CBO MEMORANDUM

COOPERATIVE APPROACHES TO HALT
RUSSIAN NUCLEAR PROLIFERATION
AND IMPROVE THE OPENNESS OF
NUCLEAR DISARMAMENT

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CONGRESSIONAL BUDGET OFFICE
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NOTES

Unless otherwise indicated, all years referred to in this memorandum are fiscal years.

Numbers in the text and tables may not add up to totals because of rounding.

In response to a request from the Senate Democratic Leader, the Congressional Budget Office (CBO) is analyzing a broad range of cooperative measures between the United States and Russia that could improve nuclear security. This CBO memorandum responds to Senator Daschle's request for findings as they become available. (Earlier publications responding to the same request included two letters: one dated September 3, 1998, on improving Russia's access to early-warning information, and another dated March 18, 1998, on the estimated budgetary effects of alternative levels of strategic forces.) The options included in this memorandum fall into two broad categories: preventing the spread of nuclear materials and technical knowledge from Russia, and improving openness, or transparency, in dismantling warheads and accounting for fissile materials. In keeping with CBO's mandate to provide objective, impartial analysis, this memorandum makes no recommendations.

The memorandum was prepared by David Mosher and Geoffrey Forden of CBO's National Security Division under the supervision of Christopher Jehn and R. William Thomas. Raymond J. Hall of the Defense Cost Estimates Unit in CBO's Budget Analysis Division analyzed the costs of the options under the supervision of Mick Miller. Evan Christman thoroughly reviewed the manuscript and provided useful comments. The authors would also like to thank Ken Luongo, Todd Perry, Glenn Schweitzer, Frank von Hippel, and the numerous people at the Department of Energy, the national laboratories, and the Department of Defense who provided invaluable help and comments. Of course, all responsibility for the memorandum lies with the authors and CBO.

Christian Spoor edited the manuscript, Leah Mazade and Liz Williams proofread it, and Cindy Cleveland and Judith Cromwell prepared the memorandum for publication. Laurie Brown prepared the electronic versions for CBO's World Wide Web site (www. cbo.gov).

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INTRODUCTION

The United States and Russia possess tens of thousands of nuclear weapons. They also have hundreds of tons of nuclear materials (primarily plutonium and highly enriched uranium) that can be used in weapons. During the Cold War, the U.S. and Soviet militaries and nuclear weapons establishments focused on preventing the theft or unauthorized use of those weapons and materials. They also took steps to ensure that the know-how necessary to make nuclear weapons did not spread.

Since the collapse of the Soviet Union in 1991, however, the security of the nuclear materials and weapons in the former empire has become a source of serious concern. The United States and other countries worry that the social upheaval in the former Soviet republics and the breakup of the Soviet security apparatus have left nuclear weapons, nuclear materials, and weapons-design expertise susceptible to proliferation. The economic implosion that followed the collapse of the ruble in August 1998 has heightened those concerns—particularly now that countries such as Iran, Iraq, and North Korea, loosed from their Cold War restraints, are actively working to acquire nuclear weapons and to develop longer-range ballistic missiles that can deliver such weapons.

The challenge that the United States and Russia face is figuring out how best to address those threats to nuclear security. The two countries have cooperated on a broad range of programs designed to improve such security in Russia. Some of the programs have focused on making warheads or weapons-usable nuclear materials (also known as fissile materials) more secure. Others have concentrated on keeping weapons scientists from being tempted to sell their skills abroad. Still others have worked to improve both countries' ability to measure and monitor each other's stockpiles of fissile materials. Cooperation has been essential to all of those programs because they could not function without the permission of the Russian government. Those efforts now cost the United States about $700 million a year.

Although those programs have had varying degrees of success, they have not solved the problems. Sizable quantities of fissile materials in Russia remain unprotected; no effective export-control system or enforcement mechanism exists to ensure that stolen materials or warheads are not smuggled out of the country; and thousands of weapons scientists and nuclear workers are facing economic hardship because of budget cuts and recession. Moreover, Russia's economic crisis may undermine some of the progress that has already been made. Faced with those facts, some experts have urged the United States to do more to address the threat of nuclear proliferation from Russia.

Ways to Expand U.S. Efforts

This memorandum examines several ways in which the United States could do more to improve the security of Russia's fissile materials and nuclear warheads. Those approaches fall into two broad categories: options intended to reduce the chance that warheads, nuclear materials, or design expertise could end up in the wrong hands, and options meant to improve the "transparency" of both countries' inventories of nuclear warheads and fissile materials.

Specifically, the options that the Congressional Budget Office (CBO) has analyzed illustrate five possible ways to improve nuclear security. The first three would increase U.S. nonproliferation efforts in Russia by:

- Expanding the Department of Energy's (DOE's) program to protect fissile materials in the former Soviet Union so it includes all of the sites in Russia's so-called nuclear cities;

- Helping the Russian customs service and border patrol improve their ability to detect nuclear materials at ports, airports, and border crossings and establish the necessary legal and regulatory framework for a nonproliferation system; and

- Funding efforts to help Russia stabilize and consolidate its nuclear cities by paying nuclear workers and scientists to stay there and by promoting economic diversification in those cities.

The remaining two options would improve the visibility, or transparency, that each country has into the other's warhead-dismantling process and inventory of fissile materials by:

- Increasing funding for DOE's warhead transparency program to allow more U.S. and joint U.S./Russian analyses and demonstrations so both sides could begin cooperating on this sensitive topic; and

- Funding a joint experiment to measure the amount of plutonium that was made in Russia's old production reactors.

Those five options could be pursued either individually or together as part of a comprehensive strategy to improve nuclear security. Although all of the options are feasible, reasonable analysts will differ on their prospects for achieving their goals. (Other approaches to improving nuclear security in Russia will be discussed in later CBO publications.)

Challenges to Improving Nuclear Security

In analyzing those options, CBO has tried, to the greatest extent possible, to determine how much the United States would improve nuclear security with each increment of money that it invested. But determining that is difficult for several reasons.

First, relating inputs (resources) directly to the desired policy outcome (improved security) can be hard for many aspects of national security, including nonproliferation and transparency.[1] In some cases, such as efforts to secure fissile materials, inputs *can* be directly related to an output (for instance, for about $10 million, the United States can help Russia secure the materials at one storage facility). But even then, locking up more material does not guarantee improved security if the equipment is not maintained or if the guards are not properly trained or must leave their posts to forage for food.

Second, many of the options include an element of human behavior that makes predicting policy outcomes, or even relating inputs to outputs, harder still. For example, how many Russian scientists would be dissuaded from helping other nations build nuclear weapons if the United States launched a program to create economic opportunities in Russia's nuclear cities? It is even difficult to know beforehand how effectively the money spent on such a program could diversify those cities' economies by establishing new business ventures and providing alternative employment for nuclear workers.

Third, the scale of the nuclear security problem is immense. Russia has produced more than 1,000 tons of highly enriched uranium and roughly 150 tons of plutonium and built and maintained a stockpile of about 45,000 warheads. That material is spread among hundreds of military and civilian facilities throughout the country. Even if current programs are effective, they are not large enough to solve the problem because their scope is not sufficient to protect every cache of fissile material, secure every border, or employ every nuclear scientist in nonweapons work.

Fourth, the state of Russia's economy and the social upheaval since the end of the Cold War can make implementing programs difficult. For example, as part of its effort to increase revenues, the central government has been taxing U.S. payments

1. In 1993, the Congress passed the Government Performance and Results Act (GPRA) to make it easier for Congressional committees and managers in the executive branch to measure the progress of a program. Agencies are now required to report the expected outputs of every program and how those outputs relate to the desired policy outcome. In this analysis, CBO has used the GPRA terms "input" for the amount of resources devoted to a program, "output" for the measure of the activity taking place in a program, and "outcome" for the results of a program.

to Russian weapons scientists working as contractors. Moreover, Russia lacks certain elements of a basic economic infrastructure, such as reliable banks and other business services.

For those reasons, CBO was unable to assess the extent to which the options it analyzed would "solve" the proliferation problem. Although each option holds the promise of reducing the risk of proliferation from Russia, none is likely to make that risk disappear even if it is completely effective. There are simply too many uncertainties. For example, can all of Russia's weapons-usable nuclear materials be accounted for? According to some experts, Russia does not even know how much it has. Or can the United States be certain that every Russian weapons scientist will not sell his or her expertise abroad even if economic diversification programs create enough jobs for all of them?

The Risks of Failure

Achieving success in this arena may be difficult, but failing to act may carry even greater risks. The security of the United States and its allies would certainly be affected if nuclear weapons spread elsewhere—particularly to countries and terrorist groups that are openly hostile to the United States. That risk accounts for the urgency with which advocates approach the problem of nuclear security in Russia. It makes them willing to try new or old approaches that are not certain to be effective but may still have some chance of reducing proliferation. In that context, instead of eliminating the proliferation threat entirely, the more useful measure of success may be the extent to which a particular option reduces the risk that a hostile country can get hold of nuclear weapons.

Many of the existing nonproliferation efforts that the United States has undertaken cooperatively with Russia operate on that principle. Those programs cannot eliminate the risks completely, but they can reduce them. The seriousness of the risks posed by proliferation argues for a careful look at what more could be done to address problems with nuclear security in Russia.

OPTIONS TO PREVENT THE SPREAD OF NUCLEAR MATERIALS, TECHNOLOGIES, AND KNOW-HOW FROM RUSSIA

Over the past seven years, the United States has instituted several programs to help Russia and the former Soviet republics prevent nuclear proliferation. As part of the Cooperative Threat Reduction (or Nunn-Lugar) program, the Department of Defense is helping Russia store its nuclear weapons securely. The program is also helping Russia secure the fissile materials (plutonium and highly enriched uranium) from weapons that it is dismantling under the Strategic Arms Reduction Talks (START) treaties. The Materials Protection, Control, and Accounting program run by the Department of Energy has helped the former Soviet republics protect their far-flung stocks of nuclear materials that could be used in weapons.

Other U.S. programs are aimed at keeping weapons scientists in Russia and helping states of the former Soviet Union halt nuclear smuggling. DOE's Initiatives for Proliferation Prevention program is trying to involve such scientists in developing commercial products. The State Department funds the United States' share of the International Science and Technology Center, a multilateral organization that employs weapons scientists in Russia and other former Soviet states to do research on topics unrelated to weapons. It also helps fund a similar center in Ukraine. In addition, the United States is starting a program to help Russia keep fissile materials and technical know-how within its weapons facilities by providing economic opportunities in the closed nuclear cities. DOE also runs a program that helps Russia improve its export-control laws and is beginning a program to help the country tighten its borders against nuclear smuggling. The Department of Defense runs a similar program for states in Eastern Europe and Central Asia. The United States has also agreed to buy surplus highly enriched uranium from Russia that has been converted to fuel for civilian nuclear reactors. And DOE is helping Russia halt the production of weapons-grade plutonium in its last three production reactors.

Some analysts argue that the United States' first priority should continue to be securing nuclear materials where they are now stored through the Materials Protection, Control, and Accounting (MPC&A) program. After all, access to fissile materials, not weapons expertise, is the primary obstacle for a country determined to develop nuclear weapons. Other analysts contend that much of that task will be accomplished under the existing MPC&A program and that the lion's share of any additional money should instead be used to improve border controls and detection methods for nuclear materials and weapons or to help stabilize and convert the economies of the nuclear cities. Still others believe that current U.S. nonproliferation efforts are sufficient and no addition to the Administration's budget is necessary.

Expand the Materials Protection, Control, and Accounting Program

The Department of Energy established the Materials Protection, Control, and Accounting program to help Russia and other countries of the former Soviet Union secure their fissile materials and set up modern systems to account for those materials. The program started with Russia's civilian nuclear facilities (research institutes and power plants). It has since expanded to include some nuclear facilities of the Russian navy and the country's weapons-design and production complex. In 1995, officials of the MPC&A program estimated that the entire job—securing nuclear materials at 80 to 100 facilities—would cost roughly $800 million through 2002, or about $10 million per facility. To date, the program has installed materials-protection systems at 62 of those facilities, and officials believe they have enough money in the 1999 budget ($388 million from 1999 through 2002) to complete work at all of those facilities.

However, after working in Russia, MPC&A officials realized that they had not fully anticipated the scope of the problem. The country turns out to have more fissile materials in more buildings in its nuclear weapons complex (the closed nuclear cities) than U.S. officials originally estimated. In addition, Russia could improve the protection of its spent naval reactor fuel, which contains highly enriched uranium and in some cases is old enough that the radiation level may no longer be a sufficient deterrent to theft. That project is one that the original MPC&A program did not anticipate. Finally, some advocates of the program argue that the United States needs to continue spending money each year after 2002 to ensure that Russia establishes and maintains the infrastructure and organization necessary for keeping its fissile materials secure well into the future.

Some MPC&A advocates also express concern that the economic crisis that has gripped Russia since last summer threatens to undermine much of the progress that the program has made so far.[2] They cite reports that the guards who protect the materials and operate the security systems that the United States helped install have been forced to leave their posts to search for food and have started ignoring alarms because they are not properly equipped to venture outdoors in frigid temperatures.

How much some of the proposed expansions of the MPC&A program would cost is unclear. DOE chose not to give CBO information during the course of its analysis that would have allowed it to estimate the cost of a specific proposal because, according to DOE officials, the department was in the process of evaluating how much work remains to be done in Russia and to what extent the United States should be involved. Without that information, CBO could not project the cost of most proposals for expanding the program, including using emergency aid to make sure that past progress in securing fissile materials is not undermined by economic deprivation, protecting spent naval nuclear fuel, or ensuring that Russia continues to maintain the MPC&A effort into the future. CBO will analyze those issues in a later report if DOE officials decide to release the necessary information.

Despite the unavailability of data, CBO was able to estimate the cost of one possible approach to expanding the program—securing more fissile materials in the

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2. See, for example, Todd E. Perry, *Preventing the Proliferation of Russian Nuclear Materials: Limits of the Current Approach* (paper prepared for the annual meeting of the International Security Studies Section, International Studies Association, Monterey, Calif., November 8, 1998); and Kenneth N. Luongo and Matthew Bunn, "A Nuclear Crisis in Russia," *Boston Globe*, December 21, 1998.

nuclear cities. Assuming that DOE's average cost of roughly $10 million to secure a facility applies in the nuclear cities as well, securing fissile materials at 20 additional facilities in those cities would cost a total of $200 million, or $40 million a year over the next five years (see Table 1). However, more than 20 additional sites may contain fissile materials. Preliminary DOE analysis suggests that the number could be as high as 150. What is not clear is whether the most cost-effective course of action is to secure the materials at the many sites where they are today or to consolidate them at only a few locations. The MPC&A program office has yet to make a case for either option.

Cost-effectiveness aside, many experts believe that securing materials and establishing a comprehensive accounting system is the best way to prevent theft. The MPC&A program has been very successful in doing that, supporters observe, because it has helped Russia secure fissile materials at most civilian sites, many naval facilities, and some weapons-design and production sites. Given that success, they argue, the program should be given enough extra money to complete the job of securing all known sources of fissile materials in Russia. (The $200 million of CBO's illustrative approach would probably not be enough, however.) Moreover, Russia's recent economic turmoil increases the urgency to finish the task quickly, supporters say, and also argues for the United States to take immediate steps to ensure that the security systems already in place are not undermined by a desperate guard force.

But additional spending on the MPC&A program will need to be weighed against other priorities. Some people argue that the high-priority MPC&A tasks have already been budgeted for and that other nonproliferation programs—such as improving Russia's border controls or the economic condition of its nuclear cities—deserve a share of any future funding increase.

Establish the "Second Line of Defense" Program

The MPC&A program helps Russia protect and control its fissile materials at the source so they are not stolen. Similarly, a portion of the Defense Department's Cooperative Threat Reduction program helps Russia protect its nuclear weapons from theft. Those programs are considered the first line of defense against proliferation. But if materials or warheads are diverted from a protected facility or were never placed under safeguards in the first place, Russia has little ability to detect or halt nuclear smuggling. That is also true for nonnuclear materials and equipment that could be used to produce nuclear weapons. DOE's newly created "Second Line of Defense" program would help Russia detect nuclear materials as well as equipment that has both nuclear and nonnuclear uses before they could be smuggled out of the country.

TABLE 1. COSTS OF ILLUSTRATIVE APPROACHES TO PREVENTING THE SPREAD OF NUCLEAR MATERIALS, TECHNOLOGIES, AND KNOW-HOW

Option	Five-Year Total (Millions of 1999 dollars)
Expand the MPC&A Program	
Secure Fissile Materials at 20 Additional Sites	200
Establish the Second Line of Defense Program	
Equip 15 High-Priority Border Points and Train Personnel	60
Improve Export-Control Laws and Regulations	10
Establish the Nuclear Cities Initiative	
Pay Scientists to Stay in the Nuclear Cities	
Pay 20,000 nuclear workers directly	1,200
Establish nonproliferation, arms control, and environmental research centers at the two design labs and hire 200 scientists	12
Create Economic Opportunity in the Nuclear Cities	
Increase the IPP program at all nuclear cities	25
Establish business incubators at all nuclear cities	30
Establish investment initiatives at three nuclear cities for three years	36
Establish IFC centers at three nuclear cities	n.a.

SOURCE: Congressional Budget Office based on data from the Department of Energy.

NOTE: MPC&A = Materials Protection, Control, and Accounting; IPP = Initiatives for Proliferation Prevention; IFC = International Finance Corporation; n.a. = not available.

The program has two goals: to help train and equip Russia's customs service and border police so they can detect nuclear smuggling, and to work with Russian officials to establish the legal and regulatory framework that forms the bedrock of any export-control regime.[3] In addition, the program will help the customs service and border police establish the necessary training infrastructure and operational procedures so they can institute and maintain an effective nonproliferation culture within their organizations. Equipment that the program could provide includes portable radiation detectors that look like pocket pagers, small portal monitors for people and baggage at airports, and larger portal monitors for trucks, automobiles, and trains at ports and border crossings. (A portal monitor is a device through which people, cargo, and vehicles must pass to get into or out of a facility. Common examples of portal monitors are the X-ray machines and metal detectors that passengers and their luggage must pass through at airports. For detecting nuclear materials, portal monitors typically detect gamma rays emitted by the radioactive decay of the material.)

That equipment can be expensive—installing detectors at all of the roughly 500 border locations in Russia could cost several billion dollars. As a result, the Second Line of Defense program intends to focus on installing key systems at principal border crossings and on a few likely smuggling routes to demonstrate how such detection technology can reduce the chances of nuclear smuggling and increase revenues. Russia could then apply similar systems at other border locations.

A number of items and commodities that Russia exports today are dual-use items. In other words, they can be used to make nuclear weapons or other weapons of mass destruction but also have legitimate uses. Examples include certain types of furnaces, metals, and machine tools. Trade in dual-use items is loosely regulated in Russia: export-control laws and regulations are incomplete, the licensing and review process is haphazard, and customs officials have neither the training nor the equipment for proper enforcement. If those shortcomings could be addressed, the customs service could generate revenue from the tariffs, licensing fees, and fines that today go uncollected from legal, but regulated, traffic in dual-use items.

Officials of the Second Line of Defense program hope that if they show Russian customs officers the security and financial benefits of establishing a better export-control regime, the customs service will find that completing the job is in its own interest. Indeed, according to program officials, the customs service has started investing its own money to equip several locations. The Department of Defense, which runs a similar program for non-Russian states of the former Soviet Union and

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3. Technically, DOE refers to the first goal as the Second Line of Defense program; the second is part of DOE's export-control assistance program. CBO has presented the two programs together to reflect the fact that both would be needed to reduce smuggling.

some Eastern European countries, has found that the customs services appreciate the potential for increased revenues and have started to train their staffs, although they have been slow to install their own equipment. To help Russia enhance its efforts to prevent nuclear smuggling, the Second Line of Defense program, perhaps in conjunction with the Nuclear Cities Initiative described in the next section, could help Russia develop the necessary domestic suppliers of detectors and other equipment.

The size of the Second Line of Defense program could vary greatly depending on how much the United States wanted to do. DOE spent $3 million in 1998 for equipment and training and plans to spend half that amount in 1999 and 2000. It also plans to spend $700,000 a year to help establish export-control laws and effective processes for screening applications for export licenses. Altogether, DOE has allocated $7.3 million through 1999 to buy equipment for demonstrations at one airport and one port in Russia, to begin training some customs officials, and to start establishing regulatory procedures for nuclear materials and dual-use items.

To illustrate one possible approach to expanding the program, CBO assumes that the United States would install detection equipment at 15 locations that Russia has identified as high priority and help the Russian customs service train its personnel in using that equipment. In addition, program officials would work with customs officials to develop and implement the necessary laws, regulations, and license-review procedures to establish an effective export-control enforcement system, not just for nuclear materials but for dual-use items as well. The program would also work to establish a domestic vendor base for detection equipment. CBO estimates that this approach would cost a total of $70 million—or $14 million a year, on average—over the next five years (see Table 1).

That amount includes an average of $10 million each year to equip the 15 high-priority locations identified by Russia. Those locations include five airports, five sea or river ports, and five border crossings. Based on information from the Department of Energy, each airport would be outfitted with nuclear-material monitors for passengers, carry-on bags, luggage, and vehicles plus a video surveillance system at a cost of about $2 million. Each port would receive similar equipment, CBO assumes, but with more emphasis on vehicles and large cargo containers. The cost per port would be about $5 million, CBO estimates. Border crossings would cost about $3 million each.

Training Russian customs personnel to operate, maintain, and repair the equipment would cost another $2 million a year, or $10 million over the next five years. It would be accomplished by developing a curriculum and installing training equipment for Russian instructors to use at their existing training facilities. Training would initially take place in the United States, with subsequent classes being held in Russia.

An additional $2 million would be spent each year to help Russia improve its export-control regulations and license-review system and establish a domestic supply of equipment. Spending a few million dollars annually after the first five years would help ensure that the customs service continued to do the necessary training of its personnel and the maintenance and calibration of its equipment and had effectively integrated the mission to halt nuclear smuggling into its organization.

What would the United States get for that investment? Fifteen high-priority locations would be able to detect smuggling of nuclear materials and dual-use items (although nearly 500 other locations would remain untouched). Russia would also have a more effective export-control system and license-review process. In addition, Russian customs officials would have a program to train their personnel to detect nuclear smuggling.

Supporters of the Second Line of Defense program believe that it represents an important start: Russia's ability to develop effective export-control laws and to enforce them by detecting nuclear materials, weapons, and technologies will be essential for halting proliferation. Some analysts may worry, however, that the problem is too big to solve. It does not matter how much the United States or Russia spends on equipment and training, they say; proliferation could happen anywhere across the thousands of miles of Russian borders. In their view, money may be more effectively spent to secure any fissile materials that are not protected. Supporters of the program acknowledge that borders cannot be made impervious but counter that effective export-control laws and increased border surveillance will boost the difficulty of nuclear smuggling, thus reducing the chance that nuclear materials or dual-use equipment will leave Russia.

Fund a Program to Stabilize and Consolidate Russia's Nuclear Cities

The MPC&A and Second Line of Defense programs focus on preventing the proliferation of nuclear materials. The Nuclear Cities Initiative is intended to address another proliferation concern: the possibility that nuclear weapons scientists may market their skills to countries that are attempting to build such weapons.

Throughout the Cold War, the Soviet Union developed and built its nuclear weapons in an archipelago of 10 secret nuclear cities spread across Russia that were closed to the world outside their fences. Those cities were operated by the Ministry of Atomic Energy (Minatom) and its predecessors, an agency similar to the U.S.

Department of Energy and its antecedents. The citizens of the nuclear cities were considered special and were well rewarded.

Russia has not yet followed the U.S. lead in significantly cutting the size of its weapons complex since the end of the Cold War. It continues to operate the same facilities and has not reduced employment despite the sharp reductions in Minatom's budget and in the number of nuclear weapons deployed in Russia. In the past few years, Minatom has rarely received anything close to its annual budget request; it received just 48 percent of its budget in 1997, according to the Minister of Atomic Energy. As a result of those shortfalls, weapons scientists and technicians have often not been paid for months at a time.

The state of affairs in the nuclear cities has worried experts in the United States: underpaid and unappreciated employees might succumb to the temptation to earn large sums by helping hostile nations or terrorist groups develop nuclear weapons. They could also make ends meet by selling fissile materials from their facilities to foreign agents or the organized crime syndicates that pervade post-Soviet Russia. Indeed, several people have been caught with relatively small amounts of fissile material stolen from Russian research institutes. Although one theft may have occurred at a nuclear city (Arzamas-16), none have yet been confirmed there or at any of Minatom's nuclear weapons facilities.[4] The most recent economic crisis has heightened U.S. concerns.

As mentioned above, the United States has established several programs to address some of those problems. The Department of Energy's Initiatives for Proliferation Prevention (IPP) program spends about $30 million a year to help roughly 1,700 scientists in Russian nuclear, chemical, and biological research institutes (not just those in the nuclear cities) develop products that can be commercialized. In addition, the State Department's $7 million a year contribution to the International Science and Technology Center (ISTC) in Moscow—combined with contributions from the European Union, Japan, Norway, South Korea, Sweden, and other sources—supports more than 15,000 nuclear, chemical, biological, and missile scientists annually (although many of them are part time, with the average researcher working 68 days a year). Finally, the Congressionally chartered Civilian Research and Development Foundation has spent more than $26 million since 1995 to support defense scientists in Russia and other former Soviet states.

Another important initiative has been the lab-to-lab efforts that DOE has undertaken as part of the MPC&A and other programs. Those efforts have paid

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4. Emily S. Ewell, "NIS Nuclear Smuggling Since 1995: A Lull in Significant Cases?" *Nonproliferation Review*, Center for Nonproliferation Studies, Monterey Institute of International Studies (Spring-Summer 1998), pp. 119-125.

Russian weapons scientists to work on a wide variety of topics of interest to the United States and Russia. In effect, the Russians work as contractors and are paid when their products (often studies or research papers) are delivered. That has been an inexpensive way to get work done—DOE has paid Russian scientists at the laboratories an average of $600 a month. But perhaps the most significant benefits of the lab-to-lab efforts have been the gradual opening of the closed cities and Russia's nuclear weapons program to U.S. officials and scientists and the strengthening of a constituency within Minatom for nonproliferation and arms control efforts.

The Nuclear Cities Initiative. Recently, Minatom has realized that it cannot afford to support its Cold War-size weapons complex. But it is hesitant to consolidate that complex out of a sense of obligation to its employees and their families. To address U.S. and Russian concerns about the nuclear weapons complex, the two countries agreed to start a program called the Nuclear Cities Initiative in March 1998 at the 10th meeting of the Gore-Chernomyrdin Commission.

The Nuclear Cities Initiative has two main goals: stabilizing the nuclear cities to reduce proliferation risks and helping Russia consolidate its nuclear complex to match the needs of smaller nuclear forces. The point of stabilizing the nuclear cities is to reduce the incentives for weapons scientists and other nuclear workers to take their skills or nuclear materials elsewhere. Another reason for stabilization is to help Minatom retain enough people who understand and can be proper stewards of the fissile materials that will remain at the nuclear facilities indefinitely. For Russia, the point of consolidating the nuclear complex is to reduce operating costs at a time when it cannot afford to retain large excess capacity. For the United States, consolidation is worthwhile for another reason: it would reduce Russia's weapons-production capability, which is much larger than that of the United States. As arsenals continue to shrink, Russia's ability to produce nuclear weapons rapidly could become a greater concern. Consolidation should also make it easier for Russia to establish an effective national accounting system for fissile materials—an important component for reducing the chances of theft.

The twin goals of the Nuclear Cities Initiative are somewhat contradictory, however. To be efficient, consolidation would quickly eliminate most of the jobs at the facilities that were closed. But for nonproliferation reasons, the last thing that the United States would like to see is large numbers of weapons scientists thrown out of work, particularly when Russia's economy offers them little chance for alternative employment. As a result, many advocates of the Nuclear Cities Initiative suggest that the United States should help Russian weapons scientists make the transition to the commercial sector—for example, by attracting businesses to those cities and creating private enterprises there. Such commercialization is the primary focus of the Nuclear

Cities Initiative agreement that Secretary of Energy Bill Richardson and Minister of Atomic Energy Yevgeny Adamov signed in September 1998.

The United States has not yet determined exactly how it will implement the Nuclear Cities Initiative. But it has agreed with Russia to create a three-level structure to oversee and implement the initiative. Those three levels will consist of a steering committee that includes the relevant government agencies from both countries, an advisory committee of experts from outside both governments, and a collection of joint working groups to address issues that arise in carrying out the initiative in the three nuclear cities that will be targeted initially (Arzamas-16, Chelyabinsk-70, and Krasnoyarsk-26).[5] DOE has been named to head the U.S. steering committee. Ultimately, many different federal and international agencies and nongovernmental organizations could be involved.

One of the first challenges the Nuclear Cities Initiative will face is funding. The Administration did not request, or the Congress provide, any new money for the initiative for 1999. The Energy and Water Appropriations Act for 1999 allows the Department of Energy to spend up to $15 million on the Nuclear Cities Initiative, but it provides no new money. In other words, any spending on the initiative for 1999 must be taken from DOE's other arms control programs. DOE plans to do just that: it has taken $7.5 million from the MPC&A program and $7.5 million from prior-year money to create a $15 million program for 1999. In addition, the department has requested $30 million in new money for 2000.

The United States could take two basic approaches to reducing the incentives for weapons scientists to market their skills or nuclear materials elsewhere: pay their salaries, or help them establish commercial enterprises that would provide an alternative source of income (one that is independent of Minatom or subsidies from the United States). Of course, the two approaches could also be combined. The second approach—commercialization—is also frequently mentioned as a way to help Minatom consolidate its nuclear facilities.

CBO has examined six options to address the problems in the nuclear cities. The first two options illustrate ways that the United States might pay people to stay in the cities, the first approach listed above. Option 1 would pay all of the roughly 20,000 scientists and workers to stay and provide as much research or other work for them as possible. Option 2 would take a more minimal approach, creating research centers for 200 weapons scientists to do nonproliferation, arms control, and environmental work. The last four options illustrate ways to create economic

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5. See Kenneth N. Luongo and William E. Hoehn, *The Nuclear Cities Initiative: Status and Issues* (Princeton, N.J.: Russian American Nuclear Security Advisory Council, January 1999), for a detailed overview of the Nuclear Cities Initiative.

opportunities in the nuclear cities: use the same approach as the IPP program, establish business incubators, emulate the State Department's Regional Investment Initiative, and stimulate investment through multilateral banks such as the World Bank. Of course, the United States could adopt a combination of those or other options.

People might disagree with the Administration's Nuclear Cities Initiative for several reasons. For some, the problem may be too big or difficult to solve: money spent on the initiative might only be marginally effective and would be diverted from other pressing needs, such as securing fissile materials. Other people may support the goals of the initiative but disagree with the way DOE is likely to implement it. Some criticize the program's narrow focus on the 10 nuclear cities. They argue that many other nuclear workers at Russia's myriad civilian nuclear power and research institutes have the skills or access to fissile materials to present proliferation risks. In their view, those experts are more vulnerable to proliferation pressures because they live and work in places that are far more accessible to foreign agents and organized criminals than people who live behind the fences of the nuclear cities. Indeed, the United States has imposed sanctions on several civilian institutes for helping Iran develop nuclear weapons technologies. Some of those critics also believe that the United States cannot address the proliferation problems in Russia with $30 million a year, so it should spend significantly more. Finally, some experts who support the goals of the Nuclear Cities Initiative worry that it may duplicate existing programs such as the ISTC or IPP. They fear that the time and money the United States will spend to establish the new program in Russia could be invested more effectively through ongoing programs. Some critics are also concerned that the initiative may divert resources from programs that they believe are more pressing. Supporters acknowledge that solving the problem will be difficult, but they believe that the danger to the United States from the spread of nuclear weapons is serious enough that the United States must try to do whatever it can to avert that threat.

<u>Paying Scientists and Nuclear Workers to Stay in the Nuclear Cities</u>. The United States could take either a comprehensive or a more limited approach to paying the salaries of Russia's weapons scientists and nuclear workers in order to reduce the incentives for them to sell their skills or the fissile materials in their custody. To illustrate those different approaches, CBO examined two possible options.

Option 1: Pay 20,000 Key Nuclear Workers to Stay. In the first option, the United States would supplement the salaries of all scientists and other nuclear workers who have the skills, knowledge, or access to nuclear materials to present proliferation risks. The number of such people in Russia's nuclear weapons complex is difficult to estimate. For the purposes of this option, CBO assumed that roughly 20,000 nuclear scientists and workers were potential proliferation risks. According to a 1996 estimate by Glenn Schweitzer, the first executive director of the ISTC, about 20,000

scientists and technicians, primarily in Minatom's 30 research and development (R&D) facilities, have experience and skills that would make them attractive to countries seeking to develop nuclear weapons.[6] Although that figure overstates the number of technical experts in the nuclear cities, since some of them are employed in Minatom's 20 other R&D facilities, it also excludes other workers and guards in the nuclear cities who have access to nuclear materials. More recently, Dr. Schweitzer indicated that 20,000 would be a reasonable rough estimate for the number of both technical and nontechnical people in the nuclear cities who pose proliferation risks.

A recent press report also suggests that 20,000 workers may be a reasonable rough estimate.[7] According to that report, Russia has about 2,500 nuclear weapons scientists (mostly at the two weapons-design laboratories), another 5,000 specialists who fabricate weapons and handle materials, and at least 12,000 to 15,000 workers involved in uranium and plutonium production, delivery systems, and other aspects of weapons of mass destruction. Clearly that total—some 20,000 to 23,000 workers —includes at least several thousand people not involved with nuclear weapons or materials. But like Dr. Schweitzer's original estimate, it does not include all of the workers and guards who have access to fissile materials in the nuclear cities, a group that could easily number several thousand.

Assuming that funding each worker costs about $1,000 a month and that 20,000 workers would be targeted, this comprehensive option could cost the United States as much as $240 million a year (see Table 1). For several reasons, however, that figure may be too high by several tens of millions of dollars. First, labor costs could be lower than CBO has assumed. The figure of $1,000 a month is based on the labor costs of the MPC&A program and assumes that there will be additional costs for equipment and oversight by DOE's weapons labs.[8] But labor costs would be lower if oversight was kept to a minimum or if a more efficient model for funding research was used. One such model is the ISTC, which does not pay the same high overhead rates to the Minatom institutes that the MPC&A program does. Second,

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6. See Glenn E. Schweitzer, *Moscow DMZ: The Story of the International Effort to Convert Russian Weapons Science to Peaceful Purposes* (Armonk, N.Y.: M.E. Sharpe, 1996), p. 103.

7. David Hoffman, "Idled Arms Experts in Russia Pose Threat: Many Take Talents to Developing States," *Washington Post*, December 28, 1998, p. A1.

8. CBO's estimated cost per worker is higher than the $600 monthly wage that DOE has been paying scientists under its lab-to-lab efforts because it includes nonpay expenses such as the cost of oversight and management by DOE's weapons labs and the cost of equipment and other supplies. If the United States chose a less expensive approach, this option could cost less, perhaps only about $140 million a year if the scientists and nuclear workers were paid an average of $600 a month. Those lower rates would be consistent with an approach that used the ISTC to fund research or an approach that used DOE's lab-to-lab efforts to pay wages but had little oversight and did not purchase equipment for scientists to conduct such research.

some of those 20,000 scientists and nuclear workers are already being compensated through existing U.S. programs such as the lab-to-lab efforts, the IPP program, the U.S. purchase of surplus bomb materials from Russia, and U.S. efforts to help Russia dispose of its surplus plutonium. Some workers could even be compensated through other programs in the Nuclear Cities Initiative aimed at creating new businesses. Costs might be higher, by contrast, if more than 20,000 nuclear workers presented proliferation risks.

The goal of the comprehensive option would be to employ as many of those people as possible in useful work, such as conducting research or helping in other nonproliferation programs. The ISTC has been engaging scientists and technicians in that way since the early 1990s and may be well equipped to expand its efforts in the nuclear cities. More at-risk nuclear workers could also be employed by expanding DOE's cooperative lab-to-lab efforts in such programs as MPC&A and IPP. Some workers could be employed in new nonproliferation, arms control, and environmental research centers, as discussed below. But it is unlikely that those programs could absorb more than a portion of the 20,000 workers right away. After all, the existing U.S. and international efforts fund roughly 10,000 Russian nuclear, chemical, and biological weapons scientists and other workers each year, only some of whom are in the nuclear cities. As a result, at least a portion of those 20,000 workers would be paid to stay in the nuclear cities without having any research or other work to do.

Would paying all 20,000 workers eliminate the potential proliferation risks they pose? Not entirely. Certainly, providing adequate wages would significantly reduce the risk that financial desperation would drive nuclear workers to sell their skills or nuclear materials. But there would be no guarantee that the few who were motivated by greed would not sell to the highest bidder. The United States could eliminate that risk only by outbidding all others—a cost that could easily exceed the $1,000 a month proposed here. Another concern about this approach and the Nuclear Cities Initiative in general is that by focusing exclusively on the cities, it overlooks nuclear scientists and technicians working at other Minatom facilities who also present proliferation risks.

One big advantage of this comprehensive approach, however, is that it would not depend on the health of Russia's economy for success. Thus, it could be particularly useful today, when the Russian economy is in crisis and developing new businesses is more difficult. Unfortunately, the incentives created by this approach would persist only as long as the United States continued the funding, or until Minatom got larger budgets. By contrast, the incentives to stay could be self-sustaining if a healthy commercial economy could be created in the nuclear cities—the second goal of the Nuclear Cities Initiative.

Paying all 20,000 workers would present a number of other problems. The first reflects the paradox in the twin goals of the Nuclear Cities Initiative: the United States would like to encourage Russia to consolidate its nuclear complex in the long run, not preserve that complex at its present size. But paying nuclear workers' salaries might create expectations of long-term assistance and thereby reduce any incentives for them to find work in the commercial sector. The United States could counter that problem by declaring that the subsidies would end after a set period (assumed here to be five years)—long enough, perhaps, for the economy to improve. The United States could also work to reduce the nuclear cities' dependence on subsidies over time by encouraging economic diversification there. Another pitfall of this approach is that the United States could end up paying the Russian scientists and engineers who continued to design and build nuclear weapons.

Option 2: Establish Nonproliferation, Arms Control, and Environmental Research Centers. Alternatively, the United States could adopt a more modest approach than the one described above by helping to create research facilities at the weapons-design labs (to work on nonproliferation, arms control, and environmental issues) and funding a few hundred weapons scientists to do work of mutual interest to the United States and Russia.

To illustrate that second approach, CBO assumes that the United States would help Minatom set up research centers at Russia's two weapons-design laboratories, Chelyabinsk-70 and Arzamas-16. Those centers would be similar to the nonproliferation centers that exist at all three U.S. weapons labs (Los Alamos, Lawrence Livermore, and Sandia). Not only would the centers hire scientists to examine important technical issues—such as ways to verifiably dismantle surplus warheads (which will be part of the negotiations for START III) or monitor and clean up environmental pollution created by 50 years of nuclear weapons production—but they could strengthen the constituency within Minatom that has an interest in nonproliferation and arms control. Employing Russian scientists would also help the United States establish better contacts within the nuclear cities.

Some analysts have suggested that one area for expanded cooperation—environmental research—could be funded as part of the science and technology development program within DOE's $6 billion Environmental Management program. Although DOE already spends about $1 million a year on such research in Russia, advocates of this approach argue that Russia's experience with nuclear pollution, its extensive data on how nuclear contamination spreads, and its ability to conduct research on cleanup technologies mean that expanding the program would be beneficial for both countries.

How much the United States would spend to establish the research centers would depend on its demand for analytical work and the number of Russian scientists it wanted to support. Funding 200 scientists (100 at each lab at $1,000 per month per person) would cost about $2.4 million a year (see Table 1). Although such a program would be much less expensive than the comprehensive option, it would support far fewer people and thus could be much less effective. This estimate assumes that DOE's commitment would last for only five years; after that, Minatom would have to fund the centers.

In some ways this option is similar to the multilateral International Science and Technology Center in Moscow, funded in part by the State Department. As noted above, the center hires former nuclear, biological, and chemical weapons scientists to do nonweapons work, whereas the proposed research centers would be located in the nuclear cities and focus on nuclear scientists. This option is also similar to DOE's lab-to-lab efforts and would fund work in the same manner, with payment received upon delivery of the product. In fact, the research centers created in this option could complement those ongoing programs.

Creating research centers avoids many of the drawbacks that would be raised by paying all 20,000 people who are estimated to be potential proliferation risks. But it would not address the larger issue of economic deprivation in the cities, so it might not be as effective in reducing the threat of proliferation. Nor would it address those nuclear workers employed in the eight other closed cities or those nontechnical people in the weapons-design labs who have access to nuclear materials. Like the comprehensive option, this option's research centers would not depend on the health of Russia's economy for success, although they would exist only as long as they were funded by the United States or Minatom.

Creating Economic Opportunity in the Nuclear Cities. Instead of paying weapons scientists to stay in the nuclear cities, the United States could help them find new jobs by creating economic opportunities in those cities. That is the main focus of the formal agreement between the United States and Russia on the Nuclear Cities Initiative. With new jobs in the private sector, weapons scientists and other nuclear workers would have less incentive to sell their skills or nuclear materials elsewhere. And Minatom would be able to consolidate its nuclear facilities without worrying about laying off thousands of workers.

CBO has examined four options for creating economic opportunities in the nuclear cities: increasing the efforts of the Initiatives for Proliferation Prevention program in the nuclear cities, establishing business "incubators" that provide equipment and support for new businesses, adopting a State Department model for stimulating regional investment, and relying on multilateral development banks such as the World Bank. Those options illustrate somewhat different strategies for encouraging the formation of small and medium-size businesses in the nuclear cities, but they are not meant to be exclusive. Other strategies are possible, and several strategies could be combined as part of a diverse effort to create businesses there.

The desire to help Russia stabilize the nuclear cities by diversifying their economies must be balanced against other factors, however. For one thing, converting defense plants and employees to commercial work has a checkered history even in countries with well-established market economies. Conversion could prove harder in Russia, which has little experience with such an economy. For another thing, Russia's current economic problems could make conversion even more difficult. New uncertainties about the future of the economy and the government's economic plans will make it tougher for start-up businesses to attract customers and investors.

Supporters of efforts to diversify the economies of the nuclear cities acknowledge the difficulty of defense conversion, particularly in today's environment. But they contend that the risks from nuclear proliferation are serious enough that the United States must try to do something. Paying scientists and other nuclear workers to stay put or establishing nonproliferation research centers can help in the short run, particularly since those programs are not sensitive to the state of the Russian economy. But the United States cannot bear those costs indefinitely, they argue; therefore, it should help develop business skills and more diverse economies in the nuclear cities soon so that workers will be ready when the economy improves. Supporters also point out that the costs of those conversion efforts would not be large.

Option 3: Use the Same Approach as the Initiatives for Proliferation Prevention Program. The United States already runs a program to encourage nuclear, chemical, and biological weapons scientists in the former Soviet Union to start commercial enterprises, but it is not focused on the nuclear cities. The IPP program helps scientists identify technologies that could be commercialized and then pairs them with a U.S. company that is interested in the technology to help develop the product and finance its production.

One approach to the Nuclear Cities Initiative would be to run it (or part of it) much like IPP but with a greater focus on the nuclear cities. IPP has experience at a broad range of facilities: some 300 projects at more than 150 institutions in the former Soviet Union. But despite its breadth and success in employing weapons scientists, the program has produced few commercial ventures. A recent audit by the General Accounting Office (GAO) echoed that assessment.[9] It also questioned how efficiently IPP has spent its money. For example, GAO found that only 37 percent of IPP's past funding was spent in the states of the former Soviet Union—the rest

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9. General Accounting Office, *Nuclear Nonproliferation: Concerns with DOE's Efforts to Reduce the Risks Posed by Russia's Unemployed Weapons Scientists*, GAO/RCED-99-54 (February 1999).

was spent in the United States, mostly at DOE's weapons laboratories. Furthermore, only a portion of the 37 percent actually spent in the target countries reached scientists, because their institutes deducted overhead charges and various Russian agencies extracted taxes and other fees. Finally, GAO raised concerns about the possible effects of the IPP program on national security. Some scientists employed by IPP continue to work in Russia's weapons programs, and some dual-use projects may have provided Russia with defense-related information. Taken together, those findings led GAO to recommend that DOE wait before expanding the Nuclear Cities Initiative beyond the original three cities.

DOE concurred with many of GAO's criticisms and said it plans to carry out most of the recommendations in the GAO report. Regarding the national security concerns, DOE stated that the dual-use projects in question occurred only during the early phase of the IPP program and at most provided only "incidental" military benefits to Russia. The department said that it has recently taken steps to ensure that all projects have only peaceful purposes. With respect to subsidizing scientists still at work on weapons, DOE argues that since the goal of IPP is to keep weapons scientists in their own country, it targets those who are employed as well as those who are not. Employed scientists are rarely paid these days and—like their unemployed colleagues—may be tempted to sell their services abroad. Moreover, DOE contends, the United States is not subsidizing weapons work because the department adjusts the value of its contracts with scientists according to the time necessary to complete the task. Finally, in DOE's view, the time a scientist spends working on an IPP project is time he or she cannot work on weapons.

Critics have raised several other concerns about the IPP program. Some people have criticized it for promoting technologies without first determining whether demand for them exists. Others believe that IPP's reliance on U.S. investment is inappropriate; Russian investment, they argue, would help ensure that products were better matched to the Russian economy. Still others criticize what they perceive as the program's emphasis on high-end technologies for which there may be little domestic demand. However, developing technologies for foreign markets may be a better course until Russia's economy improves.

In the past few years, the Congress has appropriated about $30 million annually for IPP. In 1999, however, the Congress has allowed the program to spend no more than $25 million. Program officials hope to return appropriations to the $30 million level in the future and to spend more in the nuclear cities. If the IPP program did receive annual appropriations of $30 million, the extra $5 million each year could be devoted to the nuclear cities, in which case spending for the Nuclear Cities Initiative would total $25 million over five years (see Table 1).

Option 4: Establish Business Incubators. A second way that the Nuclear Cities Initiative could help develop a private sector in those cities would be to establish so-called incubators to encourage the formation of small businesses. Rather than fund specific commercial projects, as IPP does, the United States could use incubators to provide the common support infrastructure—such as office equipment, small-scale machine shops, and computer programs—that new business ventures need to get started. Incubators can also provide support services such as a secretarial pool and accounting and payroll services.

The United States has a wide variety of business incubators, some run with significant government subsidies and others as profit-making enterprises. For-profit incubators charge rent to their tenant businesses. CBO assumes that the incubators set up at the Russian nuclear cities would follow the for-profit model. That would give their managers an incentive to select as tenants those start-up companies that appeared most likely to succeed.

In this option, Minatom would provide management teams and buildings for the incubators. The buildings would be inside the closed cities but have special arrangements to allow easy access for potential Russian financial backers and customers. The United States would provide basic equipment and specialized computer programs (such as engineering and numerical analysis programs) as well as salaries and benefits for the management teams. That subsidy would decrease gradually, with the understanding that rent collected from tenants would eventually fund the incubators.

The management teams from Minatom would be wholly responsible for selecting tenant businesses. Since successful incubators in the United States have concentrated on attracting businesses that serve local needs, Minatom would probably also find that to be a successful strategy.[10] Further, incubators that concentrated on supplying local needs might be able to receive favorable local tax status.

One advocate of incubators has suggested that Russia could expand markets for the start-up firms by implementing laws that encouraged federal, regional, and local governments to buy Russian-made products first. (According to that advocate, those governments typically have a predisposition to shun domestic products in favor of more expensive ones made overseas.) Some economists who support closed markets for developing countries argue that such laws would make sense. But many

10. See, for example, Louis G. Tornatzky and others, *The Art and Craft of Technology Business Incubation: Best Practices, Strategies, and Tools from More Than 50 Programs* (Research Triangle Park, N.C.: Southern Technology Council, 1996).

Western economists worry about the market distortions that such implicit subsidies create.

To attract former weapons scientists and engineers to the commercial sector, the United States would pay the salaries and benefits of selected categories of scientists. (Apparently, a chief worry of scientists and engineers who are contemplating starting a company is the possibility of losing benefits if the enterprise does not succeed.) That funding would follow a gradually decreasing scale, with the expectation that after five years the scientists would be fully funded by their new companies.

On the basis of DOE's experience with paying Russian scientists, and the infrastructure costs of similar incubators in the United States, CBO estimates that establishing a business incubator would cost $3 million over the first five years. That figure comprises about $1 million in one-time equipment costs and $2 million in salary subsidies to management and entrepreneurs. Thus, setting up an incubator in each of the 10 Russian nuclear cities would cost an average of about $6 million annually, or $30 million over the first five years (see Table 1). After that, recurring costs would total $3 million each year for the 10 incubators combined to pay salaries and maintain equipment.

Those estimates assume that the subsidy to incubator managers would be phased out over five years as the new businesses paid increasingly higher rents. If the businesses did not succeed, costs would be higher, and either the United States or Minatom would have to make up the difference.

Option 5: Emulate the State Department's Regional Investment Initiative. A third way the Nuclear Cities Initiative could stimulate economic opportunities would be to use the State Department's Regional Investment Initiative (RII) program in Russia as a model. Unlike the other options discussed here, the RII program focuses on an entire region (similar to a U.S. state) rather than a specific city. The philosophy is that a pro-business environment must be created at the regional level for new businesses to succeed.

The RII program was established in 1997 by the Gore-Chernomyrdin Commission to facilitate investment and business development in four selected regions of Russia that have "a proven commitment to economic reforms and investment-friendly policies." Three regions have been picked so far, none of which has a nuclear city in it. The still-to-be-determined fourth region could contain one or more nuclear cities, but program officials do not want to change their selection criteria simply to include one.

The RII program's goals and approaches are similar in many respects to some of the proposals made for the nuclear cities (although the focus is more at the regional level): work with authorities to address obstacles to investment; encourage the formation of small and medium-size businesses by matching potential projects with business consultants, training services, and sources of financing; and promote partnerships between U.S. and Russian business organizations and universities. That similarity suggests that the RII approach may be appropriate for the Nuclear Cities Initiative.

The State Department has budgeted about $17 million for the Regional Investment Initiative to cover expenses for the three selected regions over an 18-month period. Since the program aims to establish self-sustaining institutions so that U.S. funding can be phased out after two or three years, the State Department says it will seek additional funding in future budgets to complete a two- to three-year program in each region. It is still too early to tell how effective the RII program will be.

This option would create a similar program within DOE that would focus on three regions that have nuclear cities in them and last for three years. CBO estimates that this option would cost a total of about $36 million over five years, or about $12 million per city, assuming that costs were similar to those the State Department has experienced (see Table 1).

Option 6: Stimulate Investment Through Multilateral Banks. The Nuclear Cities Initiative could adopt a different approach to encourage economic opportunities: use multilateral development banks to direct the conversion effort. Researchers at Princeton University have proposed that approach, arguing that stabilizing Russia's nuclear cities will require an international effort to provide adequate funding and experience.[11] The proposal would take advantage of two programs run by the International Finance Corporation (IFC)—an agency of the World Bank—to provide the necessary business skills and aid in creating joint ventures. (The European Bank for Reconstruction and Development has similar programs that could be used instead.)

The first program would focus on the Minatom weapons facility within a closed nuclear city. It would establish a multidisciplinary technical-assistance team from the IFC to help Minatom staff identify and analyze commercial projects and conduct market research. It would also help the staff work with governments to improve the business climate by resolving property rights, tax, regulatory, and

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11. Jill Cetina, Oleg Bukharin, and Frank von Hippel, *Defense Conversion and Small Business Development: A Proposal for Two IFC Projects in Three of Russia's Closed Nuclear Cities,* PU/CEES Report 306 (Princeton, N.J.: Princeton University Center for Energy and Environmental Studies, March 1998).

security issues. In addition, the IFC team would help the facilities find strategic partners and might also provide loan guarantees and other forms of insurance.

The second IFC program would focus on the closed city surrounding the Minatom weapons facility, establishing a business training center to support the creation of small and medium-size businesses. The center would offer classes and access to computers, fax machines, and legal and tax documents. Selected staff from the Minatom facility and local government officials would be among the first students. To ensure that the center remained viable in the long term, it would eventually start charging tuition and could even be run as a private enterprise. The IFC has established 10 similar centers in Ukraine and Belarus.

The Princeton group advocates setting up training centers in three closed cities (Arzamas-16, Chelyabinsk-70, and Krasnoyarsk-26) and sending a technical assistance team to one of those cities to help the Minatom facility there establish commercial enterprises. Because these would be pilot programs, they would continue after the second year only if they were successful. Expansion should await the success of the initial program, the authors argue. CBO has not estimated the cost of this option.

The Princeton group argues that internationalizing the Nuclear Cities Initiative through multilateral development banks, such as the World Bank or the European Bank for Reconstruction and Development, is an important goal. As is the case with the International Science and Technology Center in Moscow, other major industrialized nations would help share the cost of this program to halt proliferation since it could improve security for all of them. This option would also ensure that the program was run by an institution with extensive experience in international development, rather than by the U.S. Department of Energy, which has none. Furthermore, the authors contend, the IFC has the experience and reputation in Russia to increase the chances that the program will succeed. Others analysts have raised concerns, however, about the degree to which large international organizations can promote economic development.

Combining Approaches. The best way to create economic opportunity in the nuclear cities may be to combine some of the four options described above with each other or with approaches that have not been described here. In that case, entrepreneurs who took advantage of the incubators could receive financing from the IFC or IPP and could learn how to start a business through one of the IFC's business education centers. Larger ventures within a Minatom facility could get their start with IPP money and IFC advice. All of those efforts might be aided by a pro-business regional environment created in part by the Regional Investment Initiative or a similar DOE program focusing on the regions that contain nuclear cities. Coordinating the

Nuclear Cities Initiative with other U.S. and international efforts would also be important to ensure that they did not overlap or work at cross-purposes.

Nevertheless, economic conversion efforts are likely to face difficulties in the near future, given Russia's troubled economy. For that reason, any effort to stabilize the nuclear cities will probably require striking a balance between paying scientists and other nuclear workers to stay in the short term and creating economic opportunities over the longer term as the national economy recovers.

OPTIONS FOR IMPROVING "TRANSPARENCY" IN DISMANTLING WARHEADS AND VERIFYING FISSILE-MATERIAL INVENTORIES

An important concern with many arms control agreements is how the parties can be confident that the agreed-upon activities are actually taking place. One way to boost that confidence is to increase the visibility—or "transparency"—of the activities through such measures as inspections, joint experiments, and exchanges of data. Transparency is central to a number of important ongoing and anticipated negotiations, some aimed at reducing the number of deployed warheads and others intended to protect fissile materials from theft. Currently, the United States is negotiating transparency agreements with Russia for the Highly Enriched Uranium Purchase Agreement so it can be confident that the nuclear fuel it is buying comes from nuclear weapons. The United States is also negotiating similar arrangements to ensure that the nuclear materials that will be placed in the Russian storage facility at Mayak come from dismantled Russian weapons. Both the Purchase Agreement and the Mayak storage facility are U.S. efforts to ensure that fissile materials cannot be stolen. Further, the Helsinki framework for START III calls for the treaty to contain "measures relating to the transparency of strategic nuclear warhead inventories and destruction of strategic nuclear warheads." Finally, Presidents Clinton and Yeltsin have agreed to negotiate a series of transparency initiatives and mutual reciprocal inspections relating to each country's stockpiles of nuclear weapons and materials, although those negotiations have been suspended for now.

CBO has examined two ways to improve transparency. The first would increase funding for DOE's warhead transparency program to allow more U.S. and joint U.S./Russian analyses and demonstrations so both sides could begin cooperating on this sensitive topic. The second would fund a joint experiment to measure the amount of plutonium that was made in old production reactors. If the measuring technique proves to be valid, such information may eventually be used to confirm the amount of weapons-usable fissile material that each side produced.

Increase Funding for DOE's Warhead Dismantlement and Fissile Materials Transparency Program

Many of the current negotiations on transparency depend on technical research and analysis funded by DOE's Warhead Dismantlement and Fissile Materials Transparency Program. Important aspects of that program are joint visits, demonstrations, and experiments with Russia. Because of budgetary shortfalls, however, a number of those efforts have been cut short or not yet begun, according to program officials.

This option would raise funding to the levels that the warhead transparency program office argues would be needed to support the program's planned work—at an additional cost of $10 million in 1999 and $20 million a year from 2000 through 2003 (see Table 2). That work, which is central to both ongoing and future negotiations, includes developing technology; analyzing the technical, security, and vulnerability impacts of alternative approaches; and testing proposed methods on actual U.S. and Russian nuclear warheads and their components.

The highly technical and sensitive nature of warhead and fissile-material transparency requires that proper research and analysis be done to ensure that any resulting agreement is in the United States' interests. Any transparency regime related to dismantling nuclear warheads must struggle with a basic dilemma: complete transparency cannot coexist with the need to protect closely guarded secrets about weapons design. For example, to have a high degree of confidence that what

TABLE 2. COSTS OF ILLUSTRATIVE APPROACHES TO IMPROVING TRANSPARENCY IN DISMANTLING WARHEADS AND VERIFYING FISSILE-MATERIAL INVENTORIES

Option	Five-Year Total (Millions of 1999 dollars)
Increase Funding for Research on Warhead Transparency	90
Sample Russian Reactors to Test a Technique for Measuring Past Plutonium Production	3

SOURCE: Congressional Budget Office based on data from the Department of Energy.

they are seeing is a warhead or warhead component, inspectors must take measurements that reveal important information about a weapon's design; to protect that information, they must reduce the confidence in their measurements.

DOE's Warhead Dismantlement and Fissile Materials Transparency Program is designed to address that dilemma. Through analysis, research, experiments, and demonstrations of different approaches to transparency, the program aims to provide the technical and operational inputs to help the United States determine what degree of transparency will allow it to have confidence in Russian compliance without revealing too much about its own weapons. Russia must struggle with the same question, of course. The program also conducts joint efforts with Russian weapons laboratories to broaden understanding about the ways in which each country does business and the issues that each considers sensitive. That information can be an important precursor to successful negotiations.

At its current funding level, the program can conduct conceptual studies of transparency issues and provide basic support for START III and other negotiations. But according to program officials, it can fund only a minimal lab-to-lab program on transparency and cannot adequately address transparency technologies for START III or other applications. Indeed, lower-than-expected funding has forced the program office to postpone several important projects, including U.S./Russian transparency demonstrations, analysis by a Russian laboratory of the deactivation of plutonium components of nuclear weapons, and other joint technical work with nuclear weapons labs in Russia.

At the budgets proposed in this option, DOE could support unclassified reciprocal familiarization visits to U.S. and Russian facilities where warheads are dismantled—an important first step for any serious negotiations about transparency. DOE could also complete testing, evaluation, and vulnerability analysis of the leading technologies for measuring radiation in time for them to be considered during negotiations on the START III treaty, according to program officials. Without such work, officials worry, classified information about the design of U.S. weapons could be revealed.

Joint programs with Russia could also expand under this option. DOE could support a pair of joint dismantlement demonstrations that would familiarize U.S. and Russian scientists and engineers with possible technologies for warhead transparency before negotiations begin on START III. DOE could also establish a more robust lab-to-lab program on warhead dismantlement transparency. For example, scientists from both sides could examine an approach called "templating" that would use sensitive measurements to confirm the presence of a warhead but erect information barriers to provide an inspector with only a yes-or-no answer. Although the technique has promise, both sides must study it carefully to make sure it could give them the confidence they need without revealing too much information. Through the lab-to-lab program, scientists could conduct radiation measurements on actual warheads and components at U.S. and Russian assembly and disassembly facilities.

Increasing the funding for DOE's warhead transparency program has several potential disadvantages, however. Some people may object on the grounds that reciprocal transparency runs the risk of revealing too much information about U.S. nuclear weapons. (Supporters counter that the United States is already committed to some type of transparency for START III and runs a greater risk of revealing secrets without proper research.) Another danger of adding money to a research program is that at some point, the marginal effectiveness of additional research diminishes. (Program officials argue that since the United States and Russia have only begun to experiment with transparency technologies, large areas remain untapped.) Finally, this option might take money away from programs that other people considered more important.

Sample Russian Reactors to Test a Technique for Measuring Past Plutonium Production

No arms control agreement has yet placed any limits on the number of nuclear warheads that either the United States or Russia is allowed to have in its arsenal. Instead, treaties have limited the means for delivering nuclear warheads—such as the number of missiles or bombers actually deployed. In fact, the total number of warheads in each country's arsenal is a closely guarded secret. Many analysts and policymakers, however, expect future arms control agreements to actually reduce the number of warheads that the United States and Russia have. The rationale for such limits is that they can reduce each side's ability to quickly cease complying with future START treaties that involve deep reductions.

If future arms control treaties do directly address the number of warheads that each side is allowed, steps will have to be taken to build confidence in the stockpile declarations that each country will have to make. That process began in 1995 when Presidents Clinton and Yeltsin agreed, in principle, to exchange data about stockpiles of weapons and fissile materials and to establish a monitoring regime, although negotiations are currently stalled.

The United States and Russia could increase confidence in each other's stockpile declarations by being more open about the amount of weapons-grade material they have produced over the past 50 years. The total amount of weapons-usable nuclear material that was produced would constrain the number of weapons that could have been built. Both countries could also allow some checks to be made to substantiate their declarations. Some analysts argue that using several independent checks on stockpile declarations, none of which may be sufficient by itself, would have mutually reinforcing effects on confidence. As an example, they suggest comparing the many years of production records for fissile materials with physical evidence, such as residual radiation in the structure of reactors that produced that material—one aspect of so-called nuclear archaeology.

Analyzing samples taken from reactors might considerably reduce uncertainty on both sides about the amount of plutonium that each other's reactors produced. But sampling a reactor core—the heart of a reactor—can only be done when the reactor is accessible. Currently, all of the graphite reactors used in the former Soviet Union to produce weapons-grade plutonium are still available for sampling, but that will not always be the case. Three of the reactors might soon be buried and hence be inaccessible for analysis as part of future arms control agreements. This option would fund the sampling and analysis of those three Russian reactors.

During the past half century, the Soviet Union (and now Russia) used a total of 15 reactors to produce weapons material. According to one independent source, they generated between 125 tons and 175 tons of plutonium during that period.[12] As a comparison, the United States has already published an accounting of its total plutonium production: 111.4 tons, with an uncertainty of less than 0.1 percent.

Thirteen of Russia's plutonium-production reactors used graphite (a high-purity version of the "lead" in lead pencils) to moderate the nuclear interactions in the heart of the reactor. Graphite stays in a reactor for its lifetime, and the radioactivity induced in the graphite essentially records the total power, and hence the amount of plutonium, produced. (The other two Russian reactors—principally used to produce tritium for enhancing the explosive power of weapons—use a type of water to moderate the reactions and are not as amenable to this method of analyzing the residual radiation.) Of the 13 graphite reactors, three are still operating and the other 10 have been shut down and at least partially dismantled. The three that are operating still produce weapons-quality plutonium but are scheduled to begin modifications in 2000, with financial aid from the United States, to make a type of plutonium that is not as desirable for weapons.

As soon as it can afford to, Russia plans to bury the reactor structures, including the graphite, from three of the 10 dismantled reactors. That process involves entombing the reactor at its present site in layers of special clay and other materials to prevent radiation from leaking into the environment. Once the reactor

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12. David Albright, Frans Berkhout, and William Walker, *Plutonium and Highly Enriched Uranium, 1996: World Inventories, Capabilities, and Policies* (Oxford, England: Oxford University Press, 1997). Quantities of plutonium are expressed here as metric tons. One ton equals 1,000 kilograms. The National Academy of Sciences has said that a typical nuclear weapon uses approximately 4 kilograms of plutonium. Using that number, 1 ton of plutonium translates into about 250 nuclear bombs.

has been buried, it will be very difficult and expensive to regain access to, since even microscopic cracks in the barrier could provide channels of escape for radioactive materials.

One estimate indicates that the three reactors together produced approximately 45 tons of plutonium. That estimate has some degree of uncertainty. If it were based on something as accurate as the daily production records of each reactor—which it was not—each reactor's production might be determined to plus or minus 10 percent. This option would fund the sampling, measurement, and analysis of those three cores before they were entombed; an analysis of the samples could reduce the uncertainty for each reactor to plus or minus 5 percent. Assuming that this method is free from any systematic errors, such measurements could result in a combined uncertainty of as little as plus or minus 1 ton of plutonium. CBO estimates that sampling the reactor cores and performing the necessary analysis would cost about $3 million (see Table 2).

Some critics of this method maintain, however, that the accuracy of the measurements could be worse than plus or minus 5 percent. They suggest that low levels of contaminants in the graphite used in the reactors could induce systematic uncertainties. But advocates of such measurements say those problems can be overcome by measuring the radioactivity originating from several different elements found in the graphite. As evidence, they point to experiments done at reactors in Britain that did achieve the advertised levels of accuracy.

Russia is planning to take its own samples from the three reactors to determine the environmental requirements for burying the cores safely. Russian officials have indicated a willingness to give the United States samples—but in the context of environmental cleanup. It is not clear whether they would provide enough samples for an accurate estimate of past plutonium production, since that is not their interest in taking the samples. Indeed, the Department of Energy has apparently decided to decline those samples, preferring instead to negotiate sampling as part of a joint experiment in nuclear archaeology.

Such a joint experiment could not only answer scientific questions about the method for measuring plutonium but also build mutual trust between the United States and Russia in their efforts to be more open about their stockpiles. It might then play a confidence-building role (much like the Joint Verification Experiment did in 1988 for methods used to test verification methods for underground nuclear tests). If, as part of such a reciprocal sampling experiment, three former plutonium-production reactors in the United States—which have all been shut down—were subjected to the same sampling procedures, the total cost to the United States would be approximately $5 million.

CONCLUSION

The United States currently spends about $700 million each year on a variety of cooperative programs to reduce the risks of nuclear proliferation in Russia and the other former Soviet republics. CBO has examined several additional measures that the United States and Russia could implement to improve nuclear security between the two countries. Among them are further efforts aimed at reducing the chances that nuclear materials and weapons scientists will leave Russia, as well as measures that increase the transparency of processes to dismantle warheads and account for fissile materials. The costs of those options range from $3 million to $240 million a year.

The effectiveness of such efforts would depend on a variety of factors, including the amount the United States could spend and the economic and political situation in Russia. On the one hand, Russia's troubled economy and political turmoil would make it more difficult to keep nuclear materials secure or to diversify the economies of the nuclear cities and establish new businesses there. On the other hand, as the economy worsens, the proliferation threat becomes more urgent, as does the pressure to find solutions: people who are going hungry are more likely to sell their skills or materials to countries that want to develop nuclear weapons.