEA has played an important role in setting standards and providing technical guidelines for protecting IRSs. Also, through its model project the IAEA assists countries to strengthen their security systems. As previously noted, in 2003 the IAEA revised a *Code of Conduct on the Safety and Security of Radioactive Sources* for protecting IRSs. The code is not a binding international agreement. However, by July 2006, 83 countries had formally committed to implementing the provisions of the code.[21]

The basic principle of the *Code of Conduct on the Safety and Security of Radioactive Sources* is set forth in Box 1-5. The code addresses the significance and characteristics of national legislation and regulations, the importance and role of a regulatory body, and export and import obligations. Also, it presents an international standard for categorizing sources, import-export procedures, and national registries of sources. It provides no constraints on military-related activities, however.

[21] IAEA. 2006. List of states that have made a political commitment with regard to the Code of Conduct on the Safety and Security of Radioactive Sources and the Supplementary Guidance on the Import and Export of Radioactive Sources. Informational list. Available online at www.iaea.org/Publications/Documents/Treaties/codeconduct_status.pdf. Accessed November 14, 2006.

Box 1-5

"Every [s]tate should, in order to protect individuals, society, and the environment, take appropriate measures necessary to ensure: (a) that the radioactive sources within its territory, or under its jurisdiction or control, are safely managed and securely protected during their useful lives and at the end of their useful lives; and (b) the promotion of safety culture and of security culture with respect to radioactive sources."

SOURCE: IAEA. 2004. P. 5 in Code of Conduct on the Safety and Security of Radioactive Sources. Vienna: IAEA.

The IAEA also adopted two important technical documents in 2003. They are entitled *Categorization of Radioactive Sources* (TecDoc 1344)[22] and *Security of Radioactive Sources*. (TecDoc 1355).[23] The first document considers the importance of categorization of sources, the methodology underlying the categorization approach, and the categories that were developed. The second document addresses threat assessments, administrative and technical security measures, and temporary storage of IRSs. This document has been revised significantly and will be reissued as a document in the Nuclear Security Series of the IAEA's Office of Nuclear Security in late 2006.

While there is no international binding agreement concerning imports or exports of IRSs, the IAEA has developed *Guidance on the Import and Export of Radioactive Sources*[24], which addresses Category 1 and 2 IRSs. Guidance has not been prepared on other categories of IRSs. The *Guidance on the Import and Export of Radioactive Sources* calls for an exporting state to satisfy itself insofar as practicable that the recipient is authorized by the importing state to receive and possess the IRS or IRSs in accordance with its laws and regulations. Also, the exporting state should satisfy itself to the extent practicable that the importing state has the appropriate technical and administrative capability, resources, and regulatory structure needed for the management of the resources in a responsible manner.

The *Guidance on the Import and Export of Radioactive Sources* calls for importing states to consider the following factors with respect to imports:

- Whether the recipient has been engaged in clandestine or illegal procurement of sources.
- Whether an import or export authorization for sources has been denied to the recipient or importing State, or whether the recipient has diverted for purposes inconsistent with the IAEA Code any import or export of sources that was previously authorized.

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[22] IAEA. 2003. Categorization of radioactive sources, IAEA-TECDOC-1344. Vienna: IAEA.
[23] IAEA. 2003. Security of radioactive sources, IAEA-TECDOC-1355. Vienna: IAEA.
[24] IAEA. 2005. Guidance on the Import and Export of Radioactive Sources. Vienna: IAEA. Available online at http://www-pub.iaea.org/MTCD/publications/PDF/Imp-Exp_web.pdf. Accessed November 14, 2006.

- The risk of diversion or malicious acts involving sources.

The *Guidance on the Import and Export of Radioactive Sources* does not address two key issues, however. First, should an exporting state be prepared to accept returned sources that have been exported after they have exceeded their lifetimes or have become no longer wanted? Secondly, how should the re-export to a third party by the original recipient of the first export be controlled internationally? These seem to be important issues that should be addressed in the future by the IAEA.

Intimately entwined in the export of IRSs are the activities of the producers and distributors of IRSs. During the Cold War era, the U.S. and Russia were the largest distributors of long-lived radionuclides. This historical perspective is important because many IRSs produced during that time frame are now excess, unwanted, and otherwise orphaned without a disposal path. Today the largest producer of Cs-137 is the Mayak Production Association in Russia (hereinafter referred to as Mayak) as discussed in Chapter 2, according to the IAEA. In addition, five other countries have reactors operating at a level of 100 megawatts (t) or higher that produce radionuclides, namely, the United States, Canada, China, Belgium, and India.[25] Canada and Argentina are currently major producers of Co-60.[26] In addition, 35 other countries have smaller reactors capable of producing commercial radionuclides.[27] The role of the IAEA will remain central to all aspects of the lifecycle of IRSs, and that includes containing the potential for radiological terrorism.

The IAEA supports international efforts to safely use IRSs through the model project established in 1994. As of 2005, the IAEA reported the following accomplishments that reflect the assistance provided directly or through regional approaches to 80 states.

- "About 77 percent of the participating countries had promulgated laws
- About 77 percent had established a regulatory authority
- More than 42 percent had adopted regulations
- About 80 percent had an inventory system in place and [operating]
- About 50 percent had a system for the notification, authorization, and control of sources in place and [operating]"[28]

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[25] See IAEA. 1999. Nuclear Research Reactors in the World. Web database. IAEA. Available online at http://www.iaea.org/worldatom/rrdb/. Accessed November 29, 2006.
[26] Canadian Nuclear Association. 2006. P. 3 in Nuclear Energy Technology in Canada: Nuclear at a Glance. Web PDF document. Canadian Nuclear Association. Available online at http://www.cna.ca/english/Nuclear_Facts/Nuclear_Quickfacts_Jul-06_EN.pdf. See also, IAEA. No date. Argentina. Vienna: IAEA. Available online at http://www-pub.iaea.org/MTCD/publications/PDF/cnpp2003/CNPP_Webpage/PDF/2001/Documents/Documents/Argentina%202001.pdf. Accessed on November 29, 2006.
[27] For a discussion of research reactors, see IAEA. 2004. New Life for Research Reactors? Bright Future but Far Fewer Projected. Staff Report. March 8, 2004. Vienna: IAEA. Available online at http://www.iaea.org/NewsCenter/Features/ResearchReactors/reactors20040308.html. Accessed on November 14, 2006.
[28] IAEA. 2005. P. 4 in The Model Project. Vienna: IAEA. Available online at http://www-ns.iaea.org/projects/modelproject/. Accessed August 1, 2005.

An IAEA activity worth noting is the agency's catalogue of sealed sources and containment devices, which was developed and patterned after NRC's Sealed Source and Device registry. This catalogue contains nearly 5,000 models of sources and transport containers. It identifies over 1,100 manufacturers and distributors of sources and containers. In 2005 this catalog was moved to the Internet to provide an on-line capability. The system continues to expand now with the assistance of DOE, which maintains a large database of sources and devices of U.S. manufacture. Thus, it provides a valuable resource for organizations involved in the control of IRSs including regulators, Interpol, border agents, and those responsible for the identification and recovery of IRSs when found as orphans or abandoned. With transportation nationally and internationally of radioactive material reaching 10 million packages per year, the catalog may prove to be a very important tool in combating radiological terrorism.[29]

A final topic of great interest to the U.S. government is the gradual phasing-out internationally of IRSs containing highly potent radionuclides that can be easily dispersed into the environment. Cesium chloride is at the top of the list of concerns. But practical steps that would be internationally acceptable have yet to be developed.[30]

Support at the Highest Level for Greater Security

The G-8 governments pledged their support to countering radiological terrorism at the Gleneagles, Scotland, meeting of the G-8 in 2005. They reported at that time that 70 countries had committed to implement the IAEA *Code of Conduct,* and they welcomed IAEA endorsement of an international import and export framework for IRSs. Finally, they vowed to strengthen their cooperation worldwide. This political commitment at the highest level of the leading industrial countries provides strong underpinnings for efforts of all countries, individually and collectively, to upgrade security systems.

Also, the *International Convention for the Suppression of Acts of Nuclear Terrorism* was adopted by the U.N. General Assembly in April 2005 and opened for signature in September 2005. Based on a proposal by Russia in 1998, the convention provides for a definition of nuclear terrorism and covers a broad range of possible terrorist targets, including nuclear power plants and nuclear reactors. The convention requires that any seized nuclear or radiological material be held in accordance with IAEA safeguards and handled as prescribed in the IAEA's health, safety, and physical protection standards.[31] In addition, during 2005 the UN Security Council unanimously adopted Resolution 1540, which criminalizes the proliferation of weapons of mass

[29] IAEA. 2004. Information: International Catalogue of Sealed Radioactive Sources and Devices. Information from the Waste Technology Section, Division of Nuclear Fuel Cycle and Waste Technology, Department of Nuclear Energy. January 2004. Vienna: IAEA.
[30] U.S. Department of State presentation at the first meeting of the NRC Committee on International Efforts to Counter Radiological Terrorism, January 4-5, 2006
[31] Atomic Archive. No date. International Convention for the Suppression of Acts of Nuclear Terrorism (2005): Summary. Atomic Archive. Available online at http://www.atomic archive.com/Treaties/Treaty22.shtml. Accessed July 29, 2005.

destruction and calls for states to enact and enforce strict export controls and to secure sensitive materials within their borders.

Finally, in June 2002 the United States, Russia, and the IAEA signed a Tripartite Agreement at the ministerial level to cooperate in securing sources in the former Soviet Union beyond Russia. The responsibilities are as follows:

- Locate and identify high risk sources (Russia and IAEA)
- Provide physical security for sources (U.S.)
- Provide radiation detection equipment (U.S.)
- Assist in developing the regulatory infrastructure (U.S. and IAEA)
- Source recovery (Russia and IAEA)

As of August 2005, DOE had participated in installing security upgrades and new construction at over 100 sites in the former Soviet Union. This activity included construction of new, secure storage facilities for IRSs in Uzbekistan, Moldova, Tajikistan, Kyrgyzstan, and Georgia, with a facility under construction in Azerbaijan. Security upgrades have included hardened doors and windows, intrusion detection systems, and response force equipment. Additionally, the IAEA and the Russian firm Izotop have assisted several countries in dismantling irradiators that are no longer used and in transporting IRSs to secure storage.[32]

Programs to Intercept Illicit Shipments of Nuclear and Radiological Material

The U.S. government supports several international programs designed to intercept illicit shipments of nuclear and radiological materials, including IRSs, as follows:

- The Second Line of Defense program involves outfitting border crossing points that are within the territory of the former Soviet Union and in several other European and Mediterranean nations with special detection equipment so that local customs officials can detect attempts to smuggle nuclear contraband across international borders. Most of activities are carried out by DOE although the U.S. Department of Defense (DOD), the U.S. Department of Homeland Security (DHS), and the U.S. Department of State play important roles. In Russia, the program has installed equipment at 39 sites. According to DOE, Russian customs officials have reported that 200 attempts to smuggle materials were uncovered in 2004.[33]

[32] Consultation with DOE, September 2005. For more information about the Tripartite Agreement, see U.S. General Accounting Office. 2003. Pp. 26-27 in Nuclear Nonproliferation: U.S. and International Assistance Efforts to Control Sealed Radioactive Sources Need Strengthening. GAO-03-638. Washington, D.C.: U.S. General Accounting Office. See also IAEA. No date. Global Threat Reduction Initiative Fact Sheet. IAEA. Available online at http://www-pub.iaea.org/MTCD/Meetings/PDFplus/2004/cn139fact.pdf. Accessed November 4, 2006.
[33] The Office of the Second Line of Defense. 2006. SLD Implementation Strategy, Revision B. April 2006. Available online at http://www.doeal.gov/dicce/RRSLDImplementation.aspx. Accessed November 20, 2006.

- The Megaports Initiative involves outfitting foreign seaports with detection equipment with capabilities to identify nuclear and radiological material in metal shipping containers in the absence of extensive shielding. Beginning with Rotterdam and Piraeus, about 15 ports are scheduled to receive equipment by 2010. Reports are not available as to early results of this initiative in terms of detection of unauthorized shipments of nuclear or radiological material. The Department of State and DOE work together on this program.
- In related efforts, the U.S. government has been installing x-ray scanners at U.S. seaports and border crossings. This program has been underway for a number of years. In April 2005, Oakland became the first U.S. port to have all shipping containers pass through such devices. DOE, DHS, and NRC work together with local authorities on this program.
- Also, the United States proposed the Proliferation Security Initiative which has been accepted as a nonbinding agreement among several dozen countries to increase efforts to interdict weapons of mass destruction, their components, and their delivery systems in transit, and particularly on the high seas. The principal emphasis has been on nuclear weapons and fissile materials, although material for radiological weapons along with biological and chemical weapons is also a concern. Key provisions call for the participating countries to take aggressive action in boarding and inspecting ships flying their flags if smuggling is suspected. Also, the participants are to cooperate in apprehending contraband cargo if a country suspects that a ship flying the flag of another country is suspected of smuggling. The Department of State leads U.S. participation in this program with support from DOE and other departments as appropriate.[34]

A key question in all of these activities is of course the capabilities of detection equipment to identify contraband, even radioactive contraband (See Box 1-6). Many detection techniques both passive and active have been investigated in recent years, with a focus on standard metal sea/land transport containers. Research to enhance detection techniques continues to be a thrust of several DOE national laboratories and industry as well and is expected to continue for the indefinite future.[35]

Box 1-6

There is one report of 145 incidents of illegitimate transnational movement of radiological material at a single crossing point on the border of Russia and Ukraine during a period of six and one-half months in 2004.

SOURCE. Correspondence with Argonne National Laboratory, July 20, 2005.

[34] U.S. Department of State. No date. Proliferation Security Initiative. Online. U.S. Department of State. Available at http://www.state.gov/t/np/c10390.htm. Accessed on November 20, 2006.
[35] A recent review of detection technologies is presented in Kouzes, R.T. 2005. Detecting Illicit Nuclear Materials. American Scientist 93(5):422-427.

DOE's Global Radiological Reduction Threat Initiative Program

DOE's Global Threat Reduction Initiative has two radiological components—one directed to activities in the United States and one directed to international activities. However, the domestic component is also called upon to support a limited number of international activities.

As discussed earlier in this chapter, within the United States the program focuses on identifying, recovering, and placing in secure storage excess and unwanted IRSs. Also, the program recovers certain IRSs of U.S. manufacture when found excess in other countries.

Internationally, the program has the following two goals:

- Accelerate bilateral and multilateral efforts to deny terrorists access to radiological assets by securing or removing vulnerable radioactive material
- Interdict material that has already been diverted from insecure sites.

DOE uses a variety of approaches in achieving these goals. For example, international partnerships are formed around training; infrastructure development; search, secure, and recovery operations; and disposal of high-risk sources. (see Box 1-7) DOE also provides regulatory assistance to IAEA member states lacking effective cradle to grave controls and works with the IAEA in packaging and conditioning excess IRSs and in updating IAEA's Radioactive Source Catalog.[36]

Box 1-7

International activities have involved 40 countries and have included recovery, replacement, and disposition of radioisotope thermoelectric generators in Russia; construction of radiological storage sites in Uzbekistan and Moldova; and security enhancements in Yemen, Egypt, Tanzania, Philippines, Indonesia, Chile, Ecuador, and Panama.

SOURCE: DOE presentation at the first meeting of the Committee on International Efforts to Counter Radiological Terrorism, January 4-5, 2006.

As to partnering with IAEA, DOE support has been substantial, including support for technical assistance and occasionally for recovery missions in a number of countries. In FY-2005 DOE supported IAEA in recovering IRSs from Sudan. This work has also included training IAEA recovery teams from a number of African countries in methods to package, transport, and store plutonium and americium sources. In May 2005, training in

[36] Communication from DOE, January 2006.

Pu source recovery methods was supported by DOE as part of IAEA source recovery operations in Uruguay where teams from Brazil, and Argentina attended as observers.[37]

As a final example of partnering, DOE has provided Interpol with hand-held detection devices.[38]

Coordination Among U.S. Government Departments and Agencies

The General Accounting Office (now renamed the Government Accountability Office) has for several years underscored the need for DOE, along with other government departments and agencies, to take additional steps to develop government-wide plans for international program activities in addressing security of IRSs.[39] At the same time, DHS is acquiring a greater capability to develop its own counter terrorism strategy and programs; and the department is looking beyond the U.S. border in this regard, as it should. Also, during 2005-2006 a number of federal and state agencies have been collaborating to address IRS problems. Clearly, such interagency coordination is a critical aspect of preventing the detonation of an RDD in the United States. Such coordination will also contribute significantly to the effectiveness of U.S. efforts abroad.

Coordination between U.S. enforcement agencies and international counterparts is important (e.g., Interpol, Europol, World Customs Organization). Also, sharing of information widely among interested U.S. department and agencies prior to and following international coordination meetings is essential.

[37] DOE presentation at the first meeting of the Committee on International Efforts to Counter Radiological Terrorism, January 4-5, 2006.

[38] Ibid.

[39] See for example: U.S. General Accounting Office. 2002. Nuclear Nonproliferation: U.S. Efforts to Help Other Countries Combat Nuclear Smuggling Need Strengthened Coordination and Planning. GAO-02-426. Washington, D.C.: U.S. General Accounting Office.
U.S. General Accounting Office. 2003. Nuclear Nonproliferation: U.S. and International Assistance Efforts to Control Sealed Radioactive Sources Need Strengthening. GAO-03-638. Washington, D.C.: U.S. General Accounting Office.

Chapter 2

SECURITY OF IONIZING RADIATION SOURCES IN RUSSIA

This chapter addresses the threats posed by inadequately protected ionizing radiation sources (IRSs) in Russia. After reviewing the effectiveness of current procedures to protect IRSs, particular attention is directed to (a) why inadequately protected IRSs pose a threat to the United States and U.S assets abroad, and (b) why it is in the U.S. interest to cooperate with Russia to counter this threat and other aspects of radiological terrorism that could have roots in Russia.

To better appreciate the inventory of IRSs currently located in Russia, the committee entered into a contract with the Nuclear Safety Institute of the Russian Academy of Sciences (IBRAE) to prepare a report on the distribution of IRSs within the country and to analyze a number of aspects of the physical protection, control, and accounting of these IRSs. This contract extended previous efforts by IBRAE which had been working for several years with the U.S. Department of Energy (DOE) to help obtain a more accurate inventory and to assess the general status of the security of IRSs in Russia.

In addition, the committee obtained first-hand information during its consultations and site visits in Russia during 2004 and 2005.

However, hundreds of thousands of IRSs are in use, in storage, or simply lost within the vast territory of the country. Dozens of federal and local government entities are involved in controlling IRSs. Thousands of enterprises, institutes, storage sites, and disposal facilities have IRSs in their possession. Unfortunately, the committee is unaware of readily available information on many of these activities. Thus, this report presents only very general impressions on conditions and trends concerning a complicated but very important topic.

Overview of the Inventory and Security of IRSs

As noted above, Russia possesses a very large number of IRSs, dating from production during Soviet times and continuing to today with production in Russia. The number of IRSs has been reported by IBRAE to be more than 500,000, but experts from this institute and other organizations readily acknowledge that the number is probably much greater and could be as large as one million or more. Moreover, Russia has long been one of the world's largest exporters of both radionuclides and IRSs.

Of special concern are the thousands of high-activity IRSs of IAEA Categories 1, 2, and 3 that were produced during the Soviet era and distributed throughout the Soviet Union. A significant number were also exported to other states which had close ties to Moscow. Many of these IRSs are still located in other former Soviet states as well as in Russia. A particularly troublesome aspect of the Soviet nuclear legacy is the large number of inadequately protected high-activity IRSs that have been used as radioisotope thermoelectric generators (RTGs) to supply small amounts of electrical power at remote sites, primarily in Russia with a few also sent to outlying states.

As indicated in Box 1-1, there were occasional attempts to steal IRSs during Soviet times. But it is generally believed that the overall security of IRSs was adequate, and there were few reported attempts of thefts for illegal trafficking in IRSs that were in possession of Soviet institutions. As shown in Boxes 2-1 and 2-2, theft has become a more serious concern in Russia in recent years. According to press reports, the interest of Chechen insurgents and criminal elements in Russia in malevolent uses of radioactive material, and particularly IRSs, is substantial. Other press reports that are reflected in Box 2-2 raise questions about the security of RTGs. The accumulation of these press reports, although they could not be validated by authoritative sources, raises significant concerns.

The history of a particularly significant event is set forth in Box 2-3.

Box 2-1
Examples of Incidents Involving Radioactive Materials in Russia

1987: A Cs-137 source was placed in the back of an armchair seriously injuring three persons in Norilsk.

1988: Two cesium chloride sources were broken open in a Moscow apartment and contamination spread, requiring a major cleanup of a portion of a 13-story building.

1993: A Cs-137 source was placed in the back of an armchair eventually killing one person in Moscow.

1995: Cs-137 was discovered in a container in a public park in Moscow.

1999: IRSs were stolen from a Radon special combine chemical factory in Chechnya.

2002: Plans for a dirty-bomb incident using one or more stolen IRSs from a petrochemical facility in Chechnya were discovered (see Box 2-3).

SOURCE: For examples from 1987, 1988, and 1993, see: Ilyin, L. A., O. A. Kochetkov, M. P. Grinev, M. I. Grachev, I. A. Gusev, and A. A. Kriminsky. 2004. Radiological consequences of the unauthorized application of ionizing radiation sources: response and prevention. Eleventh International Congress of the International Radiation Protection Association, Madrid, Spain, May 23-28, 2004.
Example from 1995, Izmailovsky Park, Moscow, Russia. See: Jones, S. 1997. Loose Nukes. Frontline. Show Number 1504. Television program. Boston: WGBH Educational Foundation. Available online http://www.pbs.org/wgbh/pages/frontline/shows/nukes/timeline/tl11.html. Accessed on November 20, 2006.
For example from 1999, see: Krock, L. and R. Deusser. 2003. Dirty Bomb: Chronology of Events. Online. Nova: PBS. Available at http://www.pbs.org/wgbh/nova/dirtybomb/chrono.html. Accessed on November 20, 2006.
For example from 2002, see: Kuzmin, A. V. 2003. Spetsnaz. Television program. Ostankino Television Company for Channel 1.

Box 2-2
Examples of Incidents Involving RTGs in Russia

2003: Thieves stripped metal casings off RTGs at three lighthouses in the Far North.

2004: An RTG belonging to the Russian Navy was dismantled by thieves looking for nonferrous metals in the Far East.

2004: Three RTGs were found on a military base near Norilsk where they were left behind by a military unit that had departed from the base.

2004: A helicopter encountered bad weather in Arctic and jettisoned two RTGs suspended on cables, with recovery not possible for eight months.

2004: An RTG that was lost in 1997 during helicopter transport was located off the northern coast of Sakhalin Island.

SOURCE: For the first three examples, see: Alimov, R. 2005. Radioisotope Thermoelectric Generators. Bellona working paper. Online. Belona Foundation. Available at http://www.bellona.no/en/international/russia/navy/northern_fleet/incidents/37598.html. Accessed November 20, 2006.
For fourth example, see: Alimov, R. and C. Digges. 2005. Status Report: RTGs still an underestimated foe in securing loose nukes in Russia. Online. Bellona Foundation. Available at http://www.bellona.no/en/international/russia/navy/northern_fleet/incidents/37566.html. Accessed on November 20, 2006.
For final example, see: RIA Novosti—Russian News and Information Agency. October 27, 2004. Radioisotope Generator to Be Recovered from Sea of Okhotsk in Spring 2005. Online. Available at http://en.rian.ru/onlinenews/20041027/39772095.html. Accessed November 20, 2006.

BOX 2-3
THREE RELATED INCIDENTS INVOLVING IRSs IN RUSSIA

INCIDENT 1

In February 2000, several cases of unusual health symptoms were reported in Grozny, Chechnya, including skin redness, edema, and bloodshot eyes. The largest number of cases was in the Zavodsky region, which was not under federal army control at the time. An Intelligence Service team was sent to Grozny to investigate. The team's first attempt to locate the radiation source failed because fighting broke out while the team was measuring radiation in the area. Two suspected insurgents connected to the opposition fighter Khakimov were later apprehended in Grozny. They dropped a cylinder while trying to escape. (The contents and disposition of the cylinder were not reported).

Intelligence indicated that Khakimov was planning a terrorist attack for a major city in Russia. Khakimov was thought to be capable of perpetrating a radiological attack, and he was thought to be in a particular suburb of Moscow. The search for stolen IRSs began in that suburb. An IRS was discovered in an abandoned trailer that had an unusually high radiation reading. It was recovered using robots.

INCIDENT 2

In Grozny, the Intelligence Service team gained access to the Zavodsky region again. The team observed a patch of ground where the snow had melted and the vegetation had died. An IRS the size of a pencil was found, emitting radiation that in twenty minutes constituted a "deadly exposure." The source was recovered with robots and placed in a two-ton radiation-proof transportation container.

INCIDENT 3

An insurgent turned himself in at the commandant's office in Grozny. He testified that he had assisted Khakimov by organizing the theft of IRSs from an inactive chemical plant in the Zavodsky region. The plant formerly had nine sources for use in polymerization of unvulcanized rubber. The IRSs were stored on site in a special chamber where they had remained even after the plant was no longer in operation.

The path to the plant was mined, and the chamber holding the sources was sealed by a lead and steel door. Insurgents had accessed the chamber through a hatch on the fourth floor of the building. Radiation levels in and around the hatch were high, and the hatch was protected with a concrete sarcophagus.

The lead and steel door to the chamber was destroyed, and robots were sent in with cameras to investigate the IRS container, which had been opened. The first robot failed due to extreme conditions and high temperatures in the chamber. A second robot removed the first one and continued the operation. The second robot's cameras revealed that the container had been opened improperly, and seven sources had fallen beneath the container.

Discovery of the seven IRSs beneath the container accounted for all nine IRSs from the chemical plant, since two had been collected earlier in Moscow and Grozny (see Incidents 1 and 2, above). The IRSs were placed in a special container and taken by truck to Mozdok. Personnel from Radon met the truck there and loaded the container onto a train.

SOURCE: Kuzmin, A. V. 2003. Spetsnaz. Television Program. Ostankino Television Company for Channel 1.

During its visits to Russia, the committee learned from several colleagues that security of IRSs rapidly eroded during the dramatic political and economic transitions in Russia in the early 1990s. The state system was in turmoil. The institutions that had IRSs in their possession lost much of their financial base, and individuals in charge were often changed with little advance notice. Indeed, the authority vested in various components of the regulatory system was in a state of flux, and the government soon lost track of very large numbers of IRSs. Many privatized institutions stopped reporting their inventories to the government. Some soon declared bankruptcy and simply walked away from their responsibilities for controlling and accounting for IRSs. Often scavengers collected what they thought was usable metal from equipment that may have contained IRSs.

Reports of IRSs being found abandoned in public places and in dormant industrial facilities in recent years have been many fold. The historical political and economic upheaval has dramatically affected the physical protection, control, and accounting of IRSs. The need to upgrade security is clear.

Thus, it is not surprising that in Russia accurate inventories of in-use and other IRSs are particularly difficult to determine because of the institutional turmoil and general loss of control that followed the dissolution of the Soviet Union. Apparently, many records were lost or discarded during that time. Nevertheless, recent reports are helpful in estimating the current levels and IAEA categories of IRSs in the country.

IBRAE reports that IRSs are widely used in various industries in Russia today. As previously noted, the IBRAE report estimates that more than 500,000 IRSs are located in Russia. According to a report from Rostekhnadzor (the national regulatory agency in Russia), over 2,100 organizations are licensed in Russia to have IRSs. Rostekhnadzor conducted over 3,200 inspections of these facilities during 2004. During 2005, 100 additional facilities applied for licenses.[1]

The IBRAE report points out that in one of the regions it studied, namely the Urals region, over 270 facilities are licensed to use IRSs, but there are an unknown number of defunct facilities where IRSs may still be located. Also, over 1,000 radioactive waste storage and/or disposal sites reportedly contain an unknown number of old IRSs in various stages of disposal. They range from IRSs lying in piles of rubble to vitrified packets of IRSs in secure wells.

Russia has many unwanted IRSs or orphan sources. During one of the committee's site visits, a Rostekhnadzor official stated that during the winter, unwanted sources have been at times thrown into snow-covered areas where they have been eventually discovered by the authorities many months later.[2]

As another indicator of the extent of the problem of adequately protecting IRSs, during 2001-2003, 391 radiation accidents and incidents were reported through Ministry of Health channels. Four of the six types of events that were reported involved IRSs: abandoned IRSs, IRSs discovered in scrap metal, breakage of IRSs during geophysical prospecting, and thefts of IRSs.[3] While these numbers of incidents are significant, they are not dissimilar to those reported annually in the United States through the Nuclear

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[1] Communication to the committee from Rostekhnadzor, via e-mail October 2005.
[2] Communications to the committee from Rostekhnadzor, May 2005.
[3] Romanovich, I. K. 2005. Preventing Radiological Terrorism: Problems of Radiation Safety. Presentation at the U.S.-Russian Workshop on Safety and Security of Ionizing Radiation Sources by St. Petersburg Scientific Research Institute of Radiation Hygiene, Moscow, Russia, March 14-15, 2005. See Appendix D.

Regulatory Commission's Nuclear Materials Event Database. However, a meaningful comparison is difficult since the status of IRSs in use, in storage, and excess is different in the two countries.

The Legal and Regulatory Framework for Security of IRSs

During the 1980s, the Soviet Union had an evolving structure for managing IRSs. The facilities of the Ministry that was responsible for atomic energy at that time were the only producers of IRSs. Using the Russian firm Izotop as the distributor, the Ministry provided IRSs to the entire Soviet Union. In 1991, just before the Soviet Union splintered into 15 independent states, the Ministry was in the process of preparing a comprehensive data base of IRSs using a network of 16 regional information centers, but the work was never completed. Instead the Ministry suffered the organizational turmoil experienced by most government bodies during the political transition.

Matters were even worse in some of the other 14 new independent states. Many of these states inherited IRSs that were originally distributed within countries under the direction of Moscow. In some cases the technical expertise and databases required to deal with the IRSs disappeared with the exodus of Russian specialists.

Further adding to the confusion in Russia, in 1994 Gosatomnadzor (GAN), the unit of the newly created Ministry of Atomic Energy (Minatom) responsible for safety and disposal of IRSs, became a separate regulatory organization. It struggled for years to establish its independence in nuclear safety regulations and enforcement.

Other organizations such as the Ministry of Health and its predecessor and successor organizations have been responsible for the safety of personnel involved with radioactive materials. Its institutes have monitored hazardous activities at large enterprises and collected their own data bases. But that Ministry has also gone through various transformations. In recent times, the Federal Medical Biological Agency has become an important monitoring agency of hazardous activities at selected facilities while the recently reorganized Sanitary Epidemiological Service issues sanitary passports that authorize activities involving radioactive materials.

Also in Soviet times, the Ministry of Internal Affairs (MVD) and the Committee for State Security (KGB) were responsible for countering criminal activities involving radioactive materials along with their many other assignments. These and other security services have been restructured, and roles and responsibilities have been redefined. Information was not available to the committee concerning details of their past or current responsibilities and activities with regard to IRSs.

In 2003, President Putin led a restructuring of the entire government. The number of ministries was greatly reduced with redefined roles and responsibilities. For example, GAN became a Department in a new Federal Service (Rostekhnadzor). Minatom became the Federal Atomic Energy Agency (Rosatom) with responsibilities quite similar to those of Minatom.

The foregoing changes have compounded Russia's difficulties in managing IRSs. In some of the new ministries and agencies, security of IRSs may have moved downward on their priority lists as the ministries and agencies struggled to establish their roles in the new government. Fortunately, some organizations, such as those that report to the

Committee for Shipbuilding, had traditions of strict security approaches; and these traditions reportedly continue, despite organizational adjustments.

Thus, while the nuclear industry in Russia is 60 years old, it is still adjusting its regulatory and organizational approaches. Numerous laws and regulations are now in place to address almost all aspects of security of IRSs. They include requirements for physical protection, for control, and for accounting as noted below. They call for a variety of licenses and for documentation of activities. They cover transportation, export, and disposal of IRSs.

In general, Rosatom has the ultimate responsibility for control and accounting of IRSs within the country with the exception of sources under the purview of the Ministry of Defense. (The committee did not have adequate information to comment on security of IRSs within the military complex other than observations concerning RTGs which are presented later in this and succeeding chapters.) Organizations that possess IRSs have the primary responsibility for the physical protection of IRSs and for providing information to Rosatom, directly or indirectly, concerning the control and accounting of their inventories of IRSs.

The responsibilities of Rosatom are set forth in "Improving the Safety of the Management of IRSs," Order No. 68, February 24, 2005, as follows:

- Providing methodological guidance: organizing safety, licensing, and certification efforts; and authorizing organizations of other ministries and committees to operate atomic energy facilities, including management of IRSs.
- Issuing certificates on packaging and transport of IRSs.
- Organizing systems for state accounting and control of IRSs.
- Organizing warnings and handling of the consequences of emergency situations as discussed below.
- Conducting studies of the causes of accidents and helping to eliminate the consequences of accidents.[4]

However, some Russian officials readily admit that enforcement is a problem. When organizations do not comply with Rosatom requirements for providing data on their inventories, Rosatom has two options: send a reprimand to the organization or report the violation to Rostekhnadzor which has the authority to withdraw the organization's operating license. Rostekhnadzor officials pointed out to the committee that should a license be withdrawn, the agency has no means to remove or secure the IRSs that are affected. In short, Rosatom is attempting to manage the problems of inadequate security on a comprehensive basis, but it has limited enforcement authority which is distributed among a number of organizations and their affiliated branches operating at both the federal and local levels.[5]

As in the United States, a weak link in the regulatory framework is end-of-life management of IRSs. Responsibilities become unclear when IRSs are no longer needed and are abandoned.

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[4] Agoapov, A. M. 2005. Managing Radiation Sources More Safely. Presentation at the U.S.-Russian Workshop on Safety and Security of Ionizing Radiation Sources by Rosatom, Moscow, Russia, March 14-15, 2005; see Appendix D.

[5] Committee visit to Rosatom, March 16, 2005; see list of committee activities, Appendix C.

On the whole, many skilled and dedicated people with relevant expertise are working on improving legal and regulatory systems related to IRSs and implementing security programs at the facility level. However, while organizational responsibilities seem to be reasonably well defined, the committee believes that the information presented in this chapter, including reported efforts of Chechen insurgents to use IRSs for malevolent purposes, calls for greater efforts by the Russian authorities and international partners to upgrade security efforts for IRSs.

Physical Protection of Sources at Russian Facilities

The following key laws and regulations concerning physical protection of IRSs have been enacted in recent years:

- Federal Law of the Russian Federation "On the Use of Atomic Energy," No. 170-FZ, enacted November 21, 1995 and amended March 28, 2002[6]
- Rules for the Physical Security of Nuclear Materials, Nuclear Facilities, and Nuclear Material Storage Sites, Russian Government Resolution No. 264, March 7, 1997[7]
- Rules for the Physical Security of Radiation Sources, Storage Sites, and Radioactive Substances, NP-034-01[8]
- Rules for the Physical Protection of Radiation Sources and Radioactive Substances during Shipment, draft version, Federal Norms and Rules[9]

The laws and regulations address four important safety aspects of IRSs that have considerable relevance to their security, namely:

- Technical requirements of physical protection systems: security alarms, surveillance over IRSs, communications, and intrusion detection.
- Engineering requirements: construction of structures, access checkpoints for vehicles and individuals, and barricades at checkpoints.
- Security unit operations: access pass control, access to IRSs and to storage sites, and detention of persons involved in unauthorized access.
- Classification of consequences of unauthorized access: radiation effects on the population, radiation effects limited to the sanitary-protective zone, radiation effects

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[6] IBRAE. 2005. P. 7 in Opportunities for U.S.-Russian Cooperation in Combating Radiological Terrorism. Prepared for the NRC Committee on Opportunities for U.S.-Russian Cooperation in Combating Radiological Terrorism.

[7] Pervin, V. L. 2005. Regulating Activities Regarding the Physical Security of Nuclear and Radiation Hazard Facilities. Presentation at the U.S.-Russian Workshop on Safety and Security of Ionizing Radiation Sources by Rostekhnadzor, Moscow, Russia, March 14-15, 2005; see Appendix D.

[8] Ibid.

[9] Andryushin, N. F. 2005. Preventative Measures to Stop the Unauthorized Spread of Radioactive Substances and Radioactive Wastes. Presentation at the U.S.-Russian Workshop on Safety and Security of Ionizing Radiation Sources by Rostekhnadzor, Moscow, Russia, March 14-15, 2005; see Appendix D.

limited to areas where IRSs are located, radiation effects limited to buildings where IRSs are located.[10]

Although these laws and regulations have been enacted, they have not been fully implemented. Conflicting reports have been issued by key Russian organizations. For example, in 2004, a spokesman for the Federal Atomic Energy Agency, Rosatom, pronounced "that all radioactive material and waste in Russia were under full control." Whereas, at the same meeting a spokesman for the regulatory service, Rostekhnadzor, stated that "a state system of accounting for radioactive materials and radioactive waste has not factually been created in any full sense."[11]

Similarly with regard to protection of powerful RTGs with Sr-90 activity levels ranging from 40,000 to 150,000 curies each, there are conflicting views as to their future. In 2003, officials of the Russian National Technical Physics and Automation Research Institute stated that "[RTGs] pose a serious security and safety threat and should all be taken out of service. [The design lives are] 10 to 15 years, and...no repair or maintenance has been done on any of these units since 1991." On the other hand, officials from Rosatom were described in the same report as stating "that the generators [RTGs] are technically sound and should not be completely removed from service without adequate replacement power."[12]

A report by the committee's principal collaborator in Russia, IBRAE, summarized the situation in several regions of the country as follows:

> Within the majority of the surveyed facilities, the conditions of management of IRSs meet the requirements for physical protection. However, some organizations have problems with security provisions for management of IRSs of elevated activity. Most of these facilities belong either to public health institutions or to organizations that possess IRSs that are not being used.[13]

The following on-scene observations by the committee and by IBRAE during 2004-2005 highlight security problems within a few facilities in Russia.

- Facility #1: Four Cs-137 sources of about 5,000 curies each are used and maintained in an unprotected room of a poorly guarded building that is adjacent to a forested area. There are no fences around the building which is easily accessible by an open highway. The principal problem for thieves would be their personal protection as they extracted the sources from the floor-level wells where they are stored when not in use.

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[10] Committee visit to Rostekhnadzor, Moscow, Russia, March 16, 2005; see list of committee activities, Appendix C.
[11] Alimov, R. 2004. Nuclear Officials Talk About What Isn't There. Online. Belona Foundation. Available at http://www.bellona.no/en/international/Russia/nuke_industry/34713.html. Accessed November 20, 2006.
[12] U.S. General Accounting Office. 2003. P. 14 in Nuclear Nonproliferation: U.S. and International Assistance Efforts to Control Sealed Radioactive Sources Need Strengthening. GAO-03-638. Washington, D.C.: U.S. General Accounting Office.
[13] IBRAE. 2005. P. 17 in Opportunities for U.S.-Russian Cooperation in Combating Radiological Terrorism. Prepared for the NRC Committee on Opportunities for U.S.-Russian Cooperation in Combating Radiological Terrorism.

- Facility #2: A flimsy door with a lock susceptible to manipulation with a skeleton key opens into a room with two irradiators that use Cs-137 and Co-60 sources, with activity levels in the hundreds of curies. A nearby building houses irradiators that use Co-60 sources which originally had activities of thousands of curies but have decayed to hundreds of curies, also behind a poorly secured door. The Gammator-type irradiator could be wheeled out by two men with a handcart. The source storage area in the basement also has primitive locks. Although the entire facility has perimeter security, a number of plausible scenarios of insider theft could be developed, such as placing stolen IRSs on exiting vehicles that enter and exit the facility with minimal checks. This particular facility had many IRSs of different kinds – about 6,000 in total. They have more than 1,000 sealed IRSs, most small but, as described above, many large ones. According to the staff, 70 percent of the IRSs are spent or past their working service life. But changes in regulatory requirements for transportation and disposal had increased the cost of disposal by a factor of five during the previous two years, thereby inhibiting plans to dispose of any IRSs. The cost of disposing of one of the largest excess IRSs at a Radon facility was estimated at U.S. $90,000.
- Facility #3: A dormant facility retains 36 sources of Co-60 with total activity of 20,000 curies. The storage room is on the ground floor of a building with a direct entrance into the courtyard. Under the window of the room is a bin for receiving waste paper and glass for recycling. The wooden door is covered by sheet metal. The room is equipped with outdated fire and security alarm systems with externally exposed cables connected to a guard post. There is poor security in the courtyard particularly at night. Determined thieves would be able to penetrate the facility without great difficulty.
- Facility #4: Another facility has two dormant installations: one containing 27 sources of Co-60 totaling 20,000 curies and the other having 15 sources of Cs-137 totaling 200 curies. The installations are located on the first floor of a building in the center of the facility. There are no restrictions on entering this portion of the building. The room is subjected to flooding by surface and subsoil water that has adversely affected the strength of the door and walls. Within 300 meters are a subway station, apartments, entertainment center, school, and other facilities. Should criminals extract sources from the installations, there would be little problem in removing them from the facility.
- Facility #5: Forty-two sources with a total activity of 30,000 curies are located in a decaying factory building. These sources have not been used for a number of years. The room housing the sources is connected to the alarm system of the facility but does not connect to the municipal alarm system, directly or indirectly. The guard force is not professionally trained. The facility has no fence, and there have been cases of intruders who have stolen computers, including intruders in vehicles traveling over a nearby frozen lake. Complicating protection of the facility is the presence on-site of several commercial firms that have no relationship to the activities of the facility. Meanwhile the facility is on the verge of bankruptcy.

The committee does not know how prevalent such conditions are across all Russian facilities. Indeed, IBRAE has noted that most of the dozens of facilities it has visited have adequate security. But these five examples raise serious concerns.

Each of the five sites has the classical problem of excess and unwanted IRSs with no disposal pathways. Clearly, physical security at sites such as these needs upgrading. But unwanted IRSs have no value, and the issue is whether to secure them or dispose of them? Which course would contribute most to threat reduction at such sites?

The IAEA's *Code of Conduct on the Safety and Security of Radioactive Sources* calls for security measures to deter, detect, delay, and respond. In considering security enhancements in Russia the following specific steps might be considered, based on information available to the committee concerning conditions at the facility level.

- Improved personnel and vehicle access checkpoints equipped with appropriate detection devices.
- Upgraded perimeter surveillance systems and security alarms.
- Routine surveillance at IRS storage locations.
- Improved communication and alarm capabilities within facilities, with connections to external response forces.
- Power back-up supplies and associated lighting systems.
- Special secure containers for storage and shipment of IRSs

However, in some locations partial security upgrades which are affordable might have limited value, and from the security viewpoint it might be better to expend the resources to remove the IRSs and send them to final disposition. Nevertheless, security of these IRSs remains important in the interim. Unfortunately, some facilities do not see either option as financially possible.

A number of Russian commercial companies and government organizations are certified for transporting IRSs to appropriate disposition destinations. According to Russian specialists, the following aspects of transportation need attention, particularly when transportation of highly dangerous IRSs is involved:

- Communications between vehicles and dispatchers.
- Well-developed alarm and response procedures for use during shipments.
- Specially equipped vehicles and escort cars.

Apparently, Russian officials have concerns over the general security environment along a number of Russian roads and railways. In the United States, even the highest activity IRSs are transported in routine commerce without special security features. While the committee did not have the opportunity to evaluate transportation security in Russia nor receive data that indicated security problems, transportation security may well be a much more serious problem in Russia.

Control and Accounting of IRSs

The principal legal and regulatory documents for control and accounting of IRSs include:

- Federal Law of the Russian Federation "On the Use of Atomic Energy," No. 170-FZ, enacted November 21, 1995 and amended March 28, 2002
- "On Approval of the Rules of Organization of the State System for Control and Accounting of Radioactive Substances and Radioactive Waste," Ordinance by the Government of the Russian Federation No. 1298, October 11, 1997
- Provisions on the State Control and Accounting of Radioactive Substances and Radioactive Waste in the Russian Federation," registered with the Russian Federation Ministry of Justice, Reg. No. 1976 of November 11, 1999[14]

Many more regulations have been issued both by oversight bodies at the Federal level and by organizations that have subordinate institutes or enterprises that handle IRSs. The components of the system are as follows:

- Rosatom, supported by its central Information and Analytical Center (IAC) located at the Research Institute of Chemical Technology, is responsible for control and accounting at the highest level with the exception of control over some IRSs under the purview of the Ministry of Defense as previously noted.
- Ministries, agencies, and other federal-level organizations, with the support of their own IACs, are responsible for control and accounting of IRSs within their subordinate institutions.
- Regional authorities, supported by their own IACs, are responsible for control and accounting of IRSs within organizations that are not subordinate to federal bodies, including private enterprises and joint stock companies.
- Organizations that possess IRSs are directly responsible for control and accounting of these IRSs.
- Regulatory and enforcement organizations have specified responsibilities for supervising activities at all levels.[15]

However, this system of laws and regulations is far from being fully implemented. For example, according to Rostekhnadzor officials in November 2004, "IACs of the regional authorities have been created and are operating in 39 regions. They have been created but are not operating in four. They have not been created in 42." In addition, the officials noted, "Of the 32 government departments and agencies with organizations under their auspices that use IRSs and radioactive substances, only five have created and are operating IACs. Four other departments and agencies are working to create IACs."

Two organizations are particularly important in addressing control and accounting procedures. Rostekhnadzor issues licenses for all institutions that possess IRSs, requires annual reports on the inventories of IRSs, and conducts periodic inspections with the frequency dependent on the potency of the sources (e.g., every six months, every year, or every two years). The Sanitary Epidemiological Service issues sanitary passports for all facilities having IRSs. It also carries out periodic inspections. But as previously mentioned, some military facilities are exempt from such requirements.

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[14] IBRAE. 2005. P. 7 in Opportunities for U.S.-Russian Cooperation in Combating Radiological Terrorism. Prepared for the NRC Committee on Opportunities for U.S.-Russian Cooperation in Combating Radiological Terrorism.
[15] Ibid.

As noted above, a central component of the control and accounting procedures is the network of IACs. The following difficulties confronting IACs, particularly regional IACs, have been noted in various reports available to the committee, with almost all of the problems linked to insufficient funds:

- Inadequate means of communication
- Obsolete computers and computer software
- Poor physical protection of the premises
- Staff deficiencies and inadequate training opportunities
- Lack of standardized documents that govern the activities of the IACs and their interactions with other organizations including recommended approaches for determining possible threats of unauthorized use of IRSs[16]

Although the Russian government has begun to put some of the key building blocks in place, the system of accounting and control should be strengthened. This step is especially important since accountability for many IRSs was disrupted during the transition from Soviet to Russian control. Also of critical importance are effective procedures for addressing security of the tens of thousands of IRSs in the range of 1 to 100 curies that are in circulation.[17] This is an enormous challenge for Russian organizations. DOE might play a constructive role in undertaking programs at several model facilities. In addition, according to Russian specialists, greater attention should be given by Russian organizations to open-type sources such as solutions and powders. Thus, although steps are underway to improve the accountability of IRSs, many more steps are needed to have adequate life-cycle management.

Finally, an aggressive program of disposing of unneeded IRSs could reduce the number of organizations and the locations within organizations that require protection. If no clear and affordable disposition path is available, then some facilities may resort to other means to hide or just abandon sources because they cannot afford to secure them properly or ship them to a disposal facility. Fortunately, the U.S. government has the financial resources and policies to rectify the situation of unwanted IRSs accumulating throughout the United States through a recovery program. But in Russia, the need of a comparable program may be even greater, but resources are in very short supply.

Responding to an RDD Attack

IBRAE and other organizations have examined a variety of possible radiological attack scenarios in Russia, and particularly in Moscow. These include: (a) placing a Co-60 source under a seat in the metro where it remains for an extended period of time; (b) detonating a Cs-137-based RDD in a metro station; (c) contaminating the drinking water supply with powder or pellets obtained from an IRS; (d) spreading liquid contaminated with Cs-137 or another radionuclide on roadways heavily trafficked by vehicles that could pick up the radionuclides and spread them throughout a city, and (e) detonating in

[16] Ibid.
[17] Ibid.

the atmosphere a Cs-137 or Am-241-based RDD at an outdoor concert or other crowded venue in an important urban area.[18]

As discussed in Chapter 1, the direct human health impacts of such scenarios will depend on the characteristics of the RDD or other type of radiation source and the details of the detonation or dispersal scenarios. IBRAE concludes that in some instances the health effects could be significantly compounded by disruption caused by possible panic and restriction of access to contaminated areas by first responders. Potentially devastating economic consequences, including costs for reclamation of land and buildings, could follow.

The Russian government is taking a number of steps to prepare for such emergencies, ranging from development of sophisticated technical analyses of the possible spread of radioactive clouds to assessments of potential consequences of an RDD detonation. Many relevant capabilities were developed at IBRAE following the Chernobyl accident. The increase of worldwide concern over the safety of similar reactors in Russia has been a further stimulus.

Over the years, Russian authorities have responded to many terrorist attacks, particularly in Moscow. Also, there have been incidents at nuclear power stations and other nuclear facilities that have required urgent responses. Of course, the massive response to the Chernobyl event involved many teams of first responders and nuclear specialists—often led by specialists from institutions located in Russia—on site for many months, and even years.

Rosatom has developed a comprehensive approach to provide emergency rescue and related services. A crisis center operates continually within Rosatom both to coordinate information and to manage day-to-day activities. Special emergency services have been identified throughout the country, with essentially all of Rosatom's resources on call should a need arise. Special anti-terrorist forces have been organized for deployment from both the closed nuclear cities and other cities. Special transportation units are available, and even a special militarized mountain rescue brigade is on call.[19]

Rosatom is but one of a number of ministries and agencies that is prepared to respond to an RDD attack. The emergency response ministry (Emercom), the health authorities, the police, the security services, and many other federal and local organizations would play important roles. The immediate responsibilities and indeed the longer-term structure of the response would depend to a considerable degree on where the incident occurred and the seriousness of the ensuing contamination. Whereas Moscow appears to have impressive capabilities and experience for responding to an RDD attack, the remainder of the nation's cities are less well prepared. In many cities, the financial difficulties in the 1990s severely weakened staffs and equipment capabilities to respond to any type of crisis. But in Moscow, the committee observed a level of sophistication regarding emergency operations and response capability that should be of considerable interest to the U.S. Department of Homeland Security.

The public's response is critical when considering the disruption and damage that would be caused by a radiological attack. Psychological issues have received

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[18] Ibid. Pp. 23-38.
[19] Agapov, A. M. 2005. Managing Radiation Sources More Safely. Presentation at the U.S.-Russian Workshop on Safety and Security of Ionizing Radiation Sources by Rosatom, March 14-15, 2005; see Appendix D.

considerable attention in Russia, particularly through studies and practical experience in counseling victims of terrorist attacks by institutes of the Russian Academy of Sciences and other organizations. But the Russian public's reaction to an RDD attack remains difficult to predict, of course. Would it be any different than a response in the United States, for example?

It seems likely that the public would quickly comply with governmental decisions on evacuating areas as was the case at Chernobyl. But at Chernobyl, the evacuated areas were small towns and villages with limited populations and economic activity, a far different case than evacuation of metropolitan areas where populations are larger and where many people and organizations have invested heavily, investments they might well be determined to protect.

With the passage of time following an incident, mistrust of governmental assessments and decisions will most likely arise among some elements of the population. The Russian government has not been strong on risk communication in the past—a situation that is not unique to Russia. While government services for evacuees are likely to be substantial in scope, as has been the case with previous accidents and attacks, the quality and sustainability of such services may not be high. The committee noted one apprehension among some Russian colleagues regarding the effects of a radiological attack that is not voiced in the west, namely the potential for political instability that an effective RDD event might cause as various elements of the population loose confidence in the government's ability to protect its citizens.

Exports of IRSs from Russia

Russia is the world's largest exporter of long-lived radionuclides that can be used in IRSs and of IRSs themselves. The exact number of IRSs that are exported from Russia is not publicly available information. The committee was informed that the Mayak Production Association (usually referred to as Mayak) produces over 20,000 IRSs annually using Ir-192, Cs-137, and Co- 60. Other radionuclides produced include Sr-90, Am-241, Am/Be, Pu/Be, Po-210, Np-237, and Pm-147. Mayak delivers the new IRSs; and it is prepared to receive spent IRSs through specialized companies, particularly the company Izotop in St. Petersburg. However, this policy does not extend to full return policies of IRSs after they leave the country. In recent years, Amersham and its successor companies (now QSA Global) have played key roles marketing IRSs produced at Mayak in the west. The Russian company Techsnabexport handles exports for Mayak. It has handled large orders such as the 2003 purchase of 40 kilograms of Pu-238 by the U.S. government. A similar purchase in the 1990s was for material to be incorporated into RTGs to provide electrical power for deep space exploration missions. Mayak's role is discussed in additional detail later in the chapter.

During the past decade, exports have increased significantly. It has been estimated that about 90 percent of all new IRSs produced in Russia are exported. Russia is the only producer of Cs-137 for worldwide distribution and produces roughly one-half of the world's Co-60. The second largest producer of IRSs after Mayak is the Scientific Research Institute for Atomic Reactors at Dmitrovgrad. The institute specializes in high-activity IRSs; and it uses an internal department for distribution, nationally and internationally. Other producers of IRSs for both international and domestic markets include the Institute of Physics and Power Engineering in Obninsk and the Radium Institute in St. Petersburg.[20]

Russian facilities must obtain licenses from the Ministry for Economic Development to export IRSs. Rosatom plays a very important role because most IRSs are produced in facilities under its jurisdiction. For IRSs produced outside its complex, Rosatom may serve as an adviser to the Ministry for Economic Development. In addition, the Ministry of Foreign Affairs has the opportunity to comment on the appropriateness of exports. When internal ground transportation of the IRSs to the border on the route to export is required, then Rostekhnadzor and the Ministry for Health and Social Services issue licenses and sanitary passports to the transporters, and the Ministry of Internal Affairs also issues certificates of approval of transport. At border check points, the Customs Committee reviews all documents, confirms appropriateness of shipping containers, and as necessary confirms the nature of the IRSs using appropriate detection equipment.

Russian government authorities review the export license requests. Russian manufacturers/distributors rely principally on past records of responsible stewardship of customers of IRSs. The individual contracts stipulate appropriate handling of the IRSs. However, a systematic method by which the Russian government confirms that the recipients are authorized by their own governments to own and use IRSs does not seem to be in place.

Exported radioactive material may be returned to Russia if it is to be recycled but not if it is classified as “waste.” Of course for all IRSs that are to be returned to Russia, the problem of financial responsibility for shipment, processing, and storage together with associated security measures arises. Historically Russia only accepts such material when the sender pays all costs within Russia, which may discourage owners to return IRSs that are no longer needed or have exceeded their service life. Consequently, the system of exports of IRSs from Russia requires special attention as to the security of the IRSs after they leave Russia.[21]

The efficiency with which Mayak produces and distributes its products to the satisfaction of western companies is impressive. Since these exports generate considerable income, they receive high priority. The contrast with the inadequate attention to the poor security conditions that exist at many sites where excess and unwanted IRSs are located is striking indeed. The committee has no information on the control and protection of IRSs within the Mayak complex. The IAEA has issued guidelines concerning operation of production reactors, which set a limited international standard in this field.

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[20] Information presented at U.S.-Russian Workshop on Safety and Security of Ionizing Radiation Sources, Moscow, Russia, March 14-15, 2005.

[21] Maksimenko, A. D. 2005. Production of Ionizing Radiation Sources at the Mayak Production Association and Efforts to Ensure Their Safe Use and Disposal. Presentation at U.S.-Russian Workshop on Safety and Security of Ionizing Radiation Sources by Mayak , Moscow, Russia, March 14-15, 2005. Another source that is helpful but not entirely up to date is Cochran, J. R., S. W. Longley, L. L. Price, and K. J. Lipinski. 2003. Pp. 34-56 in The Adequacy of Current Import and Export Controls on Sealed Radioactive Sources. SAND Report. SAND2003-3767. Albuquerque: Sandia National Laboratories.

Russia's Capabilities in Radiation Monitoring

For several decades Russian organizations have been developing and deploying devices to detect and measure radiation. Such devices can be used to detect IRSs and other material that might be used in RDDs. Moreover, various organizations have developed capabilities to monitor contamination levels in people, the atmosphere, structures, soil, and elsewhere should an RDD attack ensue. The Aspect suite of portal monitor detectors which are being installed in Russia as part of DOE's Second Line of Defense program is a good example of high-resolution detection equipment that Russian specialists are continuing to improve.[22] DOE experts informed the committee that at a demonstration and evaluation of Russian detection instrumentation and related equipment held at Los Alamos National Laboratory in October 2005, U.S. experts were extremely impressed with the state-of-the-art of the Russian equipment.

The committee was pleased to learn of Russian advances in this field. Not only do they highlight the technical expertise available in Russia and demonstrate development of new solutions when combating a potential nuclear or radiological threat, but they also provide a valuable demonstration of the importance of collaboration that can contribute to addressing the problem of illicit trafficking worldwide.

Russian Organizations of Special Interest

While more than 30 federal ministries, agencies, and committees have subordinate enterprises, institutions, and other organizations involved in IRS activities, several organizations are of special interest for this report.

Mayak Production Association

- Mayak began producing IRSs based on Cs-137 in 1957 and in 1962 built its first radionuclide production plant. It is the largest producer of radioisotopes in Russia using as raw materials radionuclides from spent nuclear fuel and isotopes obtained from target substances irradiated in nuclear reactors at Mayak. It produces more than 700 types of IRSs based on more than 60 radionculides. Its products are used in nondestructive testing, sterilization, radiation therapy, and measuring devices. Mayak also produces packaging and shipping materials and containers. About 90 percent of its products are exported. Box 2-4 identifies the current products of Mayak.

[22] Aspect products are described on the Aspect Scientific Production website at: http://www.aspect.dubna.ru/english/page.php?page=18. Accessed on February 15, 2006.

Box 2-4
Mayak Production Association Products

- Alpha sources for use in fire and smoke detectors, static eliminators, gas chromatographs, and gas analyzers
- Beta sources for use in anti-icing systems of helicopters and other aircraft, thickness and density gauges, and radiation facilities
- Gamma and x-ray sources for use in industrial and medical irradiation, flow detectors, measurement devices, and aerospace systems
- Neutron sources for use in moisture gauges, oil well logging, and rock proximate analysis
- Sr-90 and Pu-238 heat sources for use in RTGs in the oceans and space and at remote land locations
- C-14, Cs-137, Sr-90, Am-241, Pu-238, Np-237, and Pm-147 for use in medical, biological, and agricultural research

SOURCE: Information available online at http://www.jccem.fsu.edu/Partners/MAYAK.cfm. Accessed November 21, 2006.

Highly active IRSs that have exceeded their lifetimes or are unwanted for other reasons are processed and disposed at Mayak, while low-level IRSs may be buried at Radon sites. IRSs that are exported may not be returned to Russia for disposal, but they may be returned for recycling as previously noted.

Izotop

This state enterprise was established in St. Petersburg in the 1960s to provide radioactivity-related services to the medical institutions of northwest Russia. It has since broadened its customer base to include services for scientific organizations, agricultural organizations, and industrial firms. The enterprise provides radionuclides, radiation monitoring and control equipment, and education and training services. Izotop plays a central role in the import and export of radionuclides. It assists in preparation of documentation, in temporary storage of IRSs in transit, in customs formalities, and in arrangements for transportation. It also certifies the nature of the equipment and radioactive products.

Izotop has a particularly important accounting role for the IRSs currently located in Russia. Since it was the primary distributor of IRSs in the Soviet era and since that time has continued to distribute IRSs within Russia as well as abroad, it should have extensive records of the recipients of IRSs. However, as pointed out previously, a reasonably complete inventory of Russian sources is still a long way off. Finally, Izotop is a provider of medical preparations. They include disinfectants, serums, and vaccines as well as IRSs needed for medical treatments.[23]

[23] St. Petersburg Federal State Unitary Enterprise Izotop. No date. Brochure. Obtained from Izotop representative, July 2005.

VNIITFA

The Federal Research Institute for Physics and Automation (VNIITFA) has responsibility for decommissioning large Sr-90 RTGs. The activity of the Sr-90 contained in RTGs at the beginning of their lifetimes has ranged from 46,000 to 470,000 curies for each RTG unit. An example of an RTG retrieval that cost $200,000 is as follows:

- VNIITFA experts visited 10 RTGs on the coasts of the Barents and White Seas by boat and examined their conditions. They determined that no extra shielding was needed.
- Rosatom authorized transport of RTGs across Russia.
- RTGs were delivered by helicopter and boat to a special pad on the shore of Kola Bay.
- RTGs were taken by a special train to VNIITFA for holding in a special high-activity warehouse.
- IRSs were extracted in a hot chamber.
- A special rail car took the IRSs in special containers to Mayak.
- IRSs were taken to the plant where high-activity material is encapsulated and prepared for long-term storage.[24]

The committee visited VNIITFA and briefly reviewed recovery procedures. Clearly, the recovery of RTGs in Russia is complex and expensive given the remoteness of the sites where they are located and the high cost of logistical operations. However, the committee noted that the complex procedures in preparing RTGs for disposal differs significantly from the approach being tested in the United States whereby U.S.-manufactured RTGs are transported in robust containers. Investigations in the United States have shown that due to the combination of the robust packaging, the 29-year half-life, and the nature of the $SrTiO_3$ fuel, the RTGs provide their own high-integrity waste-form packaging that qualifies for shallow-land burial for low-level-waste. As of the end of 2005, three units have been disposed in this manner with an additional 30 scheduled in 2006. There may be a good opportunity for U.S.-Russian collaboration in finding the best disposal pathways for RTGs after primary recoveries have been achieved.

Radon

Radon has 16 complexes in Russia, each located 40-60 kilometers from a major city. The facility in Sergey Posad is controlled by the Moscow city government. The others are controlled by the Federal Construction Committee “Gostroy.”[25] All material is transported in special trucks. Service zones range from 500 to 3,000 kilometers. Usually,

[24] Murmansk Regional Government, Office of the Finnmark County Government. 2003. RITEG Dismantling in the Kola Peninsula. (Additional publication data not available.)
[25] The other facilities are located near St. Petersburg, Chelyabinsk, Yekaterinburg, Grozny (presumably no longer operating), Irkutsk, Kazan, Khabarovsk, Murmansk, Nizhny Novgorod, Novosibirsk, Rostov, Samara, Saratov, Ufa, and Volgograd. See: Bradley, D. J. and D. R. Payson. 1997. P. 119 in Behind the Nuclear Curtain: Radioactive Waste Management in the Former Soviet Union. Columbus: Battelle Press.

there are wired-based communications within and among facilities. Sometimes shortwave communications are used.

The Radon sites manage many types of radioactive wastes as follows:

- IRSs from 0.1 to 100,000 curies are placed in bunkers of various designs capable of housing 5 to 10,000 units per bunker.
- Unwanted instruments and large pieces of waste material are placed in concrete canyons.
- Contaminated soil is placed in dumps and canyons.
- Contaminated solid wastes are placed in casks or containers.
- Contaminated liquid wastes are placed in cisterns.

For security at the sites, Radon relies on passive perimeter systems, access systems, video observation systems, and movement control systems. Transportation security is particularly important to Radon facilities. Thus, they rely on special vehicles with communication systems among the vehicles in convoys and with disbursed dispatching points using GPS systems for accurate locations. The dispatchers are in turn connected to Rosatom's coordination center. Radon has also begun to explore measures to prevent returned IRSs from being used in RDDs. For example, application of plasma technology to convert dangerous sources into forms that will ensure safe storage is being explored. Also, vitrification is being used to make the disposed IRS materials mechanically durable and chemically stable.[26] Additional comments about the activities of Radon are included in Chapter 3.

Weaknesses in Russian Security Systems

In summary, the security of Russian IRSs has a number of weak links, often associated with lack of adequate financial resources. Russia was fortunate to progress through the most difficult transition years in the 1990s without a major radiological incident despite serious vulnerabilities. During the past few years, many significant security enhancements have been made – some through the DOE cooperative program. But more work is needed before Russia achieves an internationally acceptable level of security for its inventory of IRSs.

In addition to shoring up the security during all phases of the service life of IRSs, a comprehensive life-cycle management approach is essential, with adequate human resources. At the same time Russia is currently demonstrating that it can safely and securely manufacture and distribute IRSs world-wide on a competitive basis. In this revenue-generating area, the necessary infrastructure seems to be quite adequate. Russia also has a wealth of nuclear science and technology expertise, sufficient to develop, manufacture, and deploy state-of-the-art radioactive material detection equipment for protection of its own borders. This equipment is also competitive in the world

[26] Radon. Moscow State Unitary Enterprise—United Ecological and Technological and Scientific Research Center for Radwaste Decontamination and Environmental Protection. No date. Brochure provided to committee at Radon, March 2005.

marketplace and can be offered to other nations for the protection of radioactive materials.

As repeatedly stressed in this chapter, the excess, unwanted, and orphaned IRS inventory has not been adequately addressed. The Radon complex provides the basic infrastructure to accomplish secure storage for these IRSs, and Izotop can play a key role in identifying and recovering IRSs based on its historical data about original distribution. Such an effort can greatly reduce security problems. However, sufficient priority has apparently not been accorded to such an effort, and the available resources for rapid progress seem inadequate.

Interests of the United States in Protecting IRSs in Russia

The committee recognizes that there are competing priorities for U.S. resources to support nuclear security cooperation with Russia. However, we conclude that cooperation with Russia to counter the threat of radiological terrorism is in the interest of the United States, not only because incidents involving radioactive material could kill and/or injure people, but also for the following reasons:

- If IRSs are stolen or diverted in any country, they might enter the international black market with the possibility of falling into the hands of terrorist groups that could target U.S. assets in the United States or abroad. As indicated in Chapter 1 and in this chapter, a significant portion of the IRSs that have been intercepted at border crossing points and elsewhere have been of Russian origin. The likelihood of stolen Russian IRSs being smuggled into the United States seems relatively low since a terrorist group would probably try to obtain an IRS that is already located in the United States rather than risk detection at a point of entry into the country. However, the use of Russian-origin IRSs against U.S. assets in Russia itself (e.g., U.S. Embassy, facilities of U.S. companies), Central Asia (e.g., U.S. military bases), the Middle East (e.g., U.S. military or private facilities), or elsewhere could have a dramatic impact on U.S. national security interests.
- A successful RDD detonation in Russia, or indeed in any country, could provide a "proof of principle" for terrorists who to date have not yet used radiological weapons, thereby encouraging copy-cat attacks by terrorists in the United States or against U.S. interests overseas.
- A major radiological attack in any major capital or financial hub would likely adversely affect the global economy, including the U.S. economy.
- Detonation of an RDD in Russia, or in any country, could have global repercussions as to the safety of nuclear technologies. Just as the Chernobyl accident had a dampening effect on development of nuclear power in many countries, the detonation of an RDD would heighten nuclear anxieties of both public- and private-sector leaders world-wide and jeopardize the continued beneficial use of nuclear technologies.
- An RDD attack in Russia or elsewhere could undermine the credibility of the International Atomic Energy Agency (IAEA) as an effective international organization, just at a time when the United States is firmly committed to strengthening this organization to deal with nuclear security and nonproliferation issues worldwide. Since the IAEA has been in the forefront in setting standards, developing guidelines, and

analyzing threats and consequences concerning radiological terrorism, a detonation would certainly raise skepticism over the effectiveness of the organization in dealing with critical security issues.

- A radiological incident in Russia could cause the Russian government to reassess its policy of aggressively exporting Russian IRSs to dozens of U.S. public and private sector organizations that depend on such sources for medical, agricultural, or industrial applications.
- Presidents Putin and Bush committed at Bratislava in 2005 and during previous summits to cooperation in preventing fissile and radioactive material falling into the hands of terrorists. A serious radiological incident would undermine the significance of such political commitments that encompass many areas of great importance to the United States.
- The Russian government has significant experience in dealing with major nuclear accidents, such as those at Chernobyl, Mayak, and Tomsk. Significant lessons relevant to dealing with radiological incidents in the United States could be learned from their experience.
- The Russian technical community has developed impressive technologies and methodologies for detecting illicit trafficking of radioactive materials, and joint studies and field exercises could benefit both countries.
- An RDD incident in Russia could discourage the growing U.S. commercial interest in investments and operations in Russia as well as the interest of European countries. Reduction of such interest would be particularly significant in the oil and gas sectors.
- An RDD incident in Russia would erode Russia's ability to effectively participate in global efforts to combat terrorism on many fronts.

Thus, it is clear that the United States has a direct and substantial interest in the security of IRSs in Russia. While thefts of IRSs close to U.S. government and U.S. private sector facilities would be of great concern (for example, Moscow, St. Petersburg, Yekaterinburg), thefts at more distant locations where large amounts of dangerous radionuclides are located should also be of concern. In short, it is difficult to prioritize security upgrades on the basis solely of location or inventory of the facility. The entire nationwide security situation needs attention.

Chapter 3

U.S.-RUSSIAN COOPERATION TO IMPROVE SECURITY OF IONIZING RADIATION SOURCES IN RUSSIA

The Nunn-Lugar Cooperative Threat Reduction legislation enacted in 1991 opened the door for nuclear security cooperation between the United States and Russia during a difficult and dangerous period in Russia. By the time that program implementation began, the Soviet Union had disintegrated into 15 independent nations.

The first cooperative programs addressed the most immediate potential threat to the United States–the possibility of inadequate control over Soviet nuclear weapons in Russia and in the new nations of Ukraine, Kazakhstan, and Belarus. The initiation of these programs was soon followed by the lab-to-lab program of the Department of Energy (DOE) to enhance material protection, control, and accounting (MPC&A) of weapon-usable nuclear material (i.e., plutonium and highly enriched uranium) in Russia and other former Soviet states.

In the 1990s, nuclear specialists in both countries began to extend some aspects of their cooperation to addressing the threat from radiological terrorism. These efforts were included in a limited way in programs such as those of the International Science and Technology Center (ISTC) in Moscow that since 1994 has supported research and monitoring programs for redirecting Russian weapon specialists to peaceful pursuits, the Second Line of Defense program directed to border security in Russia, and the Warhead Safety and Security Exchange program which focused initially on nuclear warhead safety. These activities are discussed briefly in this chapter. In May 2002, the Secretary of Energy and the Minister of Atomic Energy agreed to initiate cooperation directed specifically at countering the threat of radiological terrorism from inadequately secured IRSs in Russia. This cooperation was to be carried out using the legal framework of the ongoing MPC&A cooperative program.

Overview of U.S.-Russian Cooperation to Protect IRSs

The U.S. Congress authorized the new program within DOE "to protect, control, and account for radiological dispersal device materials," both within Russia and on a broader global basis, during fiscal year 2003.[1] This chapter reviews the directions and progress to date of this program.

As of the end of 2005, the U.S.–Russian cooperative program to upgrade security of IRSs had focused on four activities:

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[1] National Defense Authorization Act for Fiscal Year 2003. Pub. L. No. 107-314, §3156. 2002. H.R. CONF. REP. NO. 107-772 at pp. 790-791 (2002).
Consolidated Appropriations Resolution, 2003. Pub. L. No. 108-7, 2003. H.R. CONF. REP. NO. 108-10 at p. 906 (2003).
Emergency Wartime Supplemental Appropriations Act, 2003. Pub. L. No. 108-11, 2003. H.R. CONF. REP. NO. 108-76 at p. 68 (2003).

- Analysis of information available in Russian data bases that is intended to provide inventories of the numbers, types, and locations of IRSs which are in use or in storage in Russia. These analyses are expected to lead to recommendations concerning priority sites for improved IRS protection and for consolidation of IRSs.
- Improvement of the security and related infrastructure capabilities at Radon storage and disposal sites.
- Collection and disposal of unwanted IRSs.
- Acceleration of the decommissioning of RTGs that are or have been deployed in Russia, largely in the Far North.

DOE program officials informed the committee in January 2006 that their priority was to continue working in these four areas and, if resources permit, to initiate activities that will improve physical protection at health-related facilities that use high-activity IRSs. Prior to addressing future directions for the cooperative program in Chapter 4, this report briefly describes efforts to date and their impact based on discussions with U.S. and Russian officials and specialists and observations during site visits in Russia.

Searching Databases to Determine Priority Sites for Security Upgrades

Prior to the undertaking of this study, IBRAE had been working with the Anti-Terrorist Center in St. Petersburg, the Rosatom Institute for Chemical Technology, the state enterprise Izotop, and other Russian organizations, with DOE support, to develop a more comprehensive inventory of IRSs than was currently available. In addition, IBRAE had been charged with identifying and prioritizing Russian facilities that need improved security for IRSs. Finally, IBRAE had been developing a data base on the information resources of the many Information and Analytical Centers throughout the country and constructing a model database for possible use by organizations managing IRSs.

Initially, IBRAE divided Russia into regional sectors and by 2005 had completed reviews of 20 regional databases which included information on activities of organizations that were not subordinate to Federal government bodies. It added 13 additional regional databases, primarily in the North Caucasus, during Phase II in 2005. Finally, the more than 50 remaining regional databases were to be addressed in Phase III, which has not yet been initiated. Also, databases of activities of institutions of selected ministries and agencies were examined, beginning with 11 ministries during Phase I.

IBRAE reported that during the first phase of its activities, 291 organizations were identified as possessing a total of more than 6,000 IRSs of elevated activity. Elevated activity is defined by IBRAE as alpha and beta radioactivity of greater than one curie and gamma radioactivity of greater than 100 curies. IBRAE recommended specific steps to improve security at 108 organizations handling about 3,700 IRSs. Also IBRAE recommended that 44 enterprises be considered as priority locations for installation of security upgrades.[2]

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[2] IBRAE. 2005. Opportunities for U.S.-Russian Cooperation in Combating Radiological Terrorism. Prepared for the NRC Committee on Opportunities for U.S.-Russian Cooperation in Combating Radiological Terrorism.

As discussed in Chapter 2, the databases have significant shortcomings and will require substantial upgrading. IBRAE acknowledges that many IRSs have not been identified in its analytical efforts and has made the suggestions set forth below. The distribution of IRSs is quite uneven geographically throughout the country, ranging from one IRS in Dagestan, which is adjacent to Chechnya, to tens of thousands in the city of Moscow.

IBRAE has given special attention to IRSs in the possession of the Russian Academy of Sciences, its parent organization. Within the Academy, 80 organizations use IRSs for a variety of purposes. Of these institutions, 15 manage over 600 IRSs, including IRSs using Co-60, Cs-137, and other radionuclides of elevated activity.

Although IBRAE has made substantial progress in stimulating development of more comprehensive databases, their analyses are far from complete. Activities in only about one-third of Russia's regions have been analyzed; and in particular, the Moscow region, which has the largest number of IRSs, has not been included. Moreover, a database is not an inventory. The recommendations about security upgrades were made largely on the basis of information supplied to IBRAE, although there were several dozen confirmatory site visits by IBRAE as well.

There is little doubt that this aspect of the U.S.–Russian cooperative program has resulted in a significantly better understanding both in Moscow and Washington of the IRS situation in Russia. U.S. financial support, interest, and technical expertise expedited a Russian effort that otherwise might not have been undertaken for several more years. In addition, this effort has assisted IBRAE to broaden its analytical capabilities related to radiological threats. In the process, it has established a large array of contacts with key organizations; and it has become an important center of expertise in Russia concerning the many policy, technical, and financial challenges involved in upgrading the entire system of control and accounting of IRSs. In particular, according to IBRAE officials, it has developed good working relations with Izotop, which has extensive databases on distribution of IRSs.

At the Moscow workshop in March 2005, representatives from IBRAE expressed concerns about DOE's contractual requirements. They believed that the minimum radiation limits set by DOE to be used for including IRSs in data bases were too high. In principle, all data concerning IRSs regardless of radiation intensity are important, although priorities for data collection obviously must be set. Even though the DOE guidance is generally consistent with definitions of IAEA Categories 1 and 2 IRSs, a cautionary observation made by an official of the U.S. Nuclear Regulatory Commission should be kept in mind. Only about 10 percent of the IRSs operating under licenses in the United States are Categories 1 and 2 IRSs. If a similar percentage is to be expected in Russia, then the statistical value of an inventory effort focused only on Categories 1 and 2 IRSs could be in question.

Also, the IBRAE specialists were concerned they might not be collecting sufficient data on unwanted IRSs since the reporting program is a voluntary program, and IRS custodians may be reluctant to provide data about problems. Only a small percentage of IRSs recovered in the United States have been Categories 1 or 2 IRSs. However, in the United States, IRSs have been recovered from about 500 sites with an average of about 24 IRSs taken from each site. When taking the total activity of the recovered IRSs into account (calculating alpha and beta/gamma IRSs separately), on average each site had housed the equivalent of one or more Categories 1 or 2 IRSs. DOE should consider the effect of aggregating activity levels of large numbers of low activity sources at a single site where the total activity may be over thresholds of concern. Indeed, during the committee's visits in Russia, the need for aggregating activities of low activity IRSs in at least some facilities seemed clear.

While the IBRAE contract with DOE may not have been sufficiently comprehensive, DOE officials have assured the committee that subsequent guidance to IBRAE was to include in its analyses those sites where the aggregate activity of large numbers of weak IRSs exceeds the contractual guidelines.

Further supporting the view that low activity IRSs should not be ignored, specialists the world over are in the early learning stage with regard to the impacts of radiological terrorism.

Improving Security at Radon Sites

As described previously, the Radon complex operates 16 regional storage and disposal facilities handling a wide variety of unwanted and spent IRSs as well as other forms of radioactive materials that have been collected for disposal. The complex plays a central national role in collecting and disposing of unwanted IRSs and in effect sets an important and highly visible standard for the entire nation. Individual Radon facilities are responsible for many IRSs in transit and on site. DOE's effort has been directed at upgrading the security at the sites to help prevent theft or loss of IRSs in Radon's possession. As noted in Chapter 2, an incident of theft occurred when insurgents overran a former Radon site in Grozny, Chechnya, in 2001, and escaped with an unknown number of IRSs.

The DOE-funded security upgrades at Radon sites are focused on (a) installing rapid physical security upgrades during a six-month period, (b) improving security of transportation of IRSs in the second stage, and (c) installing comprehensive upgrades with modern physical security approaches integrated with existing protection systems. The Kurchatov Institute of Atomic Energy has provided valuable technical support and advice for these activities. It has identified the following principles to guide the effort:

- Technical subsystems and equipment that reduce maintenance and training costs are to be emphasized.
- Each subsystem is to have the capability to accumulate and transmit information to the system's center.
- The overall system is to be designed so that its capacity and functions could be increased without having to interrupt operations.[3]

[3] Gnedenko, V. G., I. V. Goryachev, N. A. Petrov, N. V. Vitik, and Ye. G. Sergeeva. 2005. Improving Physical Security of Storage Sites and Ensuring the Safe Storage and Transport of Radiological Materials at Radon Special Complexes in the Russian Federation. Presentation at the U.S.-Russian Workshop on Safety and Security of Ionizing Radiation Sources by the Kurchatov Institute Russian Research Center, Moscow, Russia, March 14-15, 2005; see Appendix D.

Security upgrades were completed at the Radon site in Sergiev Posad, near Moscow, in 2004. The committee had the opportunity to visit this site, observe the upgrades that had been installed, and discuss the program with facility managers. Significant security upgrades include underground storage wells, tamper indicating devices, access control devices, and intrusion detection systems. The facility managers demonstrated very good awareness of the importance of security of IRSs and of modern methods to accomplish effective security. The buildings that were visited appeared well designed from a security perspective. The discussions with facility managers clearly indicated that DOE has done an excellent job in working jointly with Russian officials and technical specialists over many months to achieve these upgrades, and DOE has recognized their contributions in publicized ceremonies at the site.

The Radon system has some advantages over the approach in the United States where no such dedicated sites have the capability to accept and handle a broad range of excess and unwanted materials, IRSs, and radioactive waste. U.S. sites are specialized, and excess material is secured and managed on a segregated basis. For instance, DOE waste disposal sites cannot store excess radioactive material. Most unwanted IRSs being collected because of national security concerns are stored at Los Alamos until a disposal site or recycle facility becomes available. However, certain types of IRSs are not accepted at Los Alamos, and separate accommodations must be made for them at secure commercial locations or other DOE sites. Although some aspects of the U.S. recovery efforts are well ahead of Russian programs, this limitation in the United States has been expensive and has significantly slowed the recovery process. Today long delay periods are sometime necessary when recoveries of IRSs are halted by a protracted process to determine whether a particular site has the capability to accept and store a particular type of IRS.[4]

By January 2006, DOE had completed upgrades at four Radon sites and work was underway at three others. Two or three more were on the schedule for upgrade activities beginning in 2006. Clearly, a nationwide network of secure Radon sites will establish a sound foundation for efforts to recover and secure IRSs of greatest risk.

Collecting and Disposing of Unwanted Sources

The state enterprise Izotop is responsible for a number of aspects of safe handling of radionuclides in Russia, including their safe packaging and transport. Also, it is an important partner of DOE in recovering unwanted IRSs. The specific tasks assigned to Izotop under the cooperative U.S.-Russian program are as follows:

- Discover unused, poorly maintained, or abandoned radiation devices and equipment containing IRSs.
- Inspect equipment and devices proposed for return and for recycling of IRSs that are not being used for their intended purposes or that have been abandoned.
- Locate, dismantle, consolidate, transport, and bury IRSs in secure repositories.

[4] United States General Accounting Office. 2003. Nuclear Nonproliferation: DOE Action Needed to Ensure Continued Recovery of Unwanted Sealed Radioactive Sources. GAO-03-483. Washington, D. C. United States General Accounting Office.

- Identify, plan, design, and carry out measures to modernize physical protection, control, and accounting of materials at selected sites where IRSs remain

As of December 2005, the cooperative program had recovered 1,732 IRSs with total activity of about 200,000 curies. Plans for 2006 include recovery of 474 additional IRSs with total activity of about 160,000 curies. In addition, security upgrades were installed at the Izotop handling facility.

Although these achievements are welcome progress, the program thus far has only touched a very small portion of the IRSs that are unused or have become orphan sources. As previously noted, during visits to several Russian facilities, the committee saw a dire need for a much more comprehensive program of IRS returns and disposal.

Decommissioning of RTGs

More than 1,000 RTGs were produced for use in the former Soviet Union. Most of these RTGs were deployed along the coasts of Russia. Almost all were used to power remote navigational and weather stations. For example, more than 130 lighthouses in the Far North rely on RTGs for power. Most RTGs are the property of the Russian Navy while some are under the control of the Ministry of Transportation.

The RTGs typically are of very high activity and present both a safety and security concern not only to Russia but also its neighbors should these devices be taken across the border of Russia. As indicated in Chapter 2, a series of reported incidents involving RTGs in recent years have raised concerns about their security.

During the past few years, 200 to 300 RTGs have been taken out of service in Russia. Many are in various stages of dismantlement before being sent to Mayak for appropriate disposal. This work has been supported by an international task force of specialists from Russia, Canada, Norway, and the United States. It has led to the recovery and disposal of over one-half of the recovered units. The other units have been recovered by the Russian authorities without external financial assistance.

RTGs singled out for disposal are to be initially moved to five regional storage locations that are being upgraded to provide secure interim storage. Construction of these sites began in 2004. Depending on the characteristics of the radionuclides, the RTGs may remain in temporary storage for up to ten years before being moved to Mayak for disposal.

The removal of RTGs from many locations is constrained by the lack of replacement power sources. Norway has been providing solar-powered electricity generators for a number of years. DOE has used this experience as a base for also providing solar energy devices. Several DOE-financed pilot projects to test new solar power and wind generators are underway using navy sites. An additional pilot project will rely on commercial electrical lines for power. In some cases, Russian authorities have decided that replacement energy sources are not needed. Over the longer term, several of Russia's neighbors in addition to the United States are working with the Russian government with an eventual goal to decommission all RTGs and replace them with alternative power where needed.

A key Russian organization in this program is VNIITFA, which designed, constructed, and distributed most of the RTGs (using IRSs from Mayak). VNIITFA is also responsible for disassembling them in preparation for their disposition. An important aspect of the program is to improve security at the VNIITFA facility given the large concentration of RTGs there. Also the SEVMASH naval shipyard in the far north handles recovered RTGs, and security upgrades have been installed at the shipyard through the cooperative program on an expedited basis.

The DOE program has effectively worked with the Russian government to reduce the dangers of high-activity RTGs. Although much progress has been made, much more needs to be done, given the large number of RTGs that are deployed. A large fraction of the DOE budget supports this effort. As noted in Chapter 2, the greatest reduction in risk from these devices is accomplished by moving the RTGs to secure sites for storage. Whereas the Russian institutions prepare the RTGs for disposal at Mayak, in the United States they are stored for eventual land burial disposal as discussed in Chapter 2. Perhaps funds could be saved using this approach in Russia.

Related Cooperative Activities in Russia

DOE is supporting other cooperative programs with Russian organizations that are relevant to its core radiological terrorism program to improve protection of IRSs. Five such programs are described below.

Second Line of Defense Program

This program, which is designed to intercept fissile or radioactive material that is destined for illegal smuggled across borders, has been cited in Chapter 1. The program areas are (a) providing training for customs and border protection officers, (b) improving detection of nuclear material at ports, and (c) maintaining detection and related equipment installed under other programs. DOE provides considerable equipment, including stationary detectors for vehicle, rail, and pedestrian monitoring and handheld radionuclide identifiers. Future plans call for an emphasis on upgrading sites where equipment is already in place, a maintenance program whereby the United States purchases spare parts and Russia is responsible for repairs, and joint development of criteria for completion of training and fulfillment of sustainability needs.[5]

Materials Protection, Control and Accounting (MPC&A)

The U.S.-Russian cooperative MPC&A program mentioned previously focuses on security of weapon-usable material at about 50 sites in Russia, including sites where some of the most sensitive nuclear facilities in Russia are located. This program has grown from a U.S. contribution of $2 million in 1994 to approximately $150 million annually during the past few years. There are significant collateral benefits of the

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[5] Mustin, Tracy. 2004. Office of Second Line of Defense Russia Program Overview. Presentation at second meeting of the NRC Committee on Opportunities for U.S.-Russian Collaboration in Combating Radiological Terrorism, Washington, D.C., August 24-25, 2004.

MPC&A program which improves a number of aspects of facility security that also improve the security of IRSs since many of the sites covered by the MPC&A program also house significant numbers of IRSs. Some of the MPC&A upgrades such as enhancing perimeter security, installing detectors at entry/exit portal points, training of security personnel, and improving response capabilities are particularly important in improving security of IRSs.

Also, as noted in Chapter 2, some Russian regulations address the safety and security of all types of nuclear-related activities on site. The MPC&A program, in particular, has supported the strengthening and enforcement of such regulations with side benefits for enhancing security of IRSs as well as security of fissile material.

Finally, some lessons learned from the cooperative MPC&A program are relevant to the cooperative activities for protecting IRSs. For example, approaches used to upgrade transportation security during shipments of HEU and plutonium and adoption of vulnerability assessment methodologies have applicability to security of IRSs as well. On the negative side, MPC&A cooperation has sometimes been hampered by insufficient buy-in from the Russian government making it very difficult for DOE to develop a program that will be sustained over the long term.[6] Consequently, radiological terrorism cooperation must be designed as a partnership with strong Russian leadership from the beginning.

Activities of the International Science and Technology Center

Many ISTC projects in fields such as geology, medicine, and agriculture include the use of IRSs. Also, a particularly relevant ISTC program entitled *Radiation Legacy of the Soviet Union* has involved a number of Russian research institutions, with the core staff located at the Institute of Chemical Technology of Rosatom. This program has been underway for almost ten years. It emphasizes both assessments of radiation contamination throughout the country and safety and security of radioactive material. The distribution of IRSs is a small but important aspect of the program. A variety of reports have been issued on the achievements of the individual projects, and a number of them can be obtained at radleg@online.ru.

Warhead Safety and Security Exchange Program

This DOE program on Warhead Safety and Security Exchange was initiated in 1996 to foster cooperation between U.S. and Russian nuclear weapons specialists to address issues of warhead safety and security. During the past few years the cooperation among specialists has been extended to examining concerns about nuclear terrorism.

Naval Spent Nuclear Fuel

For several years, the Russian government has made the disposition of spent naval reactor fuels from the retired Russian general purpose submarine fleet one of its highest

[6] NRC Committee on Indigenization of Programs to Prevent Leakage of Plutonium and Highly Enriched Uranium from Russian Facilities. 2006. Strengthening Long-Term Nuclear Security: Protecting Weapon-Usable Material in Russia. Washington, D.C.: The National Academies Press.

priorities for nuclear cooperation with the West. Both the Russian and U.S. governments consider spent fuel to represent primarily an environmental problem. Some countries in close proximity to Russia, such as Norway, Sweden, Germany, and the United Kingdom, are funding cooperative efforts for disposal of the spent nuclear fuel. Recently the United States has increased its concern over spent fuel becoming source material for radiological terrorism.

This report does not address the threat posed by spent fuel. However, recent DOE studies indicate that radioactive material in spent fuel does not pose a particularly large RDD threat.[7] U.S.-Russian collaborative studies have been conducted of the ease of stealing spent nuclear fuel from Russian shipyards, maintenance bases, floating service vessels, transportation and storage facilities, and special trains. Recommendations have been developed on approaches for increasing the level of protection of spent nuclear fuel and for mitigation of an incident should one occur.[8]

A Good Start for the Cooperative Program

The cooperative program has made good progress. The database and inventory project is beginning to provide a broad picture of the IRS situation in Russia. The rapid physical security upgrades provide much-needed and timely improvements. Some of the most dangerous IRSs contained in high-activity RTGs have been taken out of service. However, much more needs to be done by the Russian government and cooperatively to reduce the threat to both U.S. and Russian interests.

The cooperative effort has been limited due in large measure to limited funding on both sides. Also, a number of Russian organizations that are responsible for security of IRSs have not indicated an interest in participating in the program. Of particular concern is the lack of involvement of the Ministries of Health and Social Services, Natural Resources and Energy, Agriculture, and Education and Science. All of these ministries have responsibility for stewardship of large numbers of IRSs, and the status of security procedures within the facilities of the ministries is simply not known. Also missing from active participation in the program are the hundreds of enterprises that have IRSs in their possession.

The focus of the program has been on a few quick fixes, rather than on comprehensive long-term approaches. It has been difficult to ensure that Russian facilities will embrace over the long term modern methods of protection, control, and accounting that have been used in the program; and serious questions abound as to the sustainability of activities when the program moves from one activity to the next.

Nevertheless, the cooperative program has helped Russia improve the security of some of its most vulnerable IRSs. Perhaps the most important contribution the program has made is to bring to the attention of the Russian government the seriousness of inadequate protection of IRSs. In each of the program areas, Russian activities seem to be on the rise, probably attributable in some measure to the stimulus of the cooperative

[7] Tittemore, G. W., B. Waud, and P. D. Moskowitz. 2004. Nuclear Security Studies in Russia. Presentation at the second meeting of the NRC Committee on Opportunities for U.S.-Russian Collaboration in Combating Radiological Terrorism, Washington, D.C., August 24-25, 2004.
[8] Ibid.

program. Also, the cooperative program has enhanced the ability of some Russian organizations to deal with IRSs while building DOE alliances with key Russian organizations that are prepared to do much more if resources are available.

Chapter 4

CONCLUSIONS AND RECOMMENDATIONS
Reinforcing Russian Capabilities to Protect Ionizing Radiation Sources

The Increasing Threat to U.S. Interests from Inadequately Controlled IRSs

As discussed in Chapter 1, the possible acquisition by terrorist groups of IRSs that could provide the radioactive material for RDDs is an increasing threat to U.S. interests and to global security. This form of radiological terrorism is of great concern at the highest levels of many governments, and particularly the U.S. and other G-8 governments. A number of U.S. programs and also programs supported by other governments and by international organizations to counter radiological terrorism are in place. However, many are in their early stages of development. As they mature, they will need strong support by governments and by the international community. The challenges in preventing detonations of RDDs are large, and they will persist for many years into the future.

Large numbers of inadequately protected IRSs are present in many countries, and particularly IRSs for which there is no longer a need. For these unwanted IRSs, financially affordable disposal pathways often do not exist. Many IRSs are left unattended and unprotected; and they are easy prey for terrorist groups. Groups that have experience in assembling and detonating conventional bombs should be able to readily acquire the skill to handle radioactive material used in IRSs and incorporate such material in dirty bombs.

The disruption attendant to an RDD detonation could be widespread, particularly if it occurs outdoors in a densely populated urban area. The number of radiation victims might not be great. However, the likelihood of psychological impacts of a radiological attack leading to widespread fear and social disruption would be high, and the economic costs of closing off and cleaning up contaminated areas would be very significant.

The committee concurs with the view of many experts who consider the possibility of a dirty bomb scenario in the not too distant future to be high (see Box 1-3). These apprehensions are supported by seizures in Europe of illegally obtained nuclear materials that have been linked to organized crime as well as discovery of crude drawings of dirty bombs in the possession of al Qaeda operatives. Thus, in addition to improving security of IRSs on a broad basis, the United States and other countries should be prepared to respond to dirty bomb attacks through well developed and tested consequence management plans. The number of inadequately protected IRSs is simply too large to secure them all, at least in the near term.

From the U.S. perspective, the primary concern must of course be the prevention of detonation of one or more RDDs within the United States. In the first instance, preventive measures should focus on ensuring that inadequately controlled IRSs currently in the United States are secured. DOE has mounted an aggressive program to find, collect, and secure these unwanted IRSs. At the same time, terrorist groups might try to smuggle IRSs or their radioactive components into the United States even though a variety of homeland security programs are in place to restrict penetrations of U.S. borders.

Also a priority concern of the U.S. government must be the possible targeting of dirty bombs on U.S. assets abroad—embassies, military bases, privately owned establishments, and other facilities. Disruption of activities and denial of access to contaminated areas at some of these facilities, particularly those that serve as transportation or communication hubs, could have profound security implications.

Detonation of a dirty bomb overseas, even distant from U.S. assets, would have significant political and economic repercussions throughout the world. Such an event might perturb international financial markets and raise questions about the effectiveness of international security alliances. Also, it could compel the United States and other countries to divert additional resources to enhancing protection of overseas investments and of their own homelands in recognition of new capabilities of terrorist organizations.

In the context of the foregoing global perspective over the likelihood and impact of dirty bomb scenarios, this report has focused on security of IRSs in Russia. As indicated in Chapter 2, the inventory of IRSs in Russia is measured in the hundreds of thousands, including tens of thousands of particularly dangerous IRSs that should be under stringent control. Unfortunately, the transition from a Soviet security system for IRSs that was effective in a closed society to a Russian security system that operates within a more open environment has been plagued by organizational, regulatory, and financial shortcomings that have stymied efforts to ensure adequate protection, control, and accounting of the large inventory of IRSs.

The task of securing even the most dangerous IRSs in Russia is daunting. For example, hundreds of radioisotope thermoelectric generators (RTGs) are located in northern reaches of the country, and the logistics to recover those that are no longer needed or could be replaced with other energy sources are formidable. Criminals have already stripped the metal off some of these RTGs, indicating the vulnerability to theft of the radioactive components as well. In addition to the problem of securing RTGs, the committee observed security deficiencies in protecting other types of IRSs of concern; and dangerous IRSs are located in hundreds of institutes, enterprises, hospitals, and other locations that are within reach of criminals. Also, the committee heard reports of unwanted IRSs being frequently discovered in abandoned facilities and in open fields.

As underscored in Chapter 2, should IRSs be obtained by criminals or by terrorist groups in Russia, the impact on U.S. interests could be very serious. If an IRS from Russia or any other country enters the international black market, its final destination cannot be predicted. Perhaps it would not reach the United States. However, it could be used against targets of great importance to the United States—in Russia itself, in Central Asia, in the Middle East, in Europe, or elsewhere. Also, an RDD detonation would probably encourage copy-cat attacks in other regions, including the United States.

An RDD detonation in Russia could have additional ramifications for the United States. It could certainly discourage American investors interested in commercial opportunities in the oil and other important sectors in Russia. It could raise doubts in some quarters about the effectiveness of the Russian government as a partner in addressing nuclear terrorism issues in a number of countries where Russia has considerable influence. Finally, it could affect international views on the future of nuclear technologies, even under the stewardship of a nuclear state with decades of experience in handling dangerous technologies.

Thus, the United States has considerable interest in helping to ensure that the security of IRSs in Russia meets an international level of acceptability. Also, the committee believes that through cooperation in the field of consequence management, the U.S. government can learn important lessons relevant to dealing with an RDD attack from past Russian experiences in responding to and managing the consequences of both nuclear accidents and terrorism incidents that involved conventional weaponry. Both the United States and Russia are on learning curves as to how to deal with the threat of radiological terrorism, and learning together can be an important complement to national efforts to address the threat.

Continuation of the U.S.-Russian Cooperative Program

The U.S.-Russian cooperative program for upgrading security of IRSs in Russia began in 2003. DOE has made a very good start in helping Russia deal with the challenge of security enhancement within the framework of this program. Even with the limited funds available to date, this program is improving the security of IRSs in Russia. Also, DOE has gained considerable experience in developing and carrying out significant on-the-ground activities in Russia.

Linkages have been made with key Russian organizations. Important problems were selected for initial program "quick fixes"—improved regional and Ministry inventories of IRSs, accelerated timelines to reduce the number of vulnerable RTGs, collection and disposal of unwanted IRSs, and enhanced security at Radon storage and disposal facilities. Initial projects in each of these areas have been successfully completed. Committed Russian partners seem ready to continue to move forward if they are provided with financial resources.

Of particular importance, the modest U.S. contributions to the cooperative program to date have helped focus Russian attention on critical aspects of security of IRSs and have probably stimulated Russian efforts in addition to those associated with the cooperative program. Continued encouragement of the Russian government to address the security of IRSs more aggressively in these areas is important. Also, new opportunities for collaboration that builds on early successes have emerged.

Thus, the program of quick security fixes is very important and should be continued; and the DOE leadership should expedite its implementation. All the while, DOE should evaluate the effectiveness of approaches that are being used and modify them, if appropriate, to help ensure that the greatest amount of threat reduction is being achieved for the money spent. Of particular concern to the committee is the end-of-life-cycle management of IRSs that are no longer wanted, including many that have been simply abandoned. Of course, counterpart Russian organizations should be involved in evaluation efforts as well as in planning and prioritizing future activities.

The Need for an Overall Plan for the Cooperative Program

The committee is deeply concerned over the continuing decline in the DOE resources being allocated to the cooperative program. However, the committee is not in a position to recommend expansion of current activities or initiation of new activities in the absence of an overall DOE Plan that clarifies how the cooperative program can be most effective in reducing risks attendant to inadequately protected IRSs. **Thus, a primary recommendation of the committee is that DOE develop an overall Plan for the use of resources that may become available to DOE in ways that will have the maximum impact on reducing the risks attendant to inadequately secured IRSs in Russia. This Plan should indicate how U.S. resources can leverage larger resources of the Russian government and thereby become an important basis for budget requests to support the program.** Of course, DOE should have a comprehensive plan for all of its relevant global efforts and within this framework the plan for Russia should help determine the percentage of available resources that should be allocated for the Russian program.

The Plan for the cooperative program should be developed within the context of a Comprehensive Russian Program for ensuring adequate life-cycle management of IRSs throughout the country and should take into account activities of other external partners. However, such a Comprehensive Russian Program may take years to fully develop, and DOE should move forward promptly in working with Russian counterparts to develop the Plan for the cooperative program that takes into account activities that are currently known to be underway in Russia. Clearly the Plan will need continued updating as a Comprehensive Russian Program evolves.

As discussed in Chapter 2, dozens of Russian federal ministries and organizations, hundreds of organizations at the district level, and thousands of organizations that are custodians of IRSs are involved in the protection, control, and accounting of IRSs. Ideally, these organizations should all work within a Comprehensive Russian Program of risk reduction. The Program, as well as similar programs in other countries, should concentrate on the highest risk-deficiencies in the overall approach to security and direct the country's financial resources to address these deficiencies in a manner that quickly improves life-cycle management of IRSs. A suggested framework for such a Comprehensive Program is set forth in Box 4-1. This framework does not include response and consequence management which have not been included in the cooperative program to date, but clearly a well developed Russian program in these fields is needed in recognition of the reality of past incidents in Russia involving IRSs and the possibility of future incidents.

The table of contents of the Radiation Sources Protection and Security Task Force Report released by the U.S.-Nuclear Regulatory Commission in 2006 is set forth in Appendix F.[1] It contains many important topics and should be of interest to the Russian government. The Nuclear Regulatory Commission could be very helpful to the Russian government in a number of the areas identified in Appendix F, and DOE should consider how the resources of the NRC can be used in the cooperative program.

[1] Radiation Source Protection and Security Task Force. 2006. The Radiation Source Protection and Security Task Force Report. Report to the President and the U.S. Congress Under Public Law 109-58, The Energy Policy Act of 2005. Washington, D.C.

Box 4-1
Suggested Framework for a Comprehensive Russian Program to Protect IRSs and Other Radioactive Material

- Development and enforcement of legal requirements and regulatory structures at the national, ministry, and regional levels that conform with accepted international standards.
- Development of an organizational/management structure for life-cycle management of IRSs that addresses:

  a) Quantification and characterization of existing inventories.
  b) Prioritization of IRS recovery requirements and security enhancements.
  c) Enhancement of security at user facilities, during transportation, and at temporary storage sites.
  d) Enhancement of final disposition capabilities.
  e) Development and implementation of management systems for improved accountability.
  f) Development and implementation of research and development priorities in support of the foregoing activities.

- Development of an organizational/management structure for life-cycle management of other radioactive material in addition to the material in IRSs (e.g., radioactive waste and spent nuclear fuel)
- Development of a national registry of sources in accordance with the IAEA *Code of Conduct on the Safety and Security of Radioactive Sources*
- Development of a risk-based methodology that considers the psychological consequences and economic damage of radiological terrorism as well as the threat to life and human health.
- Allocation of adequate financial resources to carry out the foregoing activities.

The committee recognizes that progress toward development of a Comprehensive Russian Program will take time due in large measure to (a) decentralized responsibilities in Moscow and throughout the country for undertaking and financing many relevant activities, (b) chronic shortages of necessary funding either from the government or the custodians of IRSs to correct security deficiencies, and (c) a legacy of security problems reflected in many inadequately protected IRSs, problems that are often attributable to organizations that no longer exist. Of course, a number of federal laws and regulations are already in place, and specialized activities at the federal level such as the operation of the Radon sites and the Izotop program to collect unwanted IRSs have been established. But a comprehensive nation-wide effort is still a long way off. Thus, the Program should include activities to meet high priority near-term objectives while also reflecting a vision of how best to address the security threats in the long term. Once such a program is in place, the need for DOE to continue to invest significant resources in the cooperative program should diminish. However cooperation in this field should continue indefinitely as both countries continue to learn from each other. Although DOE’s financial assistance should phase out in due time, DOE should not have an exit strategy for cooperation because the threat of radiological terrorism will most likely persist for decades.

Of special relevance to development of a Comprehensive Program for addressing the security of IRSs is Rosatom's approach in the area of "safety" of IRSs and radioactive waste. Rosatom has developed and regularly articulates a comprehensive overview of safety-related actions that are needed and are underway. According to Rosatom officials, this overview is very helpful in guiding the national effort.

These officials informed the committee that a comparable program strategy to help guide the approach to "security" of IRSs has not been developed. This is due in part to the sensitivity of the topic. These officials assured the committee that Rosatom recognizes the importance of such a comprehensive approach to ensure adequate security of IRSs and is making progress in developing such an approach.

At the same time, the IAEA has broadened its program directed to IRSs from a focus on safety to a focus on both safety and security.[2] The IAEA can of course have a significant impact in Russia. Its activities can complement the efforts of DOE which provide considerable political emphasis and flexibility to the overall international effort. However, the IAEA has so many competing priorities and limited funds; therefore DOE should continue to play a leadership role in Russia through its bilateral program.

DOE, working with the IAEA and other concerned governments, can have significant influence in encouraging development and implementation of a Comprehensive Russian Program that emphasizes reduction of the most serious risks as soon as possible. The Russian government has made strong commitments at the summit meeting in Bratislava and elsewhere to counter radiological terrorism, and the DOE leadership should continually refer to such Presidential commitments in stressing the importance of a Comprehensive Russian Program. Among the opportunities to underscore the importance of such a Program are the following.

- At multinational forums, DOE and other external partners can stress the importance of a Comprehensive Program to help guide external contributions to support Russia's efforts.
- The DOE cooperative program is an important asset, and in some cases DOE's efforts have encouraged parallel Russian activities beyond the cooperative program.
- Both DOE and Rosatom have relied on IBRAE for analytical support in many relevant areas for a number of years, and DOE's views are often reflected in approaches advocated by IBRAE which has a receptive client in Rosatom.

In sum, only the Russian government has the capability to strengthen the many weaknesses in the security system for IRSs. Nevertheless, DOE and other external partners are in a good position to encourage the Russian government to develop a more comprehensive approach to ensure adequate life-cycle management of IRSs than currently exists. The development of such a comprehensive approach will be the measure of DOE's success.

[2] Gonzales, A. J. 2004. Radiation Protection in the Aftermath of a Terrorist Attack Involving Exposure to Ionizing Radiation. Presentation at NCRP Fortieth Annual Meeting, Advances in Consequence Management for Radiological Terrorism Events, Arlington, Virginia, April 14-15, 2004.

Related Approaches for Countering the Threat of Radiological Terrorism

Enhancing the security of IRSs has been the thrust of the cooperative program and should remain a core element of U.S.-Russian cooperation to counter radiological terrorism. But when considering opportunities to have major impacts on reducing the threat of an RDD incident, DOE and other U.S. departments should have a broader perspective of how they can interact effectively with Russian counterparts.

For example, sound risk analysis should be a key tool in setting priorities for the cooperative program. The committee considers the current IAEA and DOE categorizations of risks associated with IRSs as discussed in Chapter 1 to be a reasonable starting point for risk assessment. But risk depends on many factors that have not yet been adequately incorporated into national or international efforts. These factors include not only total activity and half-life but also portability, dispersibility, prevalence of use, and public perceptions and fear of various radionuclides such as plutonium. At present, only a small fraction of the millions of existing IRSs are generally considered to be high risk; but thousands of other IRSs should be of great concern when taking into account all of the risk factors. A number of institutions in the United States and abroad are carrying out research on broadly based quantitative analyses of risks, and the Russian scientific community has a strong tradition in risk analysis. Thus, U.S. and Russian experts should work together to develop risk models that take into account the foregoing and other factors, which could provide an improved basis for targeting resources to problems of greatest concern.

In addition, U.S.-Russian cooperation in the following related areas is important and should be pursued through appropriate mechanisms.

- Effective information and intelligence gathering to provide early warning of an impending attack.
- Aggressive detection and tracking of illicit trafficking of IRSs, along with investigations of disablement methods.
- Effective response and mitigation activities to limit the damage associated with detonation of an RDD as previously discussed.
- Consideration of alternatives to highly radioactive IRSs

Finally, lessons can be learned relevant to enhanced security of IRSs from experiences in implementing the long-standing U.S.-Russian program to improve the protection, control, and accounting of highly enriched uranium and plutonium in Russia. (e.g., approaches to overcome problems of access to sensitive facilities, effectiveness of various types of contracts, use of local materials and equipment). The committee urges DOE to review such lessons jointly with Russian counterparts. This suggestion is not to imply that the dangers associated with weapon-usable material falling into the hands of terrorist groups or hostile governments is in any way comparable to the loss of IRSs. Still, the overall approaches to enhanced security seem to have a great deal in common.

In conclusion, the United States is not the only country vitally concerned with developments in Russia. The Scandinavian countries have long had interests in replacing the RTGs in the Far North of Russia. Japan is concerned about developments in the Far East. The Ukrainian government is concerned when smuggled radionuclides of Russian origin cross into its territory. In addition, as incidents of radiological terrorism begin to emerge in Europe, many G-8 governments recognize that Russia is a likely source of material that could be used in dirty bombs.

The committee firmly believes that the United States has played and should continue to play an important leadership role in catalyzing this widespread interest in enhancing security of IRSs in Russia and thereby significantly reducing the likelihood of dirty bombs being detonated in Russia or elsewhere. Of all of DOE's international partners, Russia is unique in a) offering challenges for improving international security and b) having capabilities that are of great interest to the United States. A cooperative program that spotlights practical solution to critical problems can continue to stimulate Russian activities to address many related problems. Nevertheless, some IRSs may fall into the hands of terrorists, but security upgrades together with preparations for responding for inevitable incidents can greatly reduce the risks associated with radiological terrorism.

APPENDIXES

Appendix A
Original Study Task for Opportunities for U.S.-Russian Cooperation in Combating Radiological Terrorism

The statement of task from the contract with Battelle Memorial Institute, Pacific Northwest National Laboratory is as follows:

> The National Academies shall support the Pacific Northwest National Laboratory (PNNL) and the Department of Energy (DOE) for an 18-month period to develop recommendations for priorities for U.S.-Russian cooperation to be considered by DOE as it develops its program for countering the threats of radiological terrorism. The National Research Council (NRC) of the Academies will assemble a committee of U.S. experts to consider threats posed by radiological dispersal devices and specifically radioactive material packed with explosives. In addition, other methods of dispersing radioactive materials, such as in ventilations systems or environmental releases in air or water, will also be considered. The study will also consider the problem of intentional exposure of the public to harmful sources of ionizing radiation, such as at airports or subways.
>
> After reviewing current DOE activities and related activities of other organizations and in consultation with Russian specialists, the NRC committee will prepare a report providing a road map for opportunities for Russian-American cooperation to help reduce the threat of radiological terrorism worldwide. The report will identify the types of threats of priority importance (e.g., public health, urban contamination, psychological apprehension), the potential Russian partners, and types of collaborative efforts (e.g., projects, studies, simulations, response strategies, educational exchanges, media communications). Interim briefings will also be provided to DOE at appropriate times during the project.

Appendix B
Committee Biographies

John F. Ahearne (National Academy of Engineering) is the director of the Ethics Program at Sigma Xi, The Scientific Research Society, a lecturer in public policy at Duke University and an adjunct scholar at Resources for the Future. His professional interests are reactor safety, energy issues, resource allocation, and public policy management. Dr. Ahearne received his bachelor of science and master of science degrees from Cornell University and a doctorate in physics from Princeton University. He served in the U.S. Air Force from 1959 to 1970, resigning as major. He has also served as deputy and principal deputy assistant secretary of defense (1972-1977), in the White House Energy Office (1977), as deputy assistant secretary of energy (1977-1978), and as commissioner and chair of the U.S. Nuclear Regulatory Commission (chair, 1979-1981). Dr. Ahearne currently serves on the Department of Energy's Nuclear Energy Research Advisory Committee. He is a fellow of the American Physical Society, the Society for Risk Analysis, the American Association for the Advancement of Science, and the American Academy of Arts and Sciences, and he is a member of the National Academy of Engineering, Sigma Xi, and the American Nuclear Society. He has chaired the National Research Council Committee on the Effects of Nuclear Earth-Penetrator Weapons and other Weapons and served as a member on the National Research Council Committee on Best Practices for Nuclear Materials Protection, Control, and Accounting. From 2001-2003, he served as co-chair of the National Research Council Committee on End Points for Spent Nuclear Fuel and High-Level Radioactive Waste in Russia and the United States.

Laurin Dodd is managing director of the Chernobyl Shelter Implementation Program (SIP) Project Management Unit, Bechtel International Systems, Inc. He held the position of deputy program director of the Threat Reduction Programs in the Moscow office of Bechtel International Systems, Inc., from 2005-2006. He held the position of associate laboratory director of the Idaho National Engineering and Environmental Laboratory (INEEL) from 1999-2005. He managed the National Security Division of INEEL, developing missions, strategies, and business plans for the division's four directorates: Infrastructure and Defense Systems; Intelligence, Sensor, and Information Systems; Safeguards and Security Programs; and Counterintelligence. Prior to this, Mr. Dodd held various positions at Battelle Pacific Northwest National Laboratory (PNNL) from 1980-1999. As manager of the International Nuclear Safety Program, he developed and managed a program to reduce the risks at nuclear facilities in nine countries of the former Soviet Union, including work to establish risk reduction priorities, assure that all work performed at FSU sites would meet licensing requirements of the host country regulators, develop and maintain capabilities for in-country logistics, and conduct bilateral program reviews regularly with Russian and Ukrainian counterparts, among other duties. Mr. Dodd's work on the International Nuclear Safety Program encompassed the Soviet Designed Reactor Safety Program, Chernobyl Initiatives, and Core Conversion Program. As manager of the Nuclear Systems and Concepts Department at PNNL, Mr. Dodd made personal efforts to initiate lab-to-lab exchanges with the Russian Academy of Sciences

Institute of Nuclear Safety, the Kurchatov Institute Russian Research Center, and other Russian institutes, resulting in work agreements on nuclear safety, plutonium disposition, and arctic environmental issues. Mr. Dodd held the position of engineer at UNC Nuclear Industries from 1976-1980. He received a bachelor of science degree in engineering physics from Oregon State University in 1973 and master of science degree in nuclear engineering from the University of Washington in 1976.

Siegfried S. Hecker (NAE) is director emeritus, Los Alamos National Laboratory; and a visiting professor at the Center for International Security and Cooperation at Stanford University. He received his bachelor of science, master of science, and doctorate degrees in metallurgy from Case Western Reserve University. His research interests include materials science and engineering, nuclear technologies, arms control and nonproliferation, and science policy. He joined Los Alamos National Laboratory in 1973 as a technical staff member, and he served as director from 1986-1997. In 1997, he returned to materials research with a focus on plutonium science and to international nuclear cooperative threat reduction efforts. He was elected a member of the National Academy of Engineering (NAE) in 1988 for outstanding research on plutonium and metal deformation and forming, and for leadership in developing energy and weapons systems. In 2003, he was elected a foreign member of the Russian Academy of Sciences. Dr. Hecker serves as chair on the National Research Council Committee on Counterterrorism Challenges for Russia and the United States, and he is a member of the National Research Council Governing Board and the Council of the NAE. In addition to his membership in several other prominent societies, Dr. Hecker is a member of the National Academy of Sciences Committee on International Security and Arms Control Nonproliferation Panel and participates in the Stanford University Five-Nations Project on Security in South Asia.

Darleane C. Hoffman is professor of the graduate school in the Department of Chemistry at the University of California, Berkeley (UCB) and faculty senior scientist in the Nuclear Science Division of the Lawrence Berkeley National Laboratory (LBNL). Her research interests include rapid chemical separation of short-lived fission products; separations chemistry of lanthanide, actinide and transactinide elements; search for heavy elements in nature; studies of radionuclide migration in geologic media; studies of the spontaneous fission process; heavy ion reactions and production of new neutron-rich heavy element isotopes; atom-at-a-time studies of the chemical and nuclear properties of the heaviest elements. Prof. Hoffman received her B. S. and Ph. D. degrees from Iowa State University, Ames, Iowa. She served as chemist at Oak Ridge National Laboratory (1952-1953) and then joined Los Alamos Scientific Laboratory in 1953. She spent sabbatical years as an NSF Senior Postdoctoral Fellow at the Institute for Atomic Energy, Kjeller, Norway in 1964-65 and as a Guggenheim Fellow at LBNL in 1978-79. She returned to the Los Alamos National Laboratory (LANL) to be Division Leader of the Chemistry-Nuclear Chemistry Division from 1979-82 and the Isotope and Nuclear Chemistry Division from 1982-1984. In 1984 Dr. Hoffman joined the Department of Chemistry at the University of California, Berkeley (UCB) as full Professor of Nuclear Chemistry and leader of the Heavy Element Nuclear and Radiochemistry Group at LBNL. She helped found the Seaborg Institute for Transactinium Science at Lawrence

Livermore National Laboratory (LNLL) in 1991, and served as its first Director (1991-1996), and as Senior Advisor and Charter Director 1996-2006. Prof. Hoffman is a fellow of the Norwegian Academy of Science and Letters, the American Association for the Advancement of Science, the American Institute of Chemists, the American Physical Society, and the American Academy of Arts and Sciences, and was inducted into the Women in Technology International Hall of Fame (2000). She has held visiting lectureships in the U. S. and abroad and was awarded honorary doctorates from Clark University, USA (2000) and Bern University, Switzerland (2001). She received American Chemical Society Awards for Nuclear Chemistry in 1983, the Garvan-Olin Medal in 1990 and the Priestley Medal in 2000. She was awarded the U. S. National Medal of Science in 1997, the Sigma Xi Proctor Prize for Scientific Achievement in 2003 and the Radiochemistry Society Lifetime Achievement Award in 2004. She has served on several boards and committees for the National Research Council including the Board on Radioactive Waste Management and the Committee on End Points for Spent Nuclear Fuel and High-Level Radioactive Waste in Russia and the United States.

Roger E. Kasperson is a research professor at the George Perkins Marsh Institute at Clark University. He has also served as executive director of the Stockholm Environment Institute. He received his doctorate from the University of Chicago and has taught at the University of Connecticut and Michigan State University. His expertise is in risk analysis, global environmental change, and environmental policy. Dr. Kasperson is a Fellow of the American Association for the Advancement of Science and the International Society for Risk Analysis. He has served on the National Research Council Board on Radioactive Waste Management (1998-2001) and the Committee on Disposition of High-Level Radioactive Waste Through Geological Isolation: Development, Current Status, and Technical Policy Challenges (1999-2001). He also has been honored by the Association of American Geographers for his hazards research. He chaired the International Geographical Union Commission on Critical Situations/Regions in Global Environmental Change. He currently serves on the Executive Committee of the Environmental Protection Agency's Science Advisory Board, is a trustee of the Institute for Global Environmental Strategies in Japan, serves on the Scientific Advisory Committee of the Potsdam Institute for Climate Change and the Science Advisory Committee of the Tyndall Center for Climate Change Research, and is a member of the National Academy of Sciences. He has authored or co-edited 18 books and monographs and more than 120 articles or chapters in scholarly journals or books.

Appendix C
List of Committee Activities

May 7-8, 2004
First meeting of the NRC Committee on Opportunities for U.S.-Russian Collaboration in Combating Radiological Terrorism, Washington, D.C.
Presentations:

- Garry Tittemore, U.S. Department of Energy
- Thomas Teneforde, President, National Council on Radiation Protection and Measurements

August 24-25, 2004
Second meeting of the NRC Committee on Opportunities for U.S.-Russian Collaboration in Combating Radiological Terrorism, Washington, D.C.
Presentations:

- Garry Tittemore, U.S. Department of Energy
- Ioanna Iliopulos, U.S. Department of Energy
- Paul Moskowitz, Brookhaven National Laboratory
- Mark Soo Hoo, U.S. Department of Energy
- Joseph Schwartzel, U.S. Department of Energy
- Tracy Mustin, U.S. Department of Energy
- Randy Atkins, National Academy of Engineering
- Charles Ferguson, Center for Nonproliferation Studies
- Cynthia Jones and Patricia Holahan, U.S. Nuclear Regulatory Commission
- Patrick Philbin, U.S. Department of Homeland Security
- Tom Bourne, U.S. Department of Homeland Security

March 14-15, 2005

- U.S.-Russian Workshop on Safety and Security of Ionizing Radiation Sources, Moscow, Russia (see Appendix D for full agenda)

March 16, 2005
Site visits to

- Rosatom
- Rostekhnadzor
- Nuclear Safety Institute (IBRAE)

March 17, 2005

- Site visit to Radon

March 18, 2005
Site visits to

- All-Russian Science and Research Institute of Technical Physics and Automation (VNIITFA)

- Nuclear Safety Institute (IBRAE)

March 21, 2005
- Site visit to the Khlopin Radium Institute

March 22, 2005
- Site visit to Gotchina RAS Institute of Nuclear Physics

May 23-24, 2005
Site visit to Yekaterinburg, Russia by Glenn Schweitzer and Laurin Dodd
Facilities visited:
- Presidium of the Russian Academy of Sciences, Urals Branch
- Rostekhnadzor
- Institute of Industrial Ecology
- Zarechny Field Station, Institute of Ecology of Plants and Animals

Appendix D

Agenda

U.S.-Russian Workshop on Safety and Security of Ionizing Radiation Sources

Russian Academy of Sciences Presidium
Moscow, Russia
March 14-15, 2005

March 14, 2005

Opening Session
Welcoming Remarks
Nikolay P. Laverov, Russian Academy of Sciences
Evgeny P. Velikhov, Kurchatov State Research Center for Atomic Energy
Siegfried S. Hecker, Los Alamos National Laboratory
Sergey V. Antipov, Federal Agency for Atomic Energy (Rosatom)
John F. Ahearne, Sigma Xi, The Scientific Research Society

Session 1—The Role of National Agencies in Controlling Sources: Regulations, Data Bases, Enforcement
Chairs: John F. Ahearne, Sigma Xi, The Scientific Research Society; Leonid Bolshov, Nuclear Safety Institute(IBRAE)

Main Problems of Safe Use of Ionizing Radiation Sources
Leonid Bolshov, Nuclear Safety Institute

Increasing Safety of Ionizing Radiation Source Management
Aleksandr M. Agapov, Rosatom

Overview of the Organization of the Global Threat Reduction Initiative
Garry Tittemore, U.S. Department of Energy

Regulating Activities Regarding the Physical Security of Nuclear and Radiation Hazard Facilities
V. L. Pervin, Rostekhnadzor

Role of the Nuclear Regulatory Commission in Enhancing the Safety and Security of Radioactive Sources
Cynthia Jones, U.S. Nuclear Regulatory Commission

Preventing of Radiological Terrorism, Problems of Radiation Safety
Ivan K. Romanovich, St. Petersburg Scientific Research Institute of Radiation Hygiene, Federal Monitoring Service for the Protection of Consumer Rights and Human Welfare

Session 2—Activities of Russian Organizations that Use Sources: Characteristics and Distribution of Sources, Procedures, Protection of Sources, and Experiences of Special Interest
Chairs: John F. Ahearne, Sigma Xi, The Scientific Research Society; Leonid Bolshov, Nuclear Safety Institute

Analysis of the Ionizing Radiation Source Management Situation in the Russian Federation (based on the results of U.S.-Russian cooperation)
Rafael F. Arutyunyan, I. A. Osipyants, Nuclear Safety Institute
S. N. Brykin, All-Russian Chemical Technology Research Institute
V. V. Khlopkov, Russian Academy of Sciences

Ensuring the Functioning of the Federal System of Accounting and Control of Radioactive Materials and Radioactive Waste, Nuclear Materials, and Security of Nuclear and Radiation Hazardous Facilities at Russian Academy of Sciences Organizations
Boris F. Myasoedov, Russian Academy of Sciences

Radiation Hazard Facilities in Russia
V. K. Klyushnik, Rostekhnadzor

Directions of Improving a System of Accounting and Control of Ionizing Radiation Sources
A. N. Rumyantsev, V. K. Sukhoruchkin, V. M. Shmelev, Kurchatov Institute Russian Research Center

Creation and Operation of a System of Physical Protection of Nuclear Materials and Radiation Sources at Petersburg Institute of Atomic Physics
D. P. Tolkachev, Petersburg Institute of Atomic Physics

Systematic Research of the Radiation Legacy of the USSR
A. A. Iskra, All-Russian Chemical Technology Research Institute
O. G. Lebedev and V. K. Popov, Kurchatov Institute Russian Research Center

March 15, 2005

Session 3—Activities that Produce, Transport, Collect, Assemble, Disassemble, and Dispose of Sources: Types of Sources of Primary Concern, Procedures in Handling Sources, and Experiences of Special Interest
Chairs: John F. Ahearne, Sigma Xi, The Scientific Research Society; Leonid Bolshov, Nuclear Safety Institute

Managing Radiation Sources More Safely
Aleksandr M. Agapov, Division of Nuclear and Radiation Safety (DNRS), Rosatom

Problems of Decommissioning of Radioisotope Thermoelectric Generators
V. D. Akhunov, Rosatom

Improving Physical Security of Storage Sites and Ensuring the Safe Storage and Transport of Radiological Materials at the Radon Specialized Complexes in the Russian Federation
Valery G. Gnedenko, I. V. Goryachev, N. A. Petrov, E. G. Sergeeva, Kurchatov Institute Russian Research Center

Production of Ionizing Radiation Sources at the Mayak Production Association and Efforts to Ensure Their Safe Use and Disposal
A. D. Maksimenko, Mayak

Utilization of Ionizing Radiation Sources Developed by the Khlopin Radium Institute
V. V. Fedorov, Khlopin Radium Institute

Generalization of Experience to Prolong the Lifetime of Ionizing Radiation Sources Used in Civil Aviation and Problems Connecting with their Utilization
D. Yu. Tchuvilin, Kurchatov Institute Russian Research Institute
V. G. Pashchinsky, Federal Research and Development Institute of Civil Aviation
V. A. Shilov, Ministry of Transport of Russia

Collecting Orphan Sources
Leroy Leonard, Los Alamos National Laboratory

Session 4—Assessment of Consequences of Unauthorized Use of Ionizing Radiation Sources; Communication to Media and the Population
Chairs: John F. Ahearne, Sigma Xi, The Scientific Research Society; Leonid Bolshov, Nuclear Safety Institute

Preventative Measures to Stop the Unauthorized Spread of Radioactive Substances and Radioactive Wastes
Nikolay F. Andryushin, Rostekhnadzor

Environmental Impact Assessment and Accident Analysis of the RTG Decommissioning
A. I. Platov, State Unitary Enterprise Russian National Technical Physics and Automation Research Institute (VNIITFA)

A Terrorist Attack Involving Plutonium: Dosimetry and Medical Aspects
Sergey A. Romanov, Federal Agency for Medicine and Biology, Ministry of Health and Social Development of Russia

The Social Amplification of Risk: Communicating with the Media and the Public
Roger Kasperson, Clark University

Direct and Indirect Harm: Value at Risk
E. M. Melikhova, Nuclear Safety Institute

Discussion

Closing Remarks

Appendix E
Defense Nuclear Nonproliferation Funding Profile by Subprogram, 2007 Request

An excerpt from the Department of Energy FY 2007 Congressional Budget Request[1] shows funds for the Russia-United States cooperative program to upgrade security of ionizing radiation sources included under Global Threat Reduction Initiative, below.

Defense Nuclear Nonproliferation

Threat and Response: The convergence of heightened terrorist activities and the ease of moving materials, technology, and information across boarders has made the potential of terrorism involving weapons of mass destruction (WMD) the most serious threat facing the Nation. Preventing WMD from falling into the hands of terrorists is the top national security priority of this Administration. The FY 2007 budget request for Defense Nuclear Nonproliferation represents an effort to protect the United States (U.S.) and its allies from this threat.

Funding Profile by Subprogram

(dollars in thousands)

	FY 2005 Current Appropriation	FY 2006 Original Appropriation	FY 2006 [a] Adjustments	FY 2006 Current Appropriation	FY 2007 Request
Defense Nuclear Nonproliferation and Verification					
Nonproliferation Research and Development	219,836	322,000	-3,220	318,780	268,887
Nonproliferation and International Security	143,764	75,000	-750	74,250	127,411
International Nuclear Materials Protection and Cooperation	403,451	427,000	-4,270	422,730	413,182
Global Initiatives for Proliferation Prevention	40,675	40,000	-400	39,600	0
HEU Transparency Implementation [a]	20,784	19,483	-195	19,288	0

[1] U.S. Department of Energy. 2006. Department of Energy FY 2007 Congressional Budget Request: National Nuclear Security Administration. Washington, D.C.: U.S. Department of Energy.

Elimination of Weapons-Grade Plutonium Production	67,331	176,185	-1,762	174,423	206,654
Fissile Materials Disposition	619,060	473,508	-4735	468,773	637,956
Offsite Recovery Project	7,540	0	0	0	0
Global Threat Reduction Initiative	0	97,975	-980	96,995	106,818
Subtotal, Defense, Nuclear Nonproliferation	1,522,441	1,631,151	-16,312	1,614,839	1,760,908
Use of Prior Year Balances	-14,475	0	0	0	-34,695
Total, Defense Nuclear Nonproliferation	1,507,966	1,631,151	-16,312	1,614,839	1,726,213

NOTE: The FY 2006 column includes an across-the-board rescission of 1 percent in accordance with the Department of Defense Appropriations Act, 2006, P.L. 109-148.

Public Law Authorization: P.L. 108-148, The Consolidated Appropriations Act, 2006.

[a] This budget request includes an across-the-board rescission of 1 percent for FY 2006 in accordance with the Department of Defense Appropriations Act 2006, P.L. 109-148.

Appendix F

Report to the President and the U.S. Congress Under Public Law 109-58, The Energy Policy Act of 2005

The Radiation Source Protection and Security Task Force Report[1]

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[1] Radiation Source Protection and Security Task Force. 2006. The Radiation Source Protection and Security Task Force Report. Report to the President and the U.S. Congress Under Public Law 109-58, The Energy Policy Act of 2005. Washington, D.C.

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