CHAPTER 6

DEMILITARIZING RUSSIAN WEAPONS SCIENTISTS: THE CHALLENGE

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The aim of this chapter is twofold: (1) to explore the threat of strategic proliferation posed by former Soviet scientists, engineers, and technicians who design, build, and maintain weapons of mass destruction (WMD); and (2) to consider whether large-scale immigration of such workers to the United States over the next 10 to 15 years could help diminish that threat.

The chapter is divided into seven sections. The first reviews the size of the Russian nuclear, chemical, and biological weapons complexes and the approximate number of scientists and engineers employed by each. The second discusses the actual and potential brain drain from the Russian scientific community and defense complex to foreign countries after 1991. The third analyzes trends regarding the entry of former Soviet scientists into the United States in the 1990s. Whereas only a relatively small number were admitted as immigrants, a larger, though still not huge, number were allowed in for temporary work or exchanges. The fourth briefly explains why U.S. Governmental and private efforts to employ Russian WMD scientists and engineers on civilian research projects within Russia are likely to have only a negligible impact on the longer-term threat of strategic proliferation. (In an Appendix to this chapter, I have prepared a detailed analysis supporting this conclusion.) The efficacy of these programs is limited not by any inherent shortcomings—though these have clearly played some role—but rather by the sheer magnitude of the problem. Even if the programs were perfectly designed and implemented, their net contribution in all likelihood would be meager.

The fifth shows why the private sector in Russia has not been able to absorb more than a relatively small proportion of former WMD personnel, a situation that is likely to continue indefinitely unless much more drastic economic changes take hold. The findings in this section reinforce the conclusions of Matthew Partan in Chapter 7 of this book. The sixth discusses the Russian government's recent efforts to curtail the brain drain from scientific research institutes and defense enterprises, particularly the WMD complexes. On one hand, the government has provided increased funding for science and has taken other steps to improve the conditions for research on nuclear weapons and other military-related technologies as well as civilian scientific projects. These measures have been designed to retain existing personnel and to attract new talent, especially younger scientists and engineers. On the other hand, the government has sought to tighten laws and decrees that severely restrict foreign travel by individuals who have had access to "state secrets" and to restore Soviet-era curbs on contacts between Russian and foreign scientists. Such restrictions, though not yet fully implemented, will inevitably hinder prospective attempts by Russian WMD personnel to immigrate to the United States.

The concluding section of the chapter considers whether the threat of strategic proliferation can be countered over the long term by encouraging the immigration of thousands of Russian WMD scientists and engineers to the West. A solution of this sort would be highly desirable, but the feasibility of it is open to serious doubt. Rather than pursuing what would likely be a futile quest, the United States would benefit most by promoting large-scale exchange programs for Russian high school students. Such exchanges would be eminently feasible and would have a positive long-term effect on the human dimension of the strategic proliferation challenge.

For reasons of space, documentation for this chapter has been omitted from the published version. An expanded and fully documented version of the chapter is available from the author upon request.

RUSSIAN WMD EXPERTS

This section discusses the size of the Russian nuclear weapons complex and then does the same for Russia's chemical and biological weapons industries.

Nuclear Weapons Complex.

When the Soviet Union collapsed in late 1991, it left behind an enormous infrastructure for the development, design, and construction of nuclear weapons. The Soviet Ministry of Atomic Power and Industry had overseen more than 150 enterprises and 1.1 million employees. From the 1940s through 1991, the weapons complex produced a total of more than 1,200 metric tons of highly enriched uranium and 150 metric tons of plutonium for use in some 55,000-60,000 nuclear warheads and bombs. The design and construction of nuclear weapons had long centered around ten "closed cities" (known in Russian as *zakrytye administrativno-territorial'nye obrazovaniya*—closed administrative-territorial entities) that were completely off-limits to the public, geographically isolated (in most cases), and omitted from public maps: Sarov (Arzamas-16), Snezhinsk (Chelyabinsk-70), Ozersk (Chelyabinsk-65), Seversk (Tomsk-7), Zheleznogorsk (Krasnoyarsk-26), Novouralsk (Sverdlovsk-44), Zelenogorsk (Krasnoyarsk-45), Lesnoi (Sverdlovsk-45), Trekhgornyi (Zlatoust-36), and Zarechnyi (Penza-19). Different areas of defense-related research were explored at the ten cities, which employed a total work force of some 750,000. Roughly 150,000 to 160,000 of these workers were involved in the design, manufacture, and testing of nuclear explosives. Sarov and Snezhinsk were the sites of the main weapons design bureaus, and Sarov also contained the Avangard weapons assembly plant. Other key weapons assembly facilities were located in Lesnoi, Trekhgornyi, and Zarechnyi. The remaining closed cities were responsible for producing weapons components and fissile material.

The Russian nuclear weapons complex continued to function at a robust level after 1991, despite a sharp reduction in the operating budget of the Russian Ministry of Atomic Energy (Minatom). As of early 2001, the nuclear weapons research institutes and manufacturing facilities still employed 125,000 to 130,000 people, a work force only slightly smaller than during the Communist period. Of these, at least 75,000 were working full-time on weapons design, production, and testing, and the remainder were responsible for support and administrative tasks. Even though precipitous cuts were made in the procurement of Russia's conventional military hardware (85-90 percent), the nuclear weapons industry was accorded a relatively privileged status. The continued presence of many thousands of former Soviet nuclear weapons specialists in the ten closed cities impeded Minatom's faltering attempts to restructure and scale back the nuclear complex. The ministry reported in the summer of 1999 that some 30,000 to 50,000 excess employees could not find alternative jobs if they were laid off. Although Minatom has claimed that it wants to reduce its current work force by almost two-thirds as of 2004, there is as yet little reason to believe that tens of thousands of excess employees will simply be laid off.

Overall, then, the nuclear weapons complex has experienced less disruption than one might have expected. The two key nuclear weapons design centers—the Scientific-Research Institute of Experimental Physics (VNIIEF) at Sarov and the Scientific-Research Institute of Technical Physics (VNIITF) at Snezhinsk—have maintained large staffs of scientists, engineers, and technicians. According to official figures, VNIIEF as of 1999 still employed as many as 24,000 people, while VNIITF still employed 11,000, nearly the same number who worked there during the 1980s. (The institutes were formally designated “federal nuclear centers” in 1995.)

The relatively modest personnel cuts in the former Soviet nuclear weapons complex have failed to mirror the huge reductions in the conventional forces and defense industries of Russia and other former Soviet republics. In that sense, as both private and governmental organizations in the West have stressed, Russia has been notably reluctant to scale back its nuclear weapons industry from the Cold War period. Scientists in the Russian nuclear weapons complex continue to refine existing weapons and components and to conduct research on new technologies for future weapons.

The precise number of nuclear weapons employees in Russia who possess specialized knowledge of critical weapons designs or technologies is unknown, but the most reliable evidence suggests that some 2,000 to 4,000 senior nuclear scientists and engineers have been directly involved in bomb design, production, and disassembly, and another 10,000 to 15,000 senior experts have been performing vital ancillary functions connected with nuclear weapons production. In January 1992 then director of the Russian nuclear weapons program Viktor Mikhailov declared that 2,000 to 3,000 of the roughly 15,000 senior nuclear weapons scientists in Russia were engaged in activities “of paramount importance involving sophisticated technologies.” He repeated these statistics in numerous other interviews over the next several years. The same figures were cited in mid-1996 by Vladislav Mokhov, a senior official at the Sarov federal nuclear center. Estimates by the U.S. Department of Energy (which oversees contacts with the former Soviet nuclear weapons laboratories) and other U.S. Government agencies are very similar to Mikhailov’s and Mokhov’s figures. A classified National Intelligence Estimate prepared by the U.S. intelligence community in the early 1990s indicated that around 2,000 senior specialists throughout the former Soviet Union possess "intimate knowledge of nuclear weapons design." Likewise, a report issued by the U.S. Congressional Budget Office in mid-1999 noted that, although 20,000 senior "nuclear scientists and workers" in Russia pose "proliferation risks," only a relatively small fraction of these (perhaps 15 to 20 percent) are involved in the most sensitive work.

These various estimates confirm that the number of senior nuclear weapons experts possessing truly sensitive information is a much smaller subset of the total population of scientists and engineers in the former Soviet nuclear weapons complex. The number of employees who pose a significant, but less acute, secondary threat is considerably larger, but still meager in comparison with the size of the post-Soviet defense complex, which employs at least a few million workers. Hence, the number of Russian nuclear weapons experts who could be recruited by Third World countries for help on a fledgling weapons program is far smaller than some Western observers had originally feared. At the same time, the pool of senior weapons scientists is large enough to keep Russia's nuclear complex operating indefinitely, provided that adequate resources are available.

Chemical and Biological Weapons Complexes.

The Soviet Union amassed a stockpile of 40,000 metric tons of chemical munitions, the largest in the world. These weapons were developed and manufactured at 24 separate facilities, including key production centers in Dzerzhinsk, Novocheboksarsk, Slavgorod, Volgograd, and Zaporozh'e. At the end of 1991, Russia inherited these facilities along with thousands of scientists, engineers, and technicians employed by the Soviet chemical weapons complex. A study released in September 2000 by Republicans in the U.S. House of Representatives claimed that "tens of thousands of scientists and technicians" were working in Russian chemical weapons facilities, but this estimate seems too high. Although the precise number is not known, most evidence suggests that several thousand scientists—perhaps ten thousand in total—are still working in Russia's chemical weapons complex. This figure is very large by world standards, but it is much smaller than the number of scientists and technicians employed in the Russian nuclear and biological weapons complexes.

The Soviet biological weapons program, code-named Enzyme, was shrouded in secrecy from the time it was launched in 1973. The Soviet Politburo, headed by Leonid Brezhnev, issued a highly classified decree establishing Biopreparat, a state pharmaceutical agency, which oversaw the development of weapons using germs and viral agents. The program continued to function (albeit at a reduced capacity) after the Soviet Union collapsed, contrary to initial assurances that it would be closed. Russian research on biological weapons has been conducted at massive facilities both close to and far from large urban centers. Among the institutes responsible for the development of weapons based on natural and genetically engineered strains of bacteria and viruses are the State Research Center of Virology and Biotechnology (VEKTOR) in Koltsovo, the State Research Center for Applied Microbiology at Obolensk, the State Research Center for Toxicology and Hygienic Regulation of Biopreparations in Serpukhov, and the Institute of Molecular Biology in Moscow.

At their height, the Soviet chemical and biological weapons (CBW) programs collectively employed over 70,000 scientists and technicians. In the early 1990s, after the Russian government made limited cuts in the program, the CBW complex continued to employ over 60,000 people, though only about one-third of these possessed truly sensitive knowledge. By the mid- to-late 1990s, after more of the Soviet WMD infrastructure had been dismantled, up to 10,000 CBW scientists still posed a proliferation threat according to a detailed study by Glenn Schweitzer of the

National Academy of Sciences. Schweitzer's estimate is compatible with figures provided in an April 2000 report by the U.S. General Accounting Office (GAO), which notes that 5,000 senior CBW scientists in Russia could pose "significant proliferation risks," and that an additional 10,000 Russian workers possess skills relevant for weapons development and production. Similar data can be found in a recent report by Amy Smithson of the Henry L. Stimson Center, who argues that 7,000 biological weapons scientists and another 3,500 chemical weapons experts in Russia pose a "high-risk proliferation concern."

These figures for the Russian CBW industries, combined with the estimates for Russia's nuclear weapons complex, give an idea of the potential for strategic proliferation. The figures bear out estimates made in 1998 that at least 15,000 senior scientists and engineers in Russia are directly involved in "production, delivery systems, and other aspects of weapons of mass destruction," beyond the 2,000-3,000 nuclear weapons design specialists who pose the greatest threat of nuclear proliferation. Moreover, as Schweitzer's study shows, if other tasks of clear "proliferation concern" are taken into account, the total number of Russian scientists and engineers with valuable WMD expertise is three to four times larger than the core 15,000-18,000. Schweitzer maintains that a total of around 60,000 former Soviet aerospace, nuclear, and chemical/biological weapons specialists "developed and designed weapons of mass destruction and their delivery systems"—thereby posing the greatest threat of proliferation—from 1992 to 1996. This figure, he argues, is largely unchanged today.

Identical estimates can be found in two recent GAO reports and in the latest annual report from the Initiatives for Proliferation Prevention (IPP), a program sponsored by the U.S. Department of Energy that seeks to provide employment for former Soviet WMD experts. The first of the two GAO reports notes that roughly 60,000 of the one million scientists, engineers, and technicians at Russia's 4,000 scientific research institutes can be regarded as high-level WMD personnel, a figure that is also cited (with breakdowns by WMD category) in the IPP document. The other GAO report, released in May 2001, cites a range of estimates by U.S. officials in Russia who believe that Soviet WMD programs as of 1991 were crucially dependent on as many as 75,000 highly-trained scientists and engineers, most of whom continue to serve in those posts.

Thus, although the risk of WMD proliferation in the former Soviet Union depends on the definitions used, it is safe to conclude that the greatest danger is posed by some 60,000 to 75,000 specially trained scientists, engineers, and technicians, nearly all of whom now reside and work in Russia. Even if the upper end of this range is used, Western countries could potentially absorb 75,000 experts and their families without extreme difficulty. The emigration of these personnel from Russia will be limited not by the West's absorptive capacity, but by obstacles within Russia itself.

RUSSIA'S SCIENTIFIC BRAIN DRAIN

The civilian side of Russian science and technology was hit hard by the economic and political turmoil that engulfed the former Soviet Union from the late 1980s through the mid-1990s. Spending on science programs dropped by nearly 45 percent in real terms during the final 2 years of the Soviet regime, and it continued sharply downward in 1992. Soaring inflation, large budget deficits, and persistent shortages of funding at scientific research institutes led to sharp declines in researchers' salaries (after adjusting for inflation), delays in wage payments, poor upkeep of facilities, and increasing obsolescence of laboratory equipment.

The severity of financial constraints and the deterioration of research facilities prompted a growing number of scientists in Russia to pursue opportunities outside their institutes, either at home (particularly in the newly emerging private sector) or abroad (at universities, research centers, and private companies). This development was not entirely unprecedented. Although Soviet citizens normally were forbidden to travel abroad (except to the Communist countries of Eastern Europe), the USSR experienced a scientific brain drain in the 1970s when a significant number of Jewish and Armenian scientists were allowed to emigrate. This earlier brain drain, however, was greatly eclipsed by the exodus that began at the end of the Soviet era, when most of the restrictions on foreign travel were lifted. Russia's brain drain in the 1990s was both external (with the departure of scientists to overseas jobs) and internal (as scientists abandoned their research and shifted into other sectors of the economy). The depletion of scientific talent was especially acute during the first 2 years after the collapse of the Soviet Union.

Data on the post-Soviet brain drain are often unreliable, but the scale and basic patterns of the phenomenon can be gauged reasonably accurately from a number of recent reports and surveys. All of these studies suggest that the scientists who moved abroad during the last few years of the Soviet regime included a disproportionate number of Jews, ethnic Germans, and Armenians. Many of the scientists were prominent researchers, and some were leaders in their fields. Nearly three-quarters of those who left during this initial wave continued their scientific research abroad at either universities or research institutes. The large majority (at least 80 percent) of the departing scientists went to either Israel or Germany, though a significant number subsequently moved to the United States. The initial wave of migration accelerated in 1990, when nearly 800 scientists and 8,000 engineers from the Soviet Union (many of whom had moved abroad in earlier years) came to the United States. Another 2,200 scientists left the Soviet Union in 1991. It is important to note, however, that only a relatively small proportion of these scientists—no more than 15 to 20 percent—applied for permanent residence abroad. Most of those who left Russia at this point were intending to return.

The exodus of Russian scientists increased after the Soviet Union collapsed at the end of 1991. In May 1992, as public concern about the external brain drain mounted, Russian president Boris Yeltsin issued a decree authorizing "emergency measures to preserve the scientific and technological potential of the Russian Federation." This decree proved largely ineffective, however. The measures proposed by Yeltsin, including tax breaks for key research institutes and competitive funding for scientific research grants, were hardly enough to offset the impact of the country's deepening economic problems. In both 1992 and 1993, roughly 3,000 Russian scientists went abroad for extended periods, particularly to Germany, Israel, and the United States. Physicists and mathematicians made up the bulk of the outflow, and biologists and chemists accounted for most of the rest. Fewer than half of the scientists who moved to foreign countries during these years continued to pursue scientific research, opting instead for more lucrative alternatives. Although only a small proportion (around 8 to 10 percent) of the scientists who went abroad in the early 1990s intended to stay away permanently, the overseas exodus from the civilian scientific institutes exacted a significant toll. The problem was not so much the magnitude of the external brain drain as the quality of those who left. The emigrants included some of the most gifted scientists, particularly those of the younger generation:

> In purely quantitative terms, the scientists who moved permanently abroad did not constitute a significant outflow. But those who left included a disproportionate number of talented, experienced, and highly trained young scientific workers. . . . The emigration of scientists and talented young researchers weakened the scientific potential of Russia and threatened to result in the country's loss of entire scientific fields and schools, which were forced to "survive" with only a narrow group of highly qualified scientific elites.

Even more worrisome from the Russian government's perspective was the internal brain drain. Thousands of scientists moved into other sectors of the economy, especially private business. A recent study suggests that the internal brain drain in 1992-1993 was at least five (and perhaps ten) times greater than the external drain, especially among younger scientists. A senior official in the Russian Academy of Sciences, Aleksandr Andreev, claimed in 1992 that 40 percent of Russia's research physicists had left the Academy's institutes and research centers. Although other sources indicate that Andreev's figures are too high, there is little doubt that a significant proportion of the Russian physics community was depleted by the internal and external brain drain.

Ominous though these trends were, they did gradually abate. Some of the most talented Russian scientists, who had received numerous offers from abroad, expressed their determination to stay in Russia to uphold and strengthen the country's scientific traditions. A typical case was Academician Aleksei Khokhlov, a distinguished physicist specializing in nonlinear optics, who committed himself to preserving the physics community in Russia:

> On numerous occasions, [foreign universities] have proposed that I move to the West. Although I value these offers, I realize that I would not be able to live there. I want to develop science here in Russia and to make a contribution to my own country. This is where my roots are, and I cannot imagine myself living outside Russia.

By the late 1990s, the external brain drain had sharply diminished. Specialists in microbiology, genetics, and computer science were still leaving the country, but far fewer mathematicians, physicists, and chemists were departing.

Recent data suggest that the annual number of Russian scientists and engineers from civilian institutes who went abroad for extended periods dropped from around 3,000 in the early 1990s to roughly 1,000 in later years, a trend that has been welcomed by the Russian government. In a statement to the Russian Duma in November 1999, the Russian minister of science and technology, Mikhail

Kirpichnikov, hailed the decrease in annual emigration. He stressed that only 1.6 percent of the scientists who had quit or been dismissed from their jobs in Russia were abroad at that time. Although the rate of departures to foreign countries rose in 1999 to 1,400 compared to an average of 1,000 in 1994-1998, this was a one-time increase sparked mainly by the financial crisis of August 1998. (Moreover, even though the number of scientists who moved abroad in 1999 was greater than in 1998, the exodus was well below the levels of emigration in the early 1990s.)

The internal brain drain also slowed markedly by the late 1990s. Most of the scientists who decided to leave their institutes for other pursuits did so in the early 1990s, and the ones who stayed were much less inclined to look for work outside the Academy. The gradual settlement of wage arrears for Academy employees in 1999-2001, and the increased funding for science programs from 1999 on, further reduced the likelihood that Russian scientists would consider giving up their institute positions. The number of scientific researchers in Russia rose in 1999 for the first time since the mid-1980s, and the trend continued upward in 2000 and 2001. Moreover, the number of graduate students enrolling in physics, mathematics, astronomy, chemistry, geology, and biology at Russian universities rose steadily in the 1990s, offering hope that an abundance of younger scientists would be available to fill posts at research institutes and universities in coming decades.

Reverberations within the WMD Complexes.

The upheavals of the late 1980s and 1990s took their greatest toll on Russia's civilian scientific institutes and non-nuclear defense plants, but the WMD complexes were not wholly immune either. During the Communist era, the living standards of nuclear weapons scientists were much higher than those of the average Soviet citizen. The privileged status of the closed cities continued for a while after the demise of the Soviet Union, but it gradually eroded. By mid-1994, the combined impact of ravaging inflation and budgetary constraints was being felt throughout the nuclear arms complex. In an interview in September 1994, the director of the Avangard weapons assembly facility in Sarov, Yurii Zavalishin, condemned the Russian ministry of defense and ministry of finance for "failing to turn over a huge amount of money they owe us." He said that his plant was "perhaps the only enterprise in the [nuclear weapons] sector that is still able to pay wages on a regular basis." The highly publicized suicide of the director of the VNIITF design center in Snezhinsk, Vladimir Nechai, in October 1996 provided only the most vivid confirmation of the hardships that arose at many weapons facilities. In at least two cases, employees of the nuclear weapons complex went on strike to demand the payment of back wages. Scientists at CBW plants encountered similar problems.

It is not surprising, then, that some of the WMD specialists began to look for work outside their institutes or even to think about moving overseas. Although very few residents of the closed cities had any foreign contacts or knew how to pursue opportunities abroad, surveys conducted in mid-1992 revealed that 46 percent of the scientists, engineers, and managers at nuclear weapons facilities were interested in seeking positions outside Russia. Among aerospace and missile experts, the level of interest in working overseas was even greater, roughly 62 percent. Comparable surveys are not available for BW or CW specialists, but it is safe to assume that they were at least as interested as the nuclear weapons scientists in going abroad. Although only a small number of the nuclear weapons specialists (an average of 1 percent a year in the 1990s) actually ended up taking jobs abroad, the outflow of these personnel in the first half of the 1990s provoked anxiety in both Russia and the West.

Whether this anxiety was fully warranted is unclear. On one hand, the surveys in 1992 revealed that the best and most experienced nuclear weapons specialists were *not* interested in working abroad. Although the situation was quite different in the aerospace and missile sector where some of the most capable experts were interested in going overseas, the lack of interest among leading nuclear weapons scientists was conducive to nonproliferation efforts. On the other hand, if even a few of the key Russian weapons scientists had moved to high-risk countries like North Korea, Iraq, and Iran, the impact on nonproliferation goals would have been grave. Scattered reports in the Russian press and some Western newspapers about the supposed presence of former Soviet WMD scientists and engineers in a variety of Third World states—Algeria, Brazil, Iran, Iraq, Libya, North Korea, Paraguay, South Korea, Syria, and Venezuela—have never been verified by any credible evidence. Although a report published by *The Russia Journal* in April 1999 claimed that around 2,000 Russian weapons specialists were working in China, these presumably were not WMD scientists but simply advisers and technicians who were temporarily based in China to facilitate Russia's ongoing transfers of advanced conventional armaments and military production technology.

Even though reports about Russian weapons scientists in Third World countries must be treated with great caution and skepticism, one cannot entirely dismiss the possibility that some departures to rogue states or the enlistment of scientists by international terrorist organizations will eventually occur. As discussed below, if projected improvements in the working conditions for most scientists in Russia are not sustained, the pool of scientific researchers and technicians who are willing to emigrate from the closed cities and other regions may grow. A Russian expert on the brain drain estimated in 1997 that as many as 8,000 scientists with experience in nuclear technology and fissile materials were prepared to leave to work abroad. This figure may not include any high-level weapons scientists, but it is conceivable that at least a few of these individuals possess expertise that would be helpful to a fledgling nuclear weapons program. Some countries of great concern to the West have reportedly tendered offers to Russian chemists and biologists as well as to nuclear physicists. A front-page article in *The New York Times* in December 1998 claimed that Iranian officials were attempting to enlist Russian scientists for germ warfare projects by offering salaries of up to $5,000 a month. Despite persistent reports of such offers and despite the well-known Russian-Iranian cooperation on the Bushehr nuclear power plant, no hard evidence has yet emerged that any Russian scientists have defected to Iran specifically to work on WMD programs. Even so, the reported magnitude of these offers is disconcerting in light of the fact that some scientists were earning monthly salaries less than one-hundredth that amount as late as 1996.

Nevertheless, the impact of the funding problems must be kept in perspective. Since the late 1990s, many of the problems have been rectified. The pay for nuclear weapons scientists and engineers was sharply increased in both 1999 and 2000, as discussed below. Moreover, even when funding shortfalls were especially severe in the mid-1990s, the rate of emigration actually began falling, not increasing. The importance of this trend was underscored by a survey of hundreds of Russian nuclear weapons specialists and ballistic missile scientists in 1999, which revealed that their desire to emigrate had decreased sharply since the early 1990s. The results of the survey are presented in a study published in 2001 by the Carnegie Endowment for International Peace. The study indicates that the rate of emigration from the ten closed cities increased from 1991 to 1996 and then began steadily dropping. Although an average of about 1 percent of the total pool of surveyed experts went to work abroad each year in the 1990s, the large majority of the departures occurred in the first half of the decade. In 1992, 46 percent of those interviewed at nuclear weapons facilities expressed a desire to work abroad, whereas only 9 percent expressed the same interest in 1999—a fivefold decline. The surveys revealed the same pattern at the ballistic missile facilities. Whereas 72 percent of respondents at ballistic missile plants in 1992 said they wanted to work abroad, only 25 percent expressed that view in 1999.

The survey also showed that even among the weapons experts who were still hoping to work abroad, very few were actively taking steps toward that end. Only one-third of the relatively small number of nuclear weapons specialists who were willing to work abroad said they were actively looking for foreign employment. Among missile experts who wanted to work abroad, only one-fifth were searching for employment. It is interesting to note, however, that some 21 percent of nuclear specialists and 42 percent of missile specialists approved of or envied those who left Russia, whereas only 16 percent of nuclear specialists and an equal percentage of missile specialists held negative views of emigrants. (About 60 percent of nuclear specialists and 42 percent of missile specialists claimed that their views were neutral.) These statistics suggest that a considerable minority of the researchers who have chosen to stay in Russia's closed cities might eventually think about seeking work abroad. This would be likely especially if economic conditions in the closed cities (and in Russia as a whole) were once again to deteriorate. One of the key findings of the survey is that 85 percent of respondents who wanted to work abroad cited economic motivations. Only 15 percent of the prospective emigrants indicated that they had purely professional reasons for leaving.

One other key finding of the survey is that the actual pattern of emigration by nuclear and missile specialists in the 1990s was very similar to that of the larger scientific community (as described above). Most of the weapons specialists who applied for permanent residence when they moved abroad went to Israel, Germany, or the United States. For those who were still in Russia but were hoping to work abroad, the most popular intended destination was Western Europe (listed in 45 percent of definitive replies), followed by North America (28 percent) and the Middle East

(10 percent), principally Israel. Missile specialists who wanted to go abroad were most interested in seeking work in Western Europe (79 percent), North America (63 percent), and Israel (9 percent). The countries most frequently rejected by nuclear weapons specialists as potential destinations were Iraq (59 percent), Pakistan (42 percent), Libya (33 percent), Iran (24 percent), North Korea (16 percent), Israel (16 percent), India (13 percent), and China (11 percent). Missile specialists who wanted to work abroad were much less inclined to rule out any countries as potential destinations, but 18 percent did not want to work in Israel, 17 percent rejected China, 16 percent rejected Pakistan, and 11 percent ruled out Iran.

These data suggest that, if there were a resurgence of interest in emigration among Russian weapons scientists, Western countries would have little to fear from it. Even the very small number of Russian experts who might be willing to work for hostile Third World regimes could undoubtedly be induced to move to the West instead.

LIMITED EFFORTS TO ADMIT RUSSIAN SCIENTISTS INTO THE UNITED STATES

The U.S. Government's primary emphasis has been on keeping former Soviet WMD scientists gainfully employed in their own countries, rather than encouraging them to move permanently to the West. The United States did, however, take in a substantial number of civilian scientists and technicians from Russia in the 1990s, perhaps as many as 7,000, most of whom emigrated shortly after the demise of the Eastern bloc. Other countries also received sizable numbers of Russian scientific experts. The three that absorbed the most in the early 1990s were Israel, Germany, and Greece. According to Schweitzer, roughly 2,000 of the 5,000 "scientific emigrants" from Russia to the West in 1991-1994 were "active researchers." It is unclear, however, how many of these emigrants were involved in WMD research or other defense-related projects.

	Russia*				Ukraine*			
FISCAL YEAR	Total	Priority Workers**	Workers with Advanced Degrees or Exceptional Ability***	Professional Specialty / Technical	Total	Priority Workers**	Workers with Advanced Degrees or Exceptional Ability***	Professional Specialty / Technical
1991§	56,980	na§§	na§§	4,491				
1992	8,857	135 (SU)	265 (SU)	851	14,383	na	na	788
1993	12,079	750 (SU)	303 (SU)	1,183	18,316	na	na	1,036
1994	15,249	1,284 (SU)	516 (SU)	1,299	21,010	na	na	907
1995	14,560	1,134 (SU)	482 (SU)	2,621	17,432	na	na	3,489
1996	19,668	1,798 (SU)	910 (SU)	2,530	21,079	na	na	1,628
1997	16,632	862	535	1,773	15,696	110	78	1,293
1998	11,529	705	385	1,587	7,448	129	69	849
1999	12,347	447	273	969	10,123	128	66	1,014
2000	-	-	-	-	-	-	-	-

Source: U.S. Immigration and Naturalization Service, *Statistical Yearbook*, Washington, DC, annual editions, 1991 to 1999. Official data for FY2000 have not yet been tabulated.

na = not applicable.

* Figures are tabulated by country of birth.

** Of the five categories of employment-based preferences for immigation to the United States, two are relevant to the topic of this chapter. "Priority workers" fall into the first employment-based category, known as EB-1 (first preference). EB-1 visas are for "persons of extraordinary ability in the sciences, arts, education, business, or athletics, outstanding professors and researchers, and certain multinational executives and managers." **NB:** The figures reported here for FY 1992 through FY 1996 are for the whole of the former Soviet Union (SU), not just for Russia. Unfortunately, the INS did not start reporting separate data for EB-1 emigrants from Russia and Ukraine until FY 1997.

*** This rubric designates the second of the five categories of employment-based preferences for immigration, a category known as EB-2 (second preference). EB-2 visas are for "professionals holding advanced degrees and persons of exceptional ability in the sciences, arts, and business." The INS must determine that the "exceptional ability" of an EB-2 immigrant will "substantially benefit the national economy, cultural, or educational interests or welfare of the United States." **NB:** The figures reported here for FY 1992 through FY 1996 are for the whole of the former SU, not just for Russia. Unfortunately, the INS did not start reporting separate data for EB-2 immigrants from Russia and Ukraine until FY 1997.

§ Figures for FY 1991 were reported only for the SU as a whole.

§§ In FY 1991 there was only one employment-based preference for immigrant admissions, a preference granted to "professionals and highly skilled workers." A total of 32 individuals from the SU were admitted within this category in FY 1991. The five-tiered system of

Table 1. Immigrant Admissions to the United States from Russia and the Ukraine, 1991-99.

FISCAL YEAR	Former Soviet Union*				
	Total Nonimmigrant Admissions	Admissions for Temporary Work, Exchanges, or Intracompany Transfers	O-1 Admissions** (for Aliens with Extraordinary Ability in Sciences and Other Fields)	H-1B Admissions*** (for Aliens with Specialty Occupations)	J-1 Admissions[1] (for Exchanges Involving Professors, Research Scholars, and Others)
1991[a]	111,646	7,304	na	3,027	3,791
1992	107,710	7,407	28	2,452	2,955
1993	127,846	12,223	163	1,380	7,040

	Russia					Ukraine				
	Total Admissions	Temporary Work, Exchanges, Transfers	O-1**	H-1B***	J-1[1]	Total Admissions	Temporary Work, Exchanges, Transfers	O-1**	H-1B***	J-1[1]
1994	107,555	14,602	190	1,674	9,546	18,728	2,381	19	196	595
1995	121,665	16,968	416	2,048	11,303	22,716	2,702	24	278	674
1996	146,536	16,860	226	2,190	10,682	26,610	3,040	29	306	682
1997[aa]	-	-	-	-	-	-	-	-	-	-
1998	164,548	15,249	320	3,014	9,251	25,674	3,845	25	533	1,156
1999	122,761	18,221	398	3,602	10,268	24,228	3,611	34	720	2,308
2000	-	-	411	3,769	-	-	-	59	798	-

Source: Data for FY1991 to FY1999 are from U.S. Immigration and Naturalization Service, *Statistical Yearbook*, Washington, DC, annual editions, 1991 to 1999. Data for FY 2000 were provided by INS and U.S. Justice Department officials.

na = not applicable.

* Only aggregate figures for all former Soviet nonimmigrants are available for the period FY 1991-93. The subsequent figures for Russia and Ukraine are tabulated by country of citizenship.

** O-1 visas are for temporary visits by aliens who have displayed "extraordinary ability in the sciences, education, business, or athletics." Several criteria must be met before an O-1 visa is granted. The INS requires, among other things, "a written advisory opinion from a peer group [or] a person designated by the group with expertise in the alien's area of ability," "a copy of any written contract between the employer and the alien," "evidence that the alien has received a major, internationally-recognized award, such as a Nobel Prize," and evidence of other extraordinary ability, possibly including membership in a professional organization based on outstanding achievement, "published material in professional or major trade publications, newspapers, or other major media about the alien and his work in the field," "original scientific, scholarly, or business-related contributions of major significance in the field," "authorship of scholarly articles in professional journals or other major media in the field," and a record of compensation and employment responsibilities commensurate with those of extremely gifted and accomplished individuals.

*** H-1B visas are given to "aliens coming temporarily to perform services in a specialty occupation, or as a fashion model of distinguished merit and ability." H-1B visas are divided into three categories: H-1B1, H-1B2, and H-1B3. The large majority of H-1B visas for individuals from Russia and Ukraine are H-1B1 visas, which apply to "an alien coming temporarily to perform services in a specialty occupation." A "specialty occupation" is defined as one involving "the theoretical and practical application of highly specialized knowledge requiring completion of a specific course of higher education." Only a relatively small number of Russians and Ukrainians qualify for H-1B2 visas (for aliens "coming temporarily to perform services of an exceptional nature relating to a cooperative research and development project administered by the Department of Defense") and H-1B3 visas (for fashion models of distinguished merit). H-1B holders are permitted to work in the United States for an initial period of 3 years, which, at the employer's request, can be renewed for a further three years.

§ J-1 visas are used for "educational and cultural exchange programs" in "the fields of education, arts, and sciences. Participants include students at all academic levels; trainees obtaining on-the-job training with firms, institutions, and agencies; teachers of primary, secondary, and specialized schools; professors coming to teach or do research at institutions of higher learning; research scholars; professional trainees in the allied and medical fields; and international visitors coming for training, sharing, or demonstrating specialized knowledge or skills."

§§ No figure for O-1 visas is given here for FY1991 because the category did not begin until FY1992. The figure given here for H-1B visas in FY1991 actually refers to H-1 visas. Figures for H1-B visas begin with FY1992.

§§§ The INS *Statistical Yearbook* for 1997 reports that "no reliable data are available for 1997" for nonimmigrant admissions (p. 111). The INS website (http://www.ins.gov) erroneously presents FY 1996 data as the figures for FY1997.

Table 2. Nonimmigrant Admissions to the United States from Russia and Ukraine, 1991-2000.

The U.S. Immigration and Naturalization Service (INS) does not regularly provide disaggregated statistics on the number of foreign scientists and engineers who move to the United States, but several of the categories used by the INS for immigrant and nonimmigrant admissions give an indication of trends in the entry of scientists from Russia and Ukraine. Tables 1 and 2 contain annual data for immigrant and nonimmigrant admissions, respectively, from both Russia and Ukraine. The trends for the two countries are essentially identical. The number of immigrants in relevant categories rose sharply each year from 1991 to 1995, but declined just as precipitously from 1996 through 1999 (the most recent year for which data are available). Assuming that scientists made up a relatively stable percentage of the numbers in each category, the trend depicted here tallies very well with the data presented above on the brain drain from the former Soviet Union. When the brain drain was increasing, the number of scientists admitted as immigrants into the United States also increased; and when the exodus of scientists from Russia and Ukraine diminished, the volume of immigrant admissions declined.

Even when the brain drain from Russia and Ukraine was at its height, the number of former Soviet scientists who moved permanently to the United States was not especially large. Data compiled unofficially by the U.S. National Science Foundation (NSF) indicate that 426 Russian scientists and engineers received immigrant visas to the United States in FY1993, and another 512 received such visas in FY1994, an increase of roughly 25 percent. The number of Russian scientists and engineers who immigrated to the United States rose again in FY1995 but then declined sharply in FY1996, FY1997, and FY1998 (the latest year for which data are available). The difference between the early 1990s and the late 1990s was striking. Whereas more than 450 scientists and engineers a year were emigrating from Russia to the United States in FY1994 and FY1995, the number emigrating from the whole of the former Soviet Union fell to under 200 annually by the late 1990s.

The INS data for nonimmigrant admissions, shown in Table 2, reveal a pattern quite different from that of immigrant admissions. The number of Russian and Ukrainian citizens entering the United States in the late 1990s for temporary work and exchanges, including science-related programs, remained considerably higher than it was earlier in the decade. In the two most relevant categories—O-1 and H-1B admissions—the trend after 1993 was steadily upward, with the one exception of O-1 visas in 1996. In a third, somewhat more diffuse visa category—for J-1 admissions—the trend was sharply upward in the early-to-mid 1990s and relatively stable thereafter. (Definitions of O-1, H-1B, and J-1 visas are provided in the explanatory notes for Table 2.) The figures for H-1B (temporary work) visas are especially useful in highlighting the pattern of scientific entrants from the former Soviet Union. Statistics compiled by the INS show that roughly three-quarters of H-1Bs in 1998-2000 went to scientists and engineers, predominantly those under 35 years of age. Computer experts, in particular, accounted for 55-60 percent of all H-1B recipients during this period. Although Russia ranked far behind India and China—the world's two most populous countries—in the number of its citizens who received H-1Bs, the surge of Russian visa holders after 1993 elevated Russia to tenth place overall, well ahead of countries like Brazil and Indonesia, whose populations are of comparable size.

In short, the trends depicted in Tables 1 and 2 confirm that even though only a relatively small and dwindling number of scientists and engineers from the former Soviet Union immigrated to the United States in the 1990s, a substantial and growing number were admitted for temporary research positions and scientific exchanges.

The U.S. emphasis on temporary rather than immigrant admissions for former Soviet scientists has been driven partly by the demand side, that is, the number of Russians and Ukrainians applying for visas each year. As the number seeking to immigrate to the United States has fallen, it is not surprising that the quantity of immigrant visas awarded has dropped. By the same token, as the number of H-1B petitions for Russians and Ukrainians has risen, the number (though not necessarily the proportion) of visas approved has grown.

The U.S. emphasis on temporary admissions for Russian scientists has been reinforced by changes in U.S. immigration law in 1990, 1998, and 2000, which set stricter limits and fewer exemptions for employment-based immigrant admissions and which expanded the number of H-1B nonimmigrant admissions. Under changes adopted in

October 2000, scientists who are admitted on H-1B visas to work for universities or nonprofit research centers are exempted altogether from the newly increased ceilings for H-1Bs.

The emphasis on temporary rather than permanent admissions has also been partly due to the limited capacity of prospective employers to absorb foreign specialists. By the mid-1990s, many U.S. companies had reached a saturation point, especially for mathematicians, physicists, and chemists, some of whom had not been as rigorously trained as their American counterparts. Only in a few select fields, such as computer programming and biotechnology, did the demand for foreign specialists persist, and even then it was only for those who had been properly trained.

One final factor that shaped U.S. admissions policy vis-à-vis Russian scientists (especially weapons scientists) was the sensitivity of the issue for the Russian authorities. The potential for bilateral friction on this matter was evident as early as October 1992, when the U.S. Congress approved the Soviet Scientists Immigration Act (SSIA), a bill that enabled up to 750 former Soviet WMD scientists, as well as their spouses and dependents, to qualify for permanent residence in the United States under an employment-based preference (EB-2), even if they had not received an actual offer of employment. The SSIA triggered a harsh response in Russia, where legislators and political officials depicted it as an ominous "attempt by the United States to open the floodgates for Russian defense scientists." Russian officials complained both publicly and privately about the U.S. law and called for it to be rescinded. Commentators in the Russian press voiced deep suspicion and nationalist recriminations against "hostile foreign powers . . . seeking to deprive our homeland of its secrets." They claimed that the United States was "exploiting our country's immense scientific resources for its own mischievous ends." The resulting backlash was precisely the type of thing that U.S. officials had hoped to avoid.

The irony of the Russian complaints is that they were based on a misreading (or willful distortion) of the U.S. legislation. The SSIA was never intended to be more than a one-time measure. It was certainly not the start of a systematic effort to induce many thousands of former Soviet WMD scientists to resettle permanently in the United States. No one in Congress or the executive branch ever contemplated offering immigration visas to tens of thousands of Russian weapons experts. On the contrary, some members of Congress—particularly those from districts in which the U.S. nuclear weapons laboratories were located—had argued in early 1992 (when the SSIA was first proposed) that the entry of even a small number of former Soviet weapons scientists to work in the United States would be undesirable:

> At a time when America's nuclear scientists are being laid off by defense cuts because of the declining Soviet threat, the United States Department of Energy is luring Soviet scientists to work on nuclear fusion and space missile defense. . . . We are now displacing our best and brightest American scientists. What do the hundreds of American scientists at Los Alamos, Sandia, Oak Ridge, and our other national laboratories facing possible layoffs think of this practice? They have been toiling against the Soviet bear for years. Because of these scientists we won the cold war. What is their reward? They may be fired and replaced by Russian scientists.

In part because of these complaints, congressional sponsors of the SSIA repeatedly emphasized its limited nature. When the House of Representatives took up the legislation in the fall of 1992, the chief sponsor, Romano Mazzoli, underscored the modest scope of the bill:

> [The SSIA] waives a legal requirement, which is in the 1990 [immigration] law now, but waives it for only a 4-year period, not permanently, and only for a total of 750 scientists. . . . [The bill] raises no quotas nor ceilings on foreign workers. It only opens the door slightly and somewhat facilitates for a limited period of time and for a limited number of former Soviet scientists their entry into the United States.

Supporters of the SSIA also stressed that it was "narrowly targeted to address a specific and highly unique situation" and would be implemented "without cost to the American taxpayer and without displacing anyone who has been waiting to immigrate to the United States." The committee hearings and brief floor discussion left no doubt that the legislation was designed to cover only a very small percentage of Russian WMD scientists.

In practice, moreover, the SSIA turned out to be even more limited than the sponsors had envisaged. The original text of the bill had to be supplemented by interim rules prepared by the INS in 1993 and 1995. After a lengthy review process, the INS adopted a final rule in February 1997 that incorporated the 1995 changes. These modifications, based on comments solicited by the INS, clarified which categories of scientists and technicians from the former Soviet Union were eligible to apply for immigration visas under the SSIA. The initial draft rule had defined eligible applicants as "scientist[s] or engineers . . . who have expertise in chemical, biological, or other high technology fields," a broad description not limited to weapons personnel. But the amended 1995 interim rule had explicitly mentioned expertise in "a high-technology field which is clearly applicable to the design, development, or production of ballistic missiles, nuclear, biological, chemical, or other high-technology weapons of mass destruction" as a qualifying criterion. The INS subsequently narrowed the scope of the rule to exclude scientists and engineers who were not directly engaged in strategic weapons projects. This revision left out all nondefense scientists and technicians whose work was potentially applicable to WMD programs. The INS preserved these changes and others in the final 1997 rule, but the impact of the guidelines was largely negated by the agency's failure to extend the cutoff date for petition approvals beyond the original deadline of October 24, 1996. Thus, contrary to the complaints voiced by Russian officials, the SSIA proved to have only a minuscule effect at best on the Russian WMD complexes.

Even though Russian commentators had misconstrued (or deliberately misrepresented) the SSIA, their adverse response to the legislation was bound to cast a pall over any further such efforts. Subsequent programs undertaken by the U.S. Department of Energy (DOE) and other U.S. Government agencies were aimed mainly at providing employment for former Soviet weapons scientists and engineers within their native countries, rather than encouraging them to immigrate to the West. Although roughly 60 Russian "technical specialists for nuclear reactors" were "semi-permanently" relocated to New Mexico in 1995 for work on the Topaz Project (a project to adapt compact nuclear power plants for space vehicle propulsion), the transfers were limited in number and did not spawn a mass exodus of scientific and engineering talent from Russia or the other former Soviet republics.

U.S. EFFORTS TO EMPLOY WEAPONS SCIENTISTS IN RUSSIA

To minimize the likelihood that Russian WMD scientists and engineers would be enticed by lucrative offers from a hostile Third World country, the United States has launched several initiatives to provide worthwhile employment for highly-trained experts who stay in Russia. This approach has been seen as a substitute for, not a supplement to, the possible immigration of these scientists to the West. After private U.S. organizations (the Carnegie Corporation and the MacArthur Foundation) began awarding research grants to former Soviet scientists in 1992-93, the U.S. Departments of Defense and Energy embarked on a number of projects of their own. By 1995, Russia had become the single largest beneficiary of U.S. funding for programs encompassed by the International Cooperation in Research and Development (ICRD) effort, with particular emphasis on aeronautics and nuclear energy. The ICRD grants were separate from the money appropriated for the Nunn-Lugar Cooperative Threat Reduction (CTR) program and for a number of DOE and State Department projects designed specifically to reduce the strategic proliferation threat posed by Russian weapons experts.

Many of the activities funded by the CTR and DOE, such as the dismantling of strategic missiles and the installation of protective devices and surveillance equipment at key storage facilities in the former Soviet republics, have been exceptionally valuable in helping to safeguard nuclear weapons and components. The focus here is not on CTR as a whole or on all DOE activities, but on the three specific DOE and State Department programs that were set up in the 1990s for the express purpose of keeping former Soviet WMD scientists gainfully employed: (1) the Science Centers program, (2) the Initiatives for Proliferation Prevention, and (3) the Nuclear Cities Initiative (NCI). These programs were championed by the Clinton administration, but their fate seemed to be in doubt when a new administration came in under George W. Bush. Whatever uncertainty may have existed, however, was dispelled in mid-December 2001 when President Bush declared that, far from eliminating the programs, he would "**expand** efforts to provide peaceful employment for scientists who formerly worked in Soviet weapons facilities." Although the administration subsequently announced that it would merge the NCI with the IPP, senior officials confirmed that the basic activities of the two programs would be continuing and that funding for the Science Centers would be increased.

The question addressed in the Appendix to this chapter is whether these sorts of programs, taken together, can provide permanent alternative sources of employment for all or most of the Russian WMD experts within the next 10 to 15 years. Even if the answer is negative, the programs may still be worth pursuing for other reasons (e.g., for intelligence-gathering or to foster professional camaraderie). For the purposes of this chapter, however, the only relevant concern is whether the programs can generate long-term alternative employment for Russian WMD specialists. The answer provided in the Appendix is unambiguously negative.

THE RUSSIAN PRIVATE SECTOR

Defense conversion and the transfer of displaced scientific and technical personnel to new jobs pose formidable challenges even for countries with highly advanced market economies like the United States. Although Silicon Valley and other private-sector opportunities have absorbed large numbers of scientists and technicians from U.S. Government weapons laboratories, the process of downsizing the U.S. nuclear weapons complex inevitably has been disruptive for many.

In Russia, the difficulty of finding opportunities for displaced weapons scientists is incomparably greater. Yurii Zavalishin, the director of the Avangard weapons assembly plant, expressed dismay in 1994 that soon after his staff "became actively involved in the state conversion program and began working on a broad scale, the whole program turned sour." Although some of the former employees of the Russian nuclear and missile complexes (mostly younger people) successfully landed jobs in the fledgling private sector or with foreign companies, the total number who managed to do so was trivial compared to the number who may be displaced over the next several years if much-needed downsizing of the Russian WMD complexes proceeds as forecast.

The lack of progress with defense conversion in Russia, the poor business climate, and the many obstacles facing aspiring entrepreneurs have stifled the emergence of a private sector that could absorb thousands of WMD scientists. Although one-third of Russian defense enterprises had been "privatized" (i.e., turned over to managers) by the mid-1990s, the rest were still owned wholly or largely by the state. Even the nominally private defense firms were kept open mainly through state largesse. Unlike in Hungary, Poland, Slovenia, the Czech Republic, and other East-Central European countries where the rapid growth of small business made up for the shortcomings of large industry, no such engine of prosperity has been available in Russia. Overweening government interference, corruption, and criminality in Russia have thwarted indigenous start-ups and deterred foreign investors from entering. As a result, nothing remotely comparable to the private-sector opportunities in the United States is likely to exist in Russia for many years to come.

The scarcity of opportunities outside the weapons complexes poses an onerous dilemma for Russian scientists who face the prospect of unemployment. Most evidence suggests that a greater number of the WMD personnel, especially those under 45, would have been inclined to take jobs in the private sector if the opportunities had been available. According to recent data, some 70,000 scientists working at Russian Academy of Sciences institutes—on projects unrelated to WMD—left their positions for the private sector after 1991. The bulk of this outflow, however, occurred in the early 1990s, a pattern that was also evident in the nuclear and missile complexes. The Carnegie Endowment study indicates that a small but significant number of weapons specialists began moving to the private sector in 1992, but the outflow soon peaked—in 1993 for the missile complex, and in 1996 for the nuclear weapons industry—and then rapidly declined. Although some of the scientists and engineers who left the defense complex for the private sector fared well, others did not. By the end of the 1990s, as economic hardship and turmoil in Russia remained acute (and showed no signs of abating in the near future), the number of weapons scientists who were inclined to venture into the private sector had greatly diminished.

It is unlikely that the situation will improve before the projected cuts in the Russian WMD complexes are due to take effect. Russian investment in technology commercialization is less than $200 million a year, and foreign direct investment in science and technology in Russia is still almost nil. The WMD specialists who are still working in the Russian weapons complexes will therefore be extremely reluctant to forsake their posts. The younger scientists and engineers who were inclined to leave for opportunities in the private sector have already done so, and the remaining weapons personnel will find it especially difficult to adapt to new lines of work.

OFFICIAL RUSSIAN EFFORTS TO FORESTALL A NEW BRAIN DRAIN

Until very recently, the Russian government had sought to forestall the emigration of key WMD scientists, engineers, and technicians by imposing severe travel restrictions on individuals who enjoyed access to "state secrets." This punitive approach is still in effect, but since early 2000 the government has also increasingly tried to offer a carrot (more attractive career opportunities) to go with the stick. Although the stick will undoubtedly remain crucial in preventing undesired emigration, the effort to adopt a more nuanced, carrot-and-stick approach suggests a recognition that the stick alone will not be effective over the long run.

Proposals to Improve Russian Science and the Weapons Complex.

Even before Vladimir Putin took over from Yeltsin as Russian president at the end of 1999, he had displayed a keen interest in bolstering Russia's scientific research capabilities, especially research on nuclear weapons and other advanced military technologies. In late April 1999, when Putin was Secretary of the Russian Security Council, he played a crucial role in the Council's adoption of a classified directive authorizing sharp increases in the salaries and benefits of nuclear weapons scientists and engineers. At a news conference after the Council met, Putin hailed the resolution as an "urgent measure" that would "ensure the stable functioning of the nuclear weapons complex." He expressed a similar view 4 months later, shortly after he became prime minister. At a ceremony marking the 50th anniversary of the first Soviet nuclear bomb test, Putin declared that "Russia's nuclear weapons complex is the foundation of our country's security," and he vowed that "the development and upkeep of the nuclear weapons complex will remain the state's highest priority."

After gaining the presidency, Putin continued to emphasize the need for major improvements in Russia's scientific prowess and weapons research. In a speech before a group of scientific workers at the science research park in Zelenograd in early February 2000, he called for "a comprehensive reform of the scientific and technological sphere," attributing the problems in Russia's scientific establishment to past mismanagement and waste. Although he lamented the earlier loss of highly trained scientists and engineers, he declared that his policies would prevent any further brain drain. A month later, Putin abolished the Ministry of Science and Technology along with several other federal agencies and replaced them with a much larger Ministry of Industry, Science, and Technology, which oversees a vast network of weapons research and testing facilities. Putin's choice of a high-ranking official from the military-industrial complex, Aleksandr Dondukov, to head the new ministry was a further sign of the growing emphasis on weapons-related research.

Putin highlighted this theme in two important speeches in late March 2000 just before and just after he was formally elected president on March 26. In the first speech, delivered at the All-Russian Conference of Employees of the Defense-Industrial Complex, he pledged that "defense production, as a core part of the overall economy, will be the driving force of industrial development." In the second speech before an enlarged session of the Minatom Collegium in Snezhinsk, Putin promised to "strengthen Russia's nuclear weapons complex" and to ensure that "the significance of this complex, far from decreasing, will increase exponentially." He stressed that Snezhinsk and the other nuclear weapons facilities would be at the heart of his scientific research program:

> We must make 100 percent use of the intellectual riches of [the nuclear weapons] industry and must support its unique collectives, laboratories, and scientific centers. They are the source of innovative technologies for all of our industries, and they are the resource for economic growth and for the successful development of the country.

Putin returned to these points on numerous occasions in both 2000 and 2001. In May 2000 he delivered a keynote address before the general assembly of the Russian Academy of Sciences, an annual event that Yeltsin had always declined to attend. In his speech, Putin called for a "comprehensive reform of the scientific-technical sphere" that would enable Russia to "make maximum use of the immense scientific and technical resources and highly-trained personnel of the military-industrial complex." Three months later, he met with 20 senior members of the Russian Academy of Sciences to discuss the future of the Russian scientific establishment. Putin decried the "brain drain that has eroded our state's potential in the world" and vowed to improve the conditions for scientific research. In particular, he promised to devote greater resources to areas vital for national security, especially nuclear weapons and other high-technology industries.

To reinforce this new approach, Putin's ministers provided more funding for science in 2000 than was actually promised in the federal budget, a striking reversal of the pattern in 1992-98, when outlays for science consistently fell short of the projected level. The government also revised the science budget for 2001, allocating an additional 820 million rubles toward salary increases for scientists, 800 million rubles to improve research facilities, 12.5 million rubles to provide for scientists' housing needs, and 80 million rubles for other “retention efforts.” In addition, Putin secured funding for a new state training plan for scientific and engineering personnel, with particular emphasis on the defense industry. As a further gesture of support for the weapons complex, Putin pledged to confer privileged tax and legal status on the “science cities” (*naukogrady*), the 60 or so defense-oriented research metropolises that had flourished during the Soviet era but had fallen on hard times in the 1990s. Putin also proposed a fourfold increase in grants for university science departments engaged in weapons-related research and 30-40 percent increases in salaries for lecturers in those departments. (Traditionally, Russian universities other than Moscow State and Leningrad State had been much less important than the Russian Academy of Sciences in carrying out basic scientific research, but the research activities of many of the universities were expanded significantly beginning in 1997.)

Putin’s emphasis on the military applications of science has caused anxiety among some Russian scientists, who worry that the new policies are little more than a reversion to the centralized, top-down system of the Soviet era. In mid-2000, the St. Petersburg Association of Scientists condemned the government’s alleged efforts to convert science into a “branch of the military.” Even many of the scientists who were more favorably disposed toward Putin’s proposals were initially skeptical that the new rhetoric and policies would be sustained over time. In the hope that a real change was in the offing, they offered suggestions about how to improve the situation in the near term. In public interviews and discussions with senior officials, a number of leading scientists complained that the government’s efforts to provide housing and monetary incentives to retain existing personnel and lure scientific researchers back to Russia had been far too limited. They also stressed that the recruitment of new scientific talent would depend on ensuring career mobility as well as material inducements. Although many scientists concurred with the government’s proposal to scale back the state's role in civilian research over time and to encourage large increases in private investment, they warned that the scarcity of private capital in Russia made it infeasible to proceed very quickly in this direction.

These concerns were taken into account by the government in its latest proposals for weapons-related research and the compensation of nuclear scientists. In August 2000, Putin issued a decree on "Urgent Measures of Social Support for Specialists of the Nuclear Weapons Complex of the Russian Federation." The decree authorized further increases in the salaries and pensions of all scientists, engineers, and other personnel involved in the "research, production, and disassembly of nuclear weapons." These new pay increases and the settlement of earlier wage arrears ensured that nuclear weapons scientists and engineers would be receiving salaries roughly two to three times higher than average, along with generous benefits. Two days after issuing this decree, Putin sent Prime Minister Mikhail Kas'yanov on a highly publicized visit to the VNIIEF nuclear weapons design center in Sarov. During the trip, Kas'yanov pledged that the government would upgrade the living standards and research conditions of employees in the nuclear weapons complex. "The development of science pertaining to nuclear weapons," Kas'yanov declared, "is one of the main objectives for Russia."

The government's efforts to bolster the scientific prowess of the weapons complex continued in 2001. As the year began, the Sarov and Snezhinsk nuclear research centers announced that they would be embarking on new state-funded defense projects and providing additional pay increases for essential personnel. Other key weapons facilities made similar announcements, and the government proposed extra funding for new military research activities. In the spring of 2001, Putin established a Science Council under his direct supervision to "choose the priorities for scientific research" in Russia and to facilitate a "reversal of the brain drain" by encouraging the "best scientific personnel to come back" to their homeland. When the Science Council advises Putin how "the state should support fundamental science and applied science," it is supposed to give particular weight to defense-related programs in "cutting-edge areas on which the future of the country depends."

Putin's emphasis on the link between scientific research and military production was reinforced in October 2001 when he upgraded the ministry of industry, science, and technology and tied it directly to the defense complex. In an unexpected move, Putin replaced the existing minister of industry, science, and technology, Aleksandr Dondukov, with Ilya Klebanov, a deputy prime minister who had been overseeing the roughly 2,000 military-industrial enterprises in Russia. Although Klebanov was removed from his post as deputy prime minister in February 2002 (largely because of political infighting), he was able to combine the two posts long enough to ensure that the ministry of industry, science, and technology (or, more likely, a successor body controlled by the Russian Security Council) would be responsible for overseeing a long-awaited overhaul and upgrading of the weapons complex. A draft program to this effect, released in March 2001, envisaged the establishment of 36 conglomerated "corporations" as conduits between the government and the large array of defense plants. Many observers expected that this program, like numerous others over the past decade, would come to naught. But now that Klebanov's position has been strengthened and the science establishment has been effectively subordinated to the defense complex, the prospects for meaningful change may be greater, especially if economic growth continues and the federal budget remains in surplus.

Until the Russian economy is drastically reformed (a process that is still in its early stages) and free-market institutions are firmly in place, the conditions for scientific research in Russia will remain precarious. But if Putin's proposals to revive the country's scientific and technological capabilities can be converted from rhetoric into sustained action, they will clearly benefit the defense complex. Whether that will be good or bad from the West's perspective remains to be seen.

Recruitment and Retention of Younger Weapons Scientists.

To ensure that the WMD complexes remain vigorous in the future, Putin has sought to increase the number of young, highly trained scientists and engineers who undertake weapons work. The influx of younger scientists to the weapons facilities had dropped significantly in the first half of the 1990s, primarily because the collapse of the Soviet Union led to the breakdown of the centrally planned higher education system in Russia, which traditionally had channeled many of the best young scientists from leading universities (the Moscow Institute of Physics and Engineering, the Moscow Institute of Physics and Technology, Moscow State University, Leningrad State University, etc.) to the WMD complexes. Similar problems arose during this period with the recruitment of newly trained engineers. In the past, most of the engineers employed in the nuclear weapons complex had been educated at the seven specialized universities (branches of the Moscow Institute of Physics and Engineering) and 18 technical schools in the closed cities that were run by the Soviet Ministry of Medium Machine-Building (and later by Minatom). Funding shortfalls of nearly 75 percent at the Minatom universities and technical schools from 1992 to 1997 deterred prospective students from enrolling. The result was a further reduction in the flow of freshly trained specialists to the WMD complexes. Initially, this trend did not pose a serious problem for staffing levels within the weapons complex—a survey by Minatom in early 1999 found that over 90 percent of key positions and areas of expertise in the nuclear weapons industry were filled—and indeed some cuts in the supply of new personnel were needed to facilitate the projected downsizing of the nuclear complex. Nonetheless, a continued failure to attract sufficient numbers of younger scientists and engineers would pose grave long-term problems for the weapons facilities. Hence, one of Minatom's chief priorities since the late 1990s has been to step up the recruitment of younger scientists and engineers and to retain those who have recently joined the nuclear weapons facilities.

The goal of encouraging younger scientists to enter the defense complex has also been a constant theme of Putin's policies and statements. In May 2000, he called for a "national program to draw young people to science," an allusion to the possible restoration of an educational system that would allocate fresh scientific talent to military research. In late November 2000, at Putin's behest, the government convened a special meeting to discuss how to ensure that younger scientists would pursue research careers within Russia, especially in the defense complex. Several of the participants warned that unless sweeping measures were taken, younger scientists would increasingly seek to enter the commercial sector or, even worse, to immigrate to the West. The reduced flow of young scientists into the weapons complex, according to those present, was posing a "threat to [Russia's] security." The minister of education, Vladimir Filippov, expressed particular concern that "the United States has set a target to attract specialists in the field of science and the defense industry, which includes a special quota for Russian experts. If we do not take urgent steps, we will be working for another country's defense." These concerns helped spur Putin's proposals to quadruple the funding for defense-related research at universities and to improve opportunities available to younger scientists.

Other steps to recruit young scientists and engineers have been taken by Minatom itself, notably through its sponsorship of events for groups of younger experts, its allotment of greater funding to the specialized universities and technical schools in the closed cities, and its success in obtaining draft exemptions for young specialists who make their careers in the nuclear weapons complex. Beginning in 1999, the section for young people in Russia's Nuclear Society (a professional organization closely affiliated with Minatom) sponsored and participated in periodic scientific conferences and annual youth congresses for freshly recruited experts working in the nuclear complex. In March 2000, a group of younger scientists and engineers employed at VNIIEF formed a youth council, which is intended to represent the interests of some 1,500 younger experts at the nuclear center. With Minatom's approval, similar councils have been set up at other nuclear facilities.

The upgrading of the specialized universities has been facilitated not only by increased funding for training and laboratory equipment, but also by the establishment of generous scholarships to attract bright students. Since the late 1990s, several dozen scholarships have been awarded each year to students at all seven universities. Another important development has been the creation of special departments and divisions in which courses are taught by senior scientists and engineers from the local nuclear weapons facilities. The degree program takes 6 years to complete, but, beginning in the third year, students are given the opportunity to pursue apprenticeships and to use laboratory equipment at the weapons facilities. Further training is available in 29 postgraduate science and engineering programs, with an enrollment of around 450 a year.

These improvements, and the increased enrollments that have resulted, have been reinforced by Minatom's ability to secure draft exemptions for younger employees of the nuclear weapons complex. Because severe hazing and other abuses in the Russian army remain pervasive, many young people in Russia have been eager to avoid conscription. At Minatom's urging, Putin issued a decree in November 2000 granting exemptions from military service to hundreds of young scientists and engineers at the Sarov, Snezhinsk, Lesnoi, and Trekhnogornyi nuclear weapons facilities. The exemptions remain in effect as long as the beneficiaries continue to work full-time in the weapons complex. This privilege offers a major incentive for talented young people to pursue careers either at weapons facilities or, under a separate decree, at civilian nuclear plants.

All these developments have led to a significant increase in the number of young specialists who are entering the weapons complex. After reaching a low point in the mid-1990s, the number of new employees recruited by Minatom rose to 2,000 in 1998, dipped to 1,500 in 1999, and then rose back above 2,100 in both 2000 and 2001. Although certain problems persist at Minatom's educational facilities and many young people in the closed cities are still seeking to move elsewhere, the dire predictions that some observers (including some senior Minatom officials) made in the mid-1990s about the growing dearth of fresh talent for the nuclear weapons complex seem less relevant since the late 1990s. For the time being, a gap remains in the lower-level staffing of the weapons facilities—a gap that resulted from the greatly reduced inflow of younger scientists and engineers in the first half of the 1990s—but there is ample reason to believe that this gap can be overcome if recruitment stays relatively buoyant and Minatom proceeds with a restructuring of the nuclear complex.

Travel Restrictions and Curbs on Foreign Contacts.

Of all the factors that limited the brain drain from Russian WMD facilities to foreign countries over the past decade, perhaps the most important was the existence of travel restrictions. The restrictions were first imposed during the Soviet period and were reaffirmed in the 1990s by Russian legislation, government directives, and presidential decrees. Under these measures, the Russian government is able to forbid individuals who have had access to "state secrets" from leaving the country for a period of 5 years after their last contact with such information. The government is also entitled, at its own discretion, to extend the period for as long as deemed necessary.

Legal restrictions on the foreign travel of weapons specialists had been in place from the moment the Soviet WMD programs were set up, but the dissolution of the Soviet Union in December 1991 raised the question of what to do about those restrictions. For decades, foreign travel for all Soviet citizens had been severely limited and controlled by the state, but in May 1991 the Soviet parliament approved a measure titled Law on the Order of Departure from and Entry into the USSR of Citizens of the USSR, which significantly liberalized the earlier travel regime. Because the Russian Federation initially lacked its own law governing the entry and exit of citizens, the Russian government simply extended the Soviet law, which remained in effect until the Russian parliament finally passed a new law in mid-1996. A resolution adopted by the Russian government in late January 1993 reaffirmed and tightened the Soviet law's restrictions on "individuals who are privy to state secrets." The resolution stipulated that organizations intending to send employees abroad on official business had to check first with the state security apparatus to determine whether there were "grounds for temporary restrictions on the [employees'] right to leave the Russian Federation." This provision applied to all employees of the WMD complexes, and the coverage was broadened through amendments to the resolution in 1993 and 1995, which explicitly empowered the head of the Kurchatov Institute (a leading nuclear physics research institute) and the director of Biopreparat (the BW pharmaceutical firm, which had been converted into a "joint-stock company") to restrict the foreign travel of their employees as well, in consultation with the state security organs. No maximum duration was set for these restrictions.

The limitations on foreign travel were tightened further in July 1993, when the Russian parliament adopted a long-awaited measure titled Law on State Secrets. The law replaced (or in some cases supplemented) Soviet-era legislation that had been extended via a Russian presidential decree in January 1992. Article 5 of the new law and the more detailed provisions of a subsequent "List of Items of Information Classified as State Secrets" make clear that all technologies, components, and procedures connected with "weapons of mass destruction, that is, nuclear, chemical, biological, or other weapons of great destructive force," are state secrets "of special importance" (*osoboi vazhnosti*), the highest level of classification. (A three-tiered classification system is laid out in Article 8 of the Law on State Secrets and in the more elaborate rules of classification adopted by the Russian government in October 1995. Under these rules, classified information is deemed to be "secret," "top secret," or "of special importance"—a division that is broadly similar to the secrecy categories used during the Soviet era.) The expansive definition of "secrets" in the law allows the security organs to prevent vast numbers of people, including all weapons scientists and engineers, from going abroad.

The most severe restrictions on travel by WMD specialists are laid out in Article 24 of the Law on State Secrets, which requires anyone working with information "of special importance" to forfeit "the right to go abroad until after a period specified in the [employee's] labor contract." Labor contracts for weapons specialists include detailed provisions forbidding disclosure of classified information and a special provision compelling each employee to "agree to a partial, temporary restriction of my rights, including the right to travel abroad for a period of _____ years," with the precise length of this period determined by the employee's rank and duties. The contracts stipulate that even if the employees lose or relinquish their access to state secrets, they must continue to abide by the obligations they "voluntarily undertook," including their acceptance of restrictions on all foreign travel.

In principle, the limitations apply only to travel outside the country, but in practice the leeway for key WMD specialists to move around **within** Russia is also still tightly controlled. During the Soviet era, employees of the closed cities were not permitted to travel anywhere (even to other Soviet cities) unless they received official permission. After 1991, the ban on traveling and moving to other cities was supposed to have been eased, but in practice it remains in effect, as Vladislav Mokhov, a senior nuclear weapons physicist at Sarov, emphasized in mid-1996:

> I work on secret projects and am therefore restricted. . . . But if I could choose my place of residence [within Russia], I would never have stayed here [at Sarov]. Unfortunately they would not let me leave. If given a choice, most of us theoreticians would go to Moscow.

Enforcement of the travel restrictions is provided for in Article 20 of the law, which authorizes the Russian president to establish an Interdepartmental Commission for the Protection of State Secrets, a body with "extra-departmental powers" to coordinate all activities needed to "protect state secrets." Yeltsin issued a decree in November 1995 that formally set up the Interdepartmental Commission and another decree in January 1996 that specified the organization and functions of the Commission, including its role vis-à-vis foreign travel. The powers of the Commission and other agencies to limit travel are laid out in greater depth in the Federal Law on the Procedure for Exiting and Entering the Russian Federation, which took effect in August 1996. The law grants wide discretionary authority to the state security organs and the Commission to prevent individuals who have had access to state secrets from leaving the Russian Federation. Under Article 15, anyone who has had access to secrets "of special importance" and has "signed a labor contract providing for the temporary restriction of his right to exit from the Russian Federation" can be denied the right to leave Russia, no matter what the purpose of the intended trip. The law thus further codified the basic restrictions described by

Yurii Tumanov, the first deputy director of the Sarov nuclear weapons center, in April 1995:

> People involved in secret research must go through a rigorous screening by the Federal Security Service [FSB] if they want to travel abroad. The FSB determines the extent of their knowledge of state secrets. Those who are most closely involved in secret research are not permitted to take private trips abroad. . . . Scientists who are privy to information of special importance are not allowed to go abroad even as members of official delegations unless they receive personal permission from the minister of atomic energy.

The initial length of the restriction is 5 years from the time of the employee's most recent contact with classified information "of special importance," and the Interdepartmental Commission is permitted to extend the term for at least another 5 years.

Some of the weapons scientists who have applied to leave Russia either temporarily or permanently were granted permission to do so, but those whose requests were denied were informed by the "internal security organs"—under Article 16 of the Law on the Procedure for Exiting and Entering—of the date of the denial, the registration number of the case, and the full name and legal address of the organization principally responsible for the denial. Unsuccessful applicants are given the right to appeal the restrictions before an Interdepartmental Commission for the Consideration of Appeals by Citizens of the Russian Federation in Regard to the Limitation of Their Right to Exit from the Russian Federation. This appeals commission was set up via a government resolution in March 1997 as a direct replacement for the Interdepartmental Commission for the Consideration of Appeals by Citizens of the Russian Federation Relating to the Denial of the Issuance of a Foreign Passport and Temporary Restrictions on Travel Abroad, which had been established by a government directive in March 1993. The new commission is obliged to respond to all appeals within 3 months.

The regulations for the appeals commission stipulate that it must supply the Interdepartmental Commission for the Protection of State Secrets with an applicant's pertinent travel documents whenever there is "a need to extend the period of restriction on a citizen's right to exit from the Russian Federation beyond 5 years as provided under [the citizen's] labor contract." The Interdepartmental Commission on State Secrets must then issue a ruling on whether the information to which the applicant had access was truly "of special importance." If the appeal is turned down, the individual can appeal it further in a court of law. In the meantime, however, anyone who has been denied permission to leave the country must immediately relinquish his or her passport and all other travel documents "for safe keeping to the state body that issued the passport."

This appeals procedure, cumbersome though it is, was used surprisingly often in the mid-1990s by scientists who were denied permission to leave the Russian Federation because they had been privy to state secrets "of special importance." From June 1994 to June 1995, the appeals commission (known informally as the Ivanov Commission after its chair, Igor Ivanov, who was then a first deputy foreign minister) heard appeals in 198 such cases. The commission rejected 16 of the appeals and, in each case, imposed an additional period of up to 4 years on the initial travel restriction. The appeals procedure has been invoked less frequently since the late 1990s, primarily because of the sharp drop in the number of scientists seeking to leave the country. The lower incidence of appeals is also partly due to the increasing likelihood that appeals will be rejected. As the appeals commission became more stringent in its rulings, it deterred potential applicants from even trying.

Violations of the law on the right to leave the Russian Federation are punishable by up to 10 years of imprisonment, the same sentence that is meted out for violations of the travel provisions in the law on state secrets. Western legal scholars and government officials, as well as human rights groups in both Russia and the West, have argued that the Russian laws are excessively broad and open-ended, and that the severity of the restrictions inevitably circumscribes the rights of scientists who pose no threat of strategic proliferation. The potential for abuse was underscored by a case in 1999 involving Raisa Isakova, a former scientific researcher at a secret institute in Omsk who had held a Grade 2 security clearance. Isakova had long been active in the local Jewish community, and in March 1999 she applied for permission to travel to Israel. After several weeks of delay, the Federal Security Service (FSB) warned her that unless she signed a compromising statement against the Jewish Agency in Russia (a nongovernmental organization that promotes immigration to Israel), her application for an exit visa would be turned down. Isakova was the head of the local branch of the Jewish Agency in Russia, and she refused to sign the statement. Her application was then rejected, and she was informed that she would not be able to receive a visa until at least December 2005. She appealed the decision, pointing out that numerous other researchers from her institute with the same level of security clearance had been permitted to travel abroad. In September 1999 the appeals commission ruled that she could reapply for a visa in January 2003 (rather than December 2005), but it did not overturn the denial of her application.

Isakova's experience is one of several cases that reflect the government's increasing determination to curtail foreign travel by individuals who have had access to state secrets. (The Isakova case is also indicative of the persistence of official anti-Semitism, but that is another matter.) The potential for abuse by the Russian authorities has sparked wide concern among scholars, human rights advocates, and legal specialists in both Russia and the West. Some have argued that the restrictions are not only repressive, but counterproductive for the Russian government itself. According to this view, the emigration of certain individuals who were denied the right to leave could actually have proven beneficial to Russia by reducing the potential for discord at home.

These sentiments, however, are not shared by senior FSB officials who, in early 1996 when the law on the right to exit the Russian Federation was being debated, claimed in interviews with the Russian news media that restrictions on emigration of Russian scientists are crucial to protect the Russian state from foreign subversion. As one official put it, "Anyone who has had access to state secrets . . . must forfeit the right to travel abroad, except on official business. Such measures are needed to ensure that hostile forces will not compromise our security."

This draconian view has been endorsed by high-ranking officials in Russia's military-industrial complex, who have even complained that the current laws on state secrets and emigration are too lax, a view that Putin himself expressed at Zelenograd in February 2000. In November 2000, amid controversy surrounding the arrest and trial of the retired American intelligence officer Edmond Pope, several prominent Russian weapons scientists sent an open letter to the leaders of the Russian government and judiciary alleging that measures to permit greater openness and freedom of travel were endangering the country's scientific establishment and compromising state secrets. The scientists echoed Putin's call for more stringent laws that would ward off "hostile encroachments" on Russian science. They asserted that "the proper balance between secrecy and openness" had shifted too far in favor of the latter and that "court hearings [connected with appeals of travel restrictions] are depriving the [Russian] state of the right to defend itself against breaches of its security resulting from the disclosure of state secrets." The scientists stressed that the increased freedom of travel both into and out of Russia was allowing foreigners to take unfair advantage of Russian scientists:

> Russia has a lot of things in the military, technical, and scientific areas to be proud of and a lot to protect against

> uninvited "guests." These guests try to exploit our openness, our economic difficulties, and the mercenary interests of certain representatives of the military-industrial complex to obtain Russian know-how and state-of-the-art technologies for next to nothing.

The Pope case inspired many other officials to express similar views. The deputy leader of Putin's Unity faction in the Russian Duma, Frants Klintsevich, condemned the "devil-may-care attitude to the defense of state secrets" and demanded that the freedom of travel—both within Russia and outside it—be restricted. The chair of the Duma's subcommittee on security and disarmament, Vitalii Sevastyanov, denounced the "imperfections and flaws in the Russian laws on state secrets" and called for "tough measures" to prevent the compromise of "technologies developed by generations of Russian scientists and the defense industry—technologies that are the national treasures of Russia." Although Sevastyanov's remarks were directed mainly against foreigners operating within Russia, he stressed that the emigration of Russian weapons scientists was posing an equally dire threat. The alleged "danger" resulting from the emigration of Russian scientists was emphasized even more explicitly in the Russian press, which decried the FSB's supposed failure to halt the brain drain and the concomitant leakage of Russian military technology. In a typical case, a commentator in the widely circulated daily *Moskovskii Komsomolets* accused Western nonprofit foundations—specifically naming Soros, Carnegie, Fulbright, MacArthur, Friedrich Ebert, and Eurasia—as well as the ISTC and the U.S. Agency for International Development of being "sieves" that were luring unemployed Russian scientists to the West.

Even before the Pope case erupted, there were ample signs that the brief period of relatively free emigration in the early 1990s had given way to much tighter restrictions. Siegfried Hecker, who was instrumental in setting up the Russian-American nuclear laboratory contacts in early 1992 when he was director of Los Alamos National

Laboratory, recently noted that by the late 1990s "the nuclear defense sector [in Russia had] experienced a significant reversal of the openness we found in the early 1990s. The rise in the presence and power of the Russian security services was felt by all nuclear installations." As far back as October 1995, a detailed set of instructions approved by the Russian government on the procedures for granting access to state secrets had required all Russian citizens holding security clearances to undergo new background checks if they got married, had a close relative who moved abroad, or experienced other changes in their lives. In subsequent years, the FSB tended to construe this provision as expansively as possible. In 1998 Susan Eisenhower wrote that her husband, the well-known Russian planetary scientist Roald Sagdeev, had recently been subjected to "an extensive and thorough background check" after his passport expired. Sagdeev had formerly held security clearances, but the reason he was forced to undergo a background check was simply that he had been traveling back and forth between Russia and the West. Eisenhower noted that in recent months Sagdeev had found "border control" in Russia to be "much tighter" than in the early 1990s, and that he had heard from scientists working in the nuclear weapons and missile complexes that they too were "under far greater scrutiny" and were "restricted in their travels" and deprived of "the right to keep a passport for foreign travel in their possession."

The increasing severity of the travel restrictions inevitably took its toll. The Carnegie Endowment survey revealed that, by 1999, nuclear weapons scientists were citing "administrative restrictions" and a lack of money as the two main obstacles to working abroad. Many of the scientists argued that "the authorities do everything to prevent a person from going abroad" by "imposing conditions . . . and putting obstacles in the way." The tighter restrictions on foreign travel were by no means the only factor that led to a sharp drop in the rate of emigration after the early to mid-1990s, but they clearly played a crucial role.

Because Russian weapons scientists knew they had to overcome formidable barriers before they could leave the country, they often sensed that it was better not to try. The small number who did apply to travel abroad were often turned down.

Moreover, the clampdown on scientists eventually extended beyond the tightening of travel restrictions to include limitations on all foreign contacts, even the most innocuous ones. In May 2001, the presidium of the Russian Academy of Sciences issued a directive outlining "Measures to be Taken by the Russian Academy of Sciences to Prevent Damage to the Russian Federation." The directive required the Academy's "special departments" (*osobye otdely*) and institute directors to "exercise constant control over trips abroad by Academy of Sciences researchers who have access to state secrets," to "tighten control over the researchers' submission of reports about their trips abroad," and to compel researchers to disclose any projects they were pursuing with foreign scientists, any grants they might seek from abroad, any articles they published in foreign journals, any visits they might host by foreign scientists, and any other contacts they might have with foreigners. The information was to be collected and transferred periodically to "appropriate officials" in the government.

Controls of this sort had been in effect during the Soviet era, but most of them were lifted after the Soviet Union disappeared. The rationale for restoring them, according to the government and senior Academy officials, was to "protect state secrets" and prevent any "leakage of scientific information." One of the vice presidents of the Academy, Gennadii Mesyats, argued that "it is of immense importance to preserve our know-how" in the defense sector. He claimed that the "increased freedom of contacts with foreign visitors" had posed serious risks:

> Many Russian scientists [in the 1990s] went abroad to earn money, and the directors of scientific research institutes, if only reluctantly, began selling off the results of projects that were

> not attracting investors within Russia. As a result, not only was the [earlier policy of] total control over foreign contacts lost. For a while these contacts were not subject to any control at all. The leakage from the country of information about promising scientific developments took on a catastrophic nature in some places.

Mesyats and other senior Academy officials also insisted that the revived controls were no different from those supposedly in effect in the United States and other Western countries. The Academy's chief press representative, Igor Milovidov, argued that "it is a universally customary practice to report to your boss" about contacts with foreigners, and Mesyats added that he had "frequently been on official trips to the United States, and they have a very tough secrecy regime. . . . I know that U.S. scientists also inform their bosses about absolutely everything. There is nothing underhanded here [in Russia]. No! This is normal." Although it is true that scientists at U.S. weapons laboratories and other highly sensitive facilities are obliged to keep their superiors informed of foreign contacts, Mesyats is wide of the mark in suggesting that expansive controls like those in Russia, applying to civilian and weapons scientists alike, would or could be adopted in the United States.

The crackdown on civilian scientists, combined with the Russian government's decision in September 2001 to establish a new Agency for the Protection of State Secrets that will "impose tighter limits on information security," suggests that the ever more stringent controls on weapons scientists are unlikely to be eased anytime soon. The increased salience of the FSB under Putin, and the Russian news media's and government's growing obsession with allegations of "foreign espionage" against Russia, imply that the trend, if anything, is likely to be toward even stricter, not looser, control over the travel and foreign contacts of weapons scientists. Should this prove to be the case, it may well derail any notion of encouraging these scientists to immigrate to the West.

CONCLUSIONS

Several points that emerge from the analysis above have a bearing on U.S. policy vis-à-vis Russian weapons scientists.

First, compared to the sharp reductions in Russia's output of conventional weapons, Russian facilities for the production of WMD have been only modestly scaled back. Even now, more than a decade after the collapse of the Soviet Union, most of the infrastructure for the Soviet nuclear weapons and CBW complexes is still in place. A very large group of highly trained weapons scientists and engineers—numbering tens of thousands—are still employed at Russian WMD facilities and are still engaged in weapons-related work.

Second, the departure of Russian civilian scientists in the early 1990s—either to foreign countries or to nonscience jobs within Russia—took a toll on Russian scientific prowess, but the brain drain did eventually subside. By the late 1990s, far fewer scientists were seeking to emigrate. Within the WMD complexes, the brain drain phenomenon was much less acute, contrary to Western fears in 1991 that the demise of the Soviet Union would spawn a mass exodus of senior weapons scientists to Third World countries pursuing WMD programs. In reality, only a minuscule percentage of highly trained weapons experts actually left, especially after the early 1990s. The best of the nuclear weapons scientists were never interested in working abroad, and recent surveys have shown that very few other senior WMD specialists nowadays are inclined even to think of moving overseas.

Third, the United States has accepted some civilian scientists from the former Soviet Union as permanent residents (mostly in the early 1990s), but has made no effort to induce former Soviet weapons specialists to immigrate en masse to the West. Instead, U.S. policy has been geared mainly toward providing meaningful employment for

Russian and Ukrainian WMD experts in their native countries. The only modest exception came in 1992 with the Soviet Scientists Immigration Act (SSIA), which was intended to cover only about 1 percent of the WMD scientists in Russia who were of greatest proliferation concern. The SSIA was subsequently hindered by administrative delays and was a source of tension with Moscow. The problems that arose with the SSIA militated against any larger-scale attempts to encourage the immigration of former Soviet WMD scientists to the West.

Fourth, U.S. and other Western efforts to provide alternative employment for the most highly trained WMD scientists in the former Soviet Union have been well-intentioned, but have not achieved the desired effect. The scale of the problem is much too large for any of these programs to have any meaningful impact. (This would be the case even if the U.S. programs were well designed. The DOE's dubious judgments about certain matters greatly compound the problem.) Only a relatively small percentage of high-level Russian weapons scientists have actually taken part in the Western-sponsored projects, and the overwhelming majority of the participants have devoted only a small percentage of their time to the projects. During the rest of their time, the Russian scientists have continued to perform weapons-related work. Once the outside projects are over, the scientists have returned full-time to their WMD work. The Western programs thus have not provided—and cannot provide—a permanent alternative source of employment for tens of thousands of highly trained Russian WMD specialists. Indeed, there is even a risk that the Western programs have inadvertently become a subsidy for the Russian WMD complexes, helping to keep them operating at a robust level.

Fifth, the private sector in Russia has absorbed some former weapons scientists, but it is hardly a panacea. Even in Western countries, defense conversion is extremely difficult. In Russia, the problems are immeasurably greater not only because the country was so highly militarized under the Soviet regime, but also because efforts to reform the Russian economy have been so disappointing. Moreover, even if the private sector in Russia were thriving (which is not yet the case, especially outside Moscow and St. Petersburg), it is unlikely that most of the highly trained WMD scientists would be well-suited to enter it. The younger scientists who could adapt more easily to the rigors of a private labor market have already left, and the senior specialists who are still working at WMD facilities would have inordinate difficulty in adapting.

Sixth, the Russian government's recent attempts to upgrade Russia's scientific capabilities, especially in the defense sector, may mean that the long-anticipated restructuring and downsizing of the Russian WMD complexes will be delayed or reduced in scope. Despite Minatom's projections of sizable layoffs in the nuclear weapons complex over the next several years, recent trends suggest that a large number of the senior weapons scientists can count on keeping their jobs for a substantial time to come, especially if the Russian economy continues to grow and the Russian federal budget remains in surplus. The stepped-up recruitment of younger weapons scientists also implies that WMD facilities will be operating at a robust level well into the future.

Seventh, restrictions on the travel of Russian weapons scientists have contributed to the sharp decline of interest among scientists in the prospect of working abroad. The laws on state secrets and on exit and entry, and the stern implementation of those laws by the FSB, pose a formidable—indeed almost insuperable—barrier for any senior WMD scientist who might seek to emigrate. Awareness of these obstacles would likely deter a would-be emigrant from seriously pursuing the option. Illegal emigration cannot be ruled out altogether, but there is no reason to believe that it would occur on anything more than a trivial scale, if that. Very few Russian weapons scientists are inclined any longer to think about working abroad (even legally, not to mention illegally), and they are certainly aware of the severe penalties for those convicted of violating the laws on state secrets and on exit and entry.

Eighth, neither Yeltsin nor Putin displayed any willingness to permit freer travel by WMD specialists. The debate in Russia was settled early on in favor of those who believe that a brain drain—especially one involving weapons scientists—is inherently a negative phenomenon. In the early 1990s, a small number of Russian officials, notably the minister of science, technology, and higher education, Boris Saltykov, were willing to countenance scientific immigration to the West because they believed that it ultimately would prove beneficial for Russia. Saltykov claimed that leading scientists would go abroad temporarily and would return to Russia having been "enriched by the experience and skills of the best laboratories in the world." This line of argument, whatever its merits, never attracted any appreciable support. The dominant view among Russian officials, journalists, and political commentators was that a further exodus of civilian scientists—not to mention the departure of highly trained weapons experts—would be detrimental to Russia's interests and should therefore, to the extent possible, be prevented. Although a small number of WMD scientists were sent abroad on temporary assignments (including possibly to Iran), the Russian government gave no indication that it would allow many thousands of highly trained weapons specialists to move permanently overseas.

All of these considerations present a sobering outlook for any prospective U.S. effort to encourage the immigration of roughly 60,000 senior Russian WMD specialists to the West. If judged in terms of **desirability**, the option of promoting immigration to the West would clearly be the route to go. Tens of thousands of key weapons scientists, engineers, and technicians are still at their posts in Russia, where they have been helping to sustain the Russian WMD complexes through troubled times. To the extent that Russia would be a lot better off—and would pose a much smaller potential threat to U.S. interests—if it drastically scaled back its nuclear weapons complex and did away with its CBW facilities, the continued presence of these tens of thousands of highly trained weapons experts in Russia is detrimental for the West. Up to now, the Russian government has been unwilling to dismantle its WMD infrastructure, and recent trends suggest that this aversion is likely to persist. The only reliable way to ensure that Russia would have to make drastic cuts in its WMD facilities is by permanently removing the most important researchers and engineers who work at those facilities—an outcome that immigration to the United States would achieve. The opportunities that the newly arrived specialists would be given in the United States would, in principle, eliminate any possible incentive they might have to consider working for a country like Iran or Libya. Despite the tightening of U.S. immigration procedures in the wake of the September 2001 terrorist attacks, the option of bringing many thousands of former Soviet WMD experts to the United States would be well worth pursuing if it seemed likely to succeed.

But if judged in terms of **practicality**, the notion of encouraging large-scale immigration to the West is dubious. Six fundamental problems would hinder any such effort.

First, the decline of interest in emigration among weapons scientists, as evidenced both in surveys and in the sharp drop in emigration since the early 1990s, would be difficult to reverse. Although a major change of policy by the West might persuade some Russian weapons scientists that they should seriously pursue the option of emigration, the majority are unlikely to be convinced. It is even conceivable that a conspicuous effort to foster a brain drain to the West would spark a nationalist backlash among WMD scientists and deter them from even considering the prospect of working abroad or leaving their weapons posts.

Second, it is extremely unlikely that the Russian government would go along with such an effort or would fail to attempt to prevent it. Saltykov's sentiments (cited above) did not win out. Even the limited provisions of the SSIA sparked a good deal of acrimony in Moscow. The severe travel restrictions and controls that have been adopted over the past several years are indicative of the Russian authorities' desire to retain the country's senior weapons personnel. Putin's recent statements merely underscore that point. It is almost inconceivable that Western countries could circumvent the administrative and legal barriers posed by the Russian government. The situation facing the Russian government today vis-à-vis its WMD experts is fundamentally different from the position of Germany after World War II. When Germany was under the control of allied occupying forces in the mid-to-late 1940s, the victorious powers enjoyed free rein to induce (or, in the Soviet case, compel) Germany's leading weapons scientists to move abroad. Russia's relationship with the outside world today is in no way comparable. Western countries have no direct say in Russia's internal affairs, and the Russian authorities can take whatever steps they want to prevent highly trained WMD scientists from leaving. Although such measures might not prove flawless, there is little reason to believe that a massive outflow of senior weapons experts could occur against the Russian government's will.

Third, if an effort to encourage large-scale emigration proved only partly successful, the result might be decidedly negative for U.S. interests. The brain drain issue has been politically volatile in Russia and has been manipulated by anti-reformist forces to discredit reform-minded, pro-Western officials. In the 1990s, numerous commentators in Moscow argued that Russian scientists were being "exploited by the West" as "cheap labor" and "sources of information about the latest research developments" in Russia. These complaints would undoubtedly increase and become more virulent if the U.S. Government made a conspicuous effort to induce tens of thousands of Russian WMD experts to immigrate to the United States. The ensuing damage to U.S.-Russian relations might be grave enough to prompt the Russian government to cease cooperating in key areas such as CTR, the Materials Protection, Control, and Accounting program, and the Missile Technology Control Regime. Russian leaders not only would be disinclined to defer to U.S. demands (e.g, on nuclear exports to Iran and Cuba), but might even seek to put up an active challenge to the West—possibly by offering assistance to North Korea or Iraq. Were this to be the case, the net result from a nonproliferation standpoint would be deleterious.

Fourth, in all likelihood an emigration drive that was only partly successful would have a counterproductive effect on the Russian WMD complexes. Presumably, the weapons scientists and engineers who would move from Russia would be those who had long been inclined to look favorably upon the West. They would leave behind many of their former colleagues who had always been deeply suspicious of U.S. intentions. Surveys of nuclear weapons and aerospace specialists have shown that a majority of those who want to stay in Russia are hostile to the West or at least are mistrustful. Such sentiments would undoubtedly intensify if the United States began actively luring away a large number of Russian weapons experts. The WMD scientists who would remain in Russia would undoubtedly want to expand (rather than downsize) the country's weapons facilities and to provide assistance to anti-Western clients such as Iran. By the same token, these scientists would be averse to the contacts and cooperative programs that Russian weapons scientists pursued with their American counterparts from 1992 on. Most likely, all such activities would come to a halt.

Fifth, even if a large-scale emigration drive proceeded and tens of thousands of Russian scientists flocked to the West, Western governments could not be certain that the people leaving were truly those of greatest proliferation concern. The U.S. Government does not know precisely who the most senior WMD specialists in Russia are. As the GAO recently pointed out, U.S. efforts to promote alternative employment for key weapons personnel in Russia have had to rely on the Russian government's own judgments about the people who should be targeted:

> [T]he State Department cannot independently verify the weapons experience of the senior scientists it has employed. The State Department relies on the scientists' national governments to certify that the senior weapons scientists listed as participants in a project proposal actually have sufficient expertise to pose a proliferation threat.

Hypothetically, if large-scale immigration to the West were occuring and U.S. intelligence officials and weapons scientists were given a chance to debrief the immigrants, they presumably could make a reasonably good judgment over time about the qualifications of the people who were being let in. Nonetheless, there would always be some residual concern that many of the best weapons scientists and engineers had secretly stayed in Russia.

Sixth, even if all these obstacles could be surmounted and Russian WMD specialists and their families moved en masse to the United States, serious questions would arise about what to do with the new immigrants. Limited numbers of foreign scientists and technicians could be accommodated quickly either in the private sector or at universities and research institutes, but an influx of tens of thousands (many of whom would not know English) would far exceed the capacity to absorb them, at least in the near term. Language barriers alone would pose a major obstacle to fruitful employment, as would the limited applicability (or potential irrelevance) of their skills to functions unconnected with the Soviet WMD complexes. Some of the specialists might be willing to take jobs outside their areas of expertise, but others would undoubtedly be averse to the notion of abandoning their traditional fields of work. If suitable posts for them were not soon available, they might eventually seek to leave. Presumably, the U.S. Government would need to establish a comprehensive monitoring system that would give prompt notice if former Soviet WMD experts decided to move back to Russia or to a Third World country. Such a system, even if practical, would be difficult to sustain over time unless the movements of the scientists were sharply circumscribed, a task that would itself be daunting. Even in Germany during the early post-war years, when all residents (not just weapons scientists) had to seek permission from the allied occupation authorities to travel abroad, the Western powers occasionally let down their guard, enabling highly trained military scientists and technicians to emigrate illegally from Germany to Argentina. The challenge of enforcing a comparable system for Russian WMD experts would be at least as formidable.

In all these respects, there seems to be little to no prospect that large-scale immigration to the West by highly trained Russian WMD scientists, engineers, and technicians is at all feasible either now or over the next 10 to 15 years. The immigration of senior personnel to the West—especially if it occurred with the Russian government's assistance—would be highly desirable, but in practical terms, the whole notion seems fanciful. The likelihood is that tens of thousands of key nuclear, biological, and chemical weapons experts will remain in Russia indefinitely and will continue to pose a threat of strategic proliferation, both horizontal and vertical.

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These conclusions may seem to offer little reason for hope, but in fact there are certain steps that could markedly improve the situation over the long term. In particular, a greatly expanded program of student exchanges would be far more practical and effective than anything that has been done up to now (or is likely to be done) vis-à-vis Russian WMD experts. Not only would a large-scale student exchange program encourage democratization in Russia and provide a sounder basis for Russia's ties with the West, it also could indirectly ameliorate the human dimension of the strategic proliferation threat. Unfortunately, student exchanges thus far have played only an insignificant role in U.S. policy, despite the hopes of Senator Bill Bradley in the early 1990s when he put together the Freedom Support Act (FSA), which provided democracy assistance to Russia. An initial $20 million was allocated under the FSA to a Secondary School Exchange Program (later known as the Future Leaders Exchange Program, or FLEX). Although the FSA also provided $30 million for exchanges of undergraduates and graduate students, the high school exchange program was deemed especially important because it would involve adolescents, whose outlooks and behavioral patterns would not yet be firmly congealed. Bradley expected that some 15,000 to 20,000 Russian high school students a year would attend school in the United States and that many thousands of others would be enrolled each year in Western Europe. Exchanges of that magnitude over a decade or two would have exposed a large cohort of young people in Russia to the values, mores, and institutions of democratic capitalism.

But, as things worked out, only a tiny fraction of the projected number of Russian high school students actually came to the United States via FLEX and other programs. From 1993 to 2001, a total of just 4,415 high school students from Russia—and another 6,076 from the rest of the former Soviet Union—attended American schools under the auspices of FLEX. This means that, during the first 9 years of FLEX, fewer than 500 Russian high school students a year took part in the program. Worse still, the annual number of Russian high school students involved in FLEX was much lower by the late 1990s than it had been earlier in the decade. From 621 students in 1993 and 744 in 1994, the annual number fell to 305 by 1999—less than 1/50th of the initial target. The number enrolled in West European schools each year was even smaller.

The meager scale of the high school exchanges has been due partly to linguistic barriers. Although a large and growing number of Russian high school students know at least some English (or German), the language requirement necessarily limits the applicant pool. In addition, many Russian high school students have been deterred from applying because their schools in Russia will not permit them to receive academic credit for the work they do overseas. FLEX has also been impeded by the difficulty of informing prospective applicants about the exchanges, a problem that is especially acute outside Moscow. The number of Russian high school students in outlying regions who enjoy regular (or even sporadic) access to the Internet is woefully inadequate. Hence, many Russian students are simply unaware of the opportunities available to them.

Serious though these problems may be, they undoubtedly could be surmounted if the United States were to devote increased resources to the effort. But a more daunting obstacle is posed by the one-sided nature of the high school exchanges. Very few American high school students have been willing to enroll in Russian schools for even a semester, not to mention a full year. Part of the problem is that only a scant number of American high school students can speak Russian. Although proficiency in Russian is not mandatory for certain short-term high school exchange programs, it obviously is required for participants in the main long-term program for American high school students—the Semester High School Exchange Program, which brought a total of 55 American students to Russia from 1993 through 2001 (an average of about six students a year). Even if language barriers did not exist, many American students would probably be hesitant about applying for a semester-long (or year-long) exchange program in Russia. Among other things, they (and their parents) would likely be concerned that a prolonged stay in Russia could pose risks for their health and well-being. Although a sizable number of American undergraduates and graduate students do pursue studies or field research in Russia, the high school exchanges envisaged under the FSA have been exchanges mostly in name. The absence of genuine exchanges has clearly circumscribed the number of Russian participants.

This problem may not be amenable to a direct solution, but potentially there is a way to get around it. If the student exchange programs were redesigned so that American high school, undergraduate, and graduate students were treated as a single category, the pool of students who could be paired with Russian high school students would be much larger. The exchanges would not be strictly one for one, but they would be far closer to genuine exchanges than in the 1990s. The same principle could be adopted by Canada, Britain, Australia, Germany, and other Western countries for their own student exchanges with Russia. The aim would be to expand the annual number of Russian high school participants to the thousands originally envisaged.

If indeed some 15,000 to 20,000 Russian high school students a year were to attend school in the United States and thousands of others were enrolled in other Western countries, the benefits would be immense. The Russian students would receive a first-hand look at democratic procedures, civic initiatives, and a market economy. Upon returning to Russia, they could try to replicate in their own society what they had seen and experienced abroad. They also could encourage many of their fellow students to take part in exchanges and to seek greater exposure to the West. A massive expansion of the high school exchanges would be particularly valuable over the longer term, as the number of alumni of the program rose into the hundreds of thousands. Such a trend would give a much-needed boost to U.S.-Russian relations and would facilitate the introduction of democratic norms and capitalist institutions in Russia, providing an alternative for young people who might otherwise have gone to work in Russia's WMD facilities. Although student exchanges are certainly not a panacea, they seem to offer the best long-term option for coping with the human dimension of the strategic proliferation threat in Russia.

CHAPTER 6

APPENDIX

EFFORTS BY WESTERN GOVERNMENTS AND ORGANIZATIONS TO EMPLOY RUSSIAN WMD SPECIALISTS

This appendix is a supplement to the fourth section of my chapter. It explains why the programs established by Western governments and organizations over the past decade to employ Russian WMD experts in nonmilitary jobs cannot provide long-term alternative employment for more than a very small fraction of the total pool of WMD specialists in Russia. A fully documented version of this appendix is available from the author upon request.

Science Centers Program.

The International Science and Technology Center (ISTC) was established in Moscow in November 1992 by the United States, Japan, Russia, and the European Union (EU), with an initial commitment of $75 million. A Ukrainian counterpart of the ISTC, the Science and Technology Center in Ukraine (STCU), was set up by the United States, Sweden, Canada, and Ukraine a year later. The main purpose of the two centers is to employ WMD scientists in "Science Projects" and "Partner" programs. The Science Projects are solicited directly by the ISTC and STCU, whereas the Partner projects are solicited by foreign businesses, scientific institutes, nongovernmental organizations (NGOs), and government agencies, working in coordination with the ISTC or STCU. Teams of scientists from research institutes in the former Soviet Union (FSU) carry out the requisite work.

From 1992 through the end of 2000, a total of 590 science center projects involving 431 research institutes in the FSU received a total of $329 million. The large bulk (more than 85 percent) of this money was provided by the ISTC, which approved another 141 projects in 2001 for an additional $34.7 million. Roughly half of the funding for the two science centers has come from the United States (initially via the CTR program, and since 1995 mainly through the State Department), and most of the rest has been provided by the EU and Japan. The foreign businesses, laboratories, governments, and NGOs that fund the science center Partner projects are supposed to be able to send untaxed monetary contributions and duty-free shipments of capital equipment to researchers and their institutes in the FSU. In Russia, however, the nontaxable provisions have been difficult to enforce. Although the ISTC established individual bank accounts for grant recipients to prevent taxes from being assessed, the Russian government has levied taxes on ISTC capital purchases.

The science centers may provide a temporary diversion from WMD work, but their ability to create *long-term* alternative employment for Russian weapons experts is almost nil. The ISTC's Annual Report for 2000 claimed that 21,275 "scientists and their technical team members" in the FSU received payment for at least 1 day of work on ISTC projects in 2000, but the report also noted that the average number of days spent by team members on the projects was only 59. This figure is put into even starker perspective by a recent GAO report, which reveals that approximately half of the former Soviet scientists taking part in science center activities in 2000 spent a total of no more than a few days on their projects. Only about 3 percent of the participants devoted nearly all of their time to the projects, and even in those cases, the outside work ceased once the projects ended.

There is little reason to believe that the ISTC will be better able to secure permanent placements for Russian scientific workers over the next 10 to 15 years. Very few of the current ISTC projects appear sustainable over the longer term. One of the leading American experts on the program acknowledged in March 2001 that only five of the current projects—on synthetic neural networks, water quality monitoring, leak detection monitoring, titanium-nickel alloys, and early warning sensors for nuclear power plants—offer any hope of commercial success in the future. Not a single one of these projects, however, has yet been commercialized.

The ISTC program has been plagued by a number of other serious problems, especially the persistent indications that Russian scientists receiving ISTC support are continuing to pursue weapons research. The ISTC charter explicitly prohibits funding for defense-related projects, but, as the GAO recently noted, "the project agreements do *not* prohibit the scientists from continuing to work on research for their institutes including, in Russia, research related to nuclear weapons." Even if the ISTC *did* try to ban all weapons research (something the Russian government would never accept), such a ban would be very difficult to enforce. As the GAO pointed out, the science centers "cannot track what the scientists are doing while they are not working on the projects or after the projects end. . . . [T]here is no formal way to monitor what other research these scientists are performing or for whom they are performing it." In an earlier (1999) report, the GAO had presented disturbing evidence that many of the ISTC recipients were conducting weapons-related research when they were not working on the funded projects. There is little reason to believe that the situation has changed since then, particularly because so many of the Russian scientists spend so little time on the ISTC projects.

These considerations have spurred some analysts to warn that the ISTC cannot prevent foreign governments or terrorist groups from enlisting the aid of Russian weapons scientists. The ISTC, they argue, is unable to halt the sharing of information over the Internet or "moonlighting by modem." Moreover, rogue states could try to set up front businesses in Russia or Ukraine that would approach weapons scientists working on ISTC projects. Other concerns have been expressed about the misappropriation of funds from collaborative projects and the development of dual-use products under ISTC auspices that could later be incorporated into weapons programs.

To the extent that the ISTC projects are allowing Russian weapons scientists to spend only a limited amount of time on ISTC work while devoting most of their time to weapons research, the ISTC money can be seen, at least to some extent, as a subsidy for the Russian WMD complexes. There is even a risk, as the GAO acknowledges, that "financing certain [ISTC] projects could help sustain a weapons institute infrastructure in the former Soviet Union by keeping institutes in operation that might [otherwise] have curtailed their research functions for lack of funds." If indeed the ISTC is inadvertently keeping some of the Russian WMD facilities in business, the negative consequences of the ISTC may outweigh any of the center's gains.

Even if some of these problems can be remedied in the future, enough obstacles have emerged to cast doubt on the value of the ISTC in ensuring that former Soviet weapons scientists will be able to take permanent jobs outside the defense complex.

Initiatives for Proliferation Prevention (IPP).

The IPP, a program launched in 1994 (under a different name) by the U.S. Department of Energy, promotes partnerships between research institutes in the FSU and members of the U.S. Industry Coalition (USIC), an alliance of private American companies. Beginning in 2002, the IPP will be expanded to encompass the activities of the NCI, which is being merged with the IPP. From 1994 to 2001, the

IPP established a total of more than 400 projects at 171 research institutes in the FSU. Of these projects, roughly 85 percent were in Russia, though only about a quarter of them were in the nuclear closed cities. When the IPP started, 70 percent of its funding was earmarked for the employment of nuclear weapons scientists, and 30 percent was to be used for CBW researchers. In practice, however, well over 70 percent of funded projects have involved nuclear-related institutes, and most of these have been outside the ten closed cities. (In 2000, for example, 26 of the 29 newly approved projects involved nuclear-related facilities, whereas only three involved biological institutes.) Because the IPP recently changed its guidelines to stipulate that "reasonable [FSU] institute openness and access are a requirement of receiving funding," it is unclear how feasible it will be in the future to set up projects in the closed nuclear cities or at the main CBW institutes.

For several years after 1994, the IPP was plagued by egregious administrative deficiencies, most of which have now been corrected. The deficiencies were highlighted in a February 1999 GAO report, which disclosed that relatively little of the money allocated to IPP projects had actually reached scientists in the FSU. The remainder of the funding—some 63 percent—had been spent in the United States on oversight and implementation costs. The GAO also discovered that the number of scientists receiving funds was sometimes unknown, and that IPP officials could not always confirm that the programs were targeting the institutes and researchers for which they were intended. In addition, the GAO found that a substantial number of Russian participants were using their IPP projects to pursue "dual-use technologies" that could be adapted later on for military purposes, and it revealed that some of the scientists at DOE laboratories who were responsible for overseeing IPP projects were unaware of the amount of funding their Russian counterparts had received. In at least one case cited by the GAO, not a single Russian scientist or engineer was employed at the institute that was being funded. In another case, the Russian institute had failed to spend any of its IPP funding on scientists' salaries and had used the money instead for "overhead, travel, computers, and Internet access."

The public disclosure of these shortcomings (and the controversy that ensued) prompted major reforms. The head of the IPP was replaced, and important administrative safeguards were adopted. Beginning in 2000, at least 60-65 percent of IPP funding was supposed to be allocated directly to projects in Russia, rather than to administrative expenses in the United States. In addition, the IPP increased the stringency of the multi-stage review conducted by the Inter-Laboratory Board (ILAB, a body consisting of experts from ten DOE national laboratories and DOE's Kansas City plant) to ensure that new projects conform to the program's goals. In particular, the ILAB adopted stricter criteria to guard against the dual-use phenomenon. The IPP also established an accounting and auditing system to ensure that funds are transferred to the proper recipients and are used for the intended purposes. The focus of the program has shifted as well. Whereas the IPP originally envisioned a three-phase life cycle for most projects—a start-up period supported by government funding (Thrust 1), joint capital investment by government and private sources (Thrust 2), and full privatization (Thrust 3)—the program since 1999 has concentrated primarily on phases two and three. The IPP thus has implemented all of the recommendations proposed by the GAO in its 1999 report.

Significant though these improvements have been, the ability of the IPP to provide permanent nonmilitary employment for large numbers of Russian WMD experts is and will remain inadequate. As Siegfried Hecker, the long-time director of Los Alamos National Laboratory, recently observed, "The scale of the [IPP] has never been commensurate with the magnitude of the problem." Although the IPP in recent years has sought to promote commercialization efforts and cost-share partnerships with private corporations, this effort as of late 2001 had yielded little by way of long-term employment opportunities—a mere eight projects that support only 294 permanent jobs, most of which are not filled by highly trained WMD experts. None of these eight ventures involves spinoffs of the major nuclear weapons institutes or CBW facilities. Although IPP officials claim that a few other cost-shared projects also "have good prospects of commercial success" in the years ahead, there is in fact relatively little that can be accomplished in the absence of sufficient capital investment from Russia's private sector. The net commercialization results have been—and undoubtedly will continue to be—minuscule compared to the enormous number of Russian WMD experts who need to be absorbed.

The daunting scale of the problem would overshadow the IPP's achievements under the best of circumstances, but the situation is made even worse by certain aspects of the program. According to official data, a total of 10,874 scientists and engineers from the FSU have taken part in IPP projects from 1994 through the start of 2002. However, many of these participants have never actually been involved with WMD programs. The IPP has no ironclad way—even with the help of U.S. intelligence agencies—to ensure that the right people are actually taking part in its projects. Under recent IPP guidelines, "new project proposals must list the [former Soviet] scientists and engineers, along with the nature of their involvement in weapons of mass destruction work during Soviet times." But IPP officials have no independent means of corroborating this information. Although the IPP officially "expects that a preponderance of [Russian and FSU] staff involved in IPP-funded projects" will have worked at one time or another on WMD programs, the phrasing of this guideline contains two glaring loopholes: First, "expecting" something is not the same as "requiring" it. Second, there is no way to tell whether the IPP's "expectation" has been met unless one assumes that the information provided by the Russian institutes and Minatom is correct—an assumption that is dubious at best.

As for the Russian IPP participants who *have* been engaged in WMD work, the large majority have returned full-time to weapons research after their IPP projects were completed. Indeed, even when Russian WMD experts have been working part-time on IPP projects, they have continued to be actively involved with WMD programs. This arrangement is explicitly permitted under the IPP's General Program Guidance:

> Given that IPP projects may not always employ Russian nuclear weapons scientists and engineers full time, it is possible that these specialists may work on nuclear weapons-related activities of the Russian Federation while not engaged on IPP projects. . . . Scientists and engineers still employed in Russian nuclear weapons facilities are not precluded from working on IPP-funded projects.

Whether such activities are compatible with the underlying purpose of the IPP is, however, far from clear. Doubts about the matter were expressed in late 2001 by the GAO, which, after noting that former Soviet weapons experts who are employed part-time on IPP projects "often continue to work at former Soviet WMD research institutes," warned that "aiding such scientists . . . could create new risks for U.S. national security." The GAO also emphasized that efforts to "assess the impact of [U.S.] aid" on the Russian WMD complexes have been stymied by "Russia's reluctance to provide U.S. officials with full access to relevant sites and materials." Thus, even if the dimensions of the problem were not so overwhelming, the IPP may inadvertently be making things worse by subsidizing experts who continue to work on WMD programs.

On balance, then, despite notable improvements in the IPP since 1999, its role in countering the threat of strategic proliferation is questionable. The IPP may prove more effective than the Science Centers program (which is limited to grant-making), but there is no reason to believe that the IPP can foster permanent alternative jobs for tens of thousands of Russian WMD experts over the next 10 to 15 years. The magnitude of the problem is too vast, no matter how well the IPP is run.

Nuclear Cities Initiative (NCI).

The NCI, another program run by DOE, was founded in September 1998 as a Russian-American partnership. Beginning in 2002, the NCI will be folded into the IPP. As the name implies, the NCI was supposed to "assist the Russian Federation in its announced intention of reducing the size of its nuclear weapons complex" and to "promote nonproliferation goals through redirecting the work of nuclear weapons scientists, engineers, and technicians in the Russian closed nuclear cities." Together with officials from Minatom, the NCI developed five strategies to achieve these goals: the development of city-by-city plans for downsizing; the development of local infrastructure; the facilitation of the transition from weapons research to commercial research; training and other community resource development activities; and the leveraging of funds and general encouragement of investment.

During the 4 years of its existence, the NCI established several projects each in Sarov, Snezhinsk, and Zheleznogorsk, the three closed nuclear cities that were initially targeted. Two International Development Centers, two Open Computing Centers, and two Nonproliferation Centers were set up, and some very limited commercial ventures were initiated or expanded. In total, however, only 100 new jobs were created for Russian scientists and engineers, a result that even supporters of the NCI described as "paltry." Part of the problem was that only 30 percent of the $16 million allocated to the NCI during its first few years was actually spent in Russia. The rest went toward administrative and other costs in the United States. Even if the funding had been several times greater and more of it had been spent in Russia, it is not at all clear that the NCI would have fared any better. A number of circumstances inherently limited the value of the initiative.

First, DOE and the U.S. nuclear laboratories were not—and are not—well suited to promote commercial development, particularly among Russian weapons scientists who lack any tradition of entrepreneurialism. A recent analysis of the IPP showed that U.S. Government funding had not gone toward projects that respond to "the technology innovation needs of Western industry." DOE's handling of the NCI was even more dismal. A GAO report on the program in mid-2001 highlighted DOE's inability to promote commercial activity in the closed cities, citing, among other examples, the undue emphasis given to community development:

> DOE officials told us that community development activities are needed to help make the cities more attractive to potential Western investors. However, none of the [private] industry officials whom we talked to during the course of our audit indicated that they would be more likely to invest in the nuclear cities because of municipal and social improvements.

The GAO report also noted that "the most successful commercial effort we observed in the nuclear cities" involving former weapons scientists was a computer venture in Sarov that was "undertaken *without* U.S. Government assistance."

Second, the Russian government's priorities for the NCI were never really conducive to U.S. nonproliferation goals. In particular, the Russian authorities prevented the NCI from extending to facilities that were of genuine proliferation concern. Siegfried Hecker, the former director of Los Alamos, recently acknowledged that the NCI "was handicapped from the beginning" because "the Russian government insisted, and the U.S. Government agreed, to restrict [the NCI's] activities only to the " 'open' parts of the closed cities," meaning the portions outside the fences of the nuclear weapons institutes. Conflicts over this matter, and the two sides' diverging views of the best projects to pursue, spawned what Hecker described as "an atmosphere of increasing hostility and mistrust between the Russian and U.S. Governments" from 1998 on.

Third, even after the key WMD facilities were excluded from the program at Moscow's insistence, the Russian government prevented NCI officials and potential foreign investors from gaining adequate access to other parts of the closed cities. The Russian authorities kept the number of visits to a minimum, required long lead-times (at least 45 days and sometimes several months) for approval of visits, limited the size of the visits to no more than a few people, and prohibited any access to a large number of facilities. Many requests for visits were simply turned down. The result was that NCI personnel were unable to maintain adequate supervision over projects, and prospective investors were deterred from even considering most ventures.

Fourth, even if the NCI projects had been impeccably designed and structured, there were many barriers in the closed nuclear cities—and in Russia as a whole—to commercial success (beyond the uncertainty about access just described). The geographic and economic remoteness of most of the cities was itself a major obstacle to development. To be viable over the longer term, the projects eventually would have had to receive sizable loans from Russian banks or direct foreign investment. Yet, even now, despite recent improvements in the Russian economy, almost nothing has been done in Russia to transform the banking sector into a viable institution that will function as banking systems do in the West. In the absence of key features of a market economy—a sound financial infrastructure, solid guarantees of property rights, and reliable means of enforcing contracts—foreign investors would have been extremely reluctant to commit funds to Russian-based ventures, even if physical access to the sites could have been assured. Hence, NCI projects were bound to encounter the same sorts of problems that bedeviled the commercialization efforts of the IPP.

Thus, there is no reason to believe that the merger of the NCI with the IPP will increase the IPP's ability to provide permanent alternative employment for many thousands of Russian WMD scientists and engineers. At best, the NCI amounted to what the GAO described as "a subsidy program for Russia . . . rather than a stimulus for economic development." At worst, the NCI may actually have helped keep the Russian nuclear weapons complex larger than it should be. Russian officials acknowledged in 2001 that "most of the scientists receiving [NCI] funds continue to work on Russia's weapons of mass destruction programs." Oles Lomacky, the executive director of the ISTC from 1995 until 1997, warned that it was a "fantasy" to believe that "if you give Russian scientists enough money, they will stop doing what they were doing before, which was designing weapons. . . . [T]he same people who were designing bombs in the Soviet era are still there." Lomacky added that "our objective ought not to be maintaining the nuclear cities" through the NCI; instead, the United States should promote "opportunities for these [bomb designers] to do other things somewhere else."

Although only some of the NCI's activities will be continued under the auspices of the IPP (the other activities will simply be terminated), it is conceivable that the merger will be a net detriment for the IPP. The risk of the NCI all along, as a U.S. Congressional Budget official warned in 1999, was that it would simply "create expectations of long-term assistance and thereby reduce any incentives for [Russian nuclear scientists] to find work in the commercial sector," leaving the United States in the position of supporting "Russian scientists and engineers who continue to design and build nuclear weapons." That is clearly something that IPP officials will want to avoid.

Even if the merger can be handled smoothly, the only question for the purposes of this chapter is whether the transfer of NCI activities to the IPP will significantly increase the likelihood that the IPP can generate permanent, non-military jobs for the 60,000 or so highly-trained WMD scientists, engineers, and technicians who are of greatest proliferation concern. There is no basis for concluding that this will be the case.

Nongovernmental Efforts.

The Civilian Research and Development Foundation (CRDF), a semi-private American venture set up by the U.S. Government in 1995, is supposed to arrange collaborative research projects between scientists in the United States and the former Soviet Union. One of the major aims of the CRDF is to fund civilian R&D projects that will help weapons scientists in Russia's closed cities leave the defense sector and focus on civilian pursuits. To date, however, the organization's accomplishments have been negligible. The CRDF Closed Cities Program funded 19 projects in Sarov and Snezhinsk from 1996 to 2000, but the amount of investment ($275,000) was too small to create any permanent new jobs. Moreover, none of the ventures proved commercially viable.

Most of the other U.S. and West European non-profit foundations that have supported Russian science have dealt exclusively with the civilian institutes. In the early 1990s, foreign foundations provided an extremely important boost to scientific research in Russia. The MacArthur Foundation, the Fulbright program, and the Carnegie Corporation launched pioneering efforts, and other American foundations soon followed suit. In 1993 the Russian Academy of Sciences received more funding from the International Science Foundation (ISF, an organization established in late 1992 by the American billionaire George Soros) than from the Russian government. During the 4 years of the ISF's existence, from 1993 through 1996, the foundation provided roughly $130 million for scientific research in the former Soviet Union. As late as 1995, up to one-third of all money for civilian science in Russia and Ukraine was still coming from foreign organizations and foundations, including the ISF. Professional scientific societies in the United States, including the American Astronomical Society, the American Physical Society, and the American Mathematical Society, launched separate fund-raising efforts in the early 1990s for their Russian counterparts and transferred tens of thousands of scientific periodicals and books free of charge to Russian scientists and research institutes.

Similar efforts were made in Western Europe (especially Germany) by professional organizations and non-profit foundations such as the Friedrich Ebert Stiftung, the Volkswagen Stiftung, and the Konrad Adenauer Stiftung. In May 1993 the European Union established the International Association for the Promotion of Cooperation with Scientists from the New Independent States of the Former Soviet Union (INTAS). With an initial annual budget of $27 million and a mandate to "promote cooperation with scientists" from the former Soviet Union until at least the end of 2002, INTAS was able to support a wide range of activities throughout the 1990s.

Since 1995, the level of foreign foundation support for scientific activities in Russia has declined, but funding from abroad (including money from Western private companies) remains crucial for scientific research in Russia. As of 1999, some 16.9 percent of gross expenditures on R&D in Russia came from foreign sources, well above the level of just a few years earlier. Although Western foundations have shifted most of their emphasis from individual grants (which were heavily funded in the early 1990s) to basic support for research institutes and science education, a number of key grant programs are still operating. Foreign funding is likely to remain extremely important even though the future of some activities (especially the International Soros Science Education Project, a successor to the ISF) was temporarily thrown into doubt in 2001 when the second part of Russia's new tax code took effect. Under the guidelines accompanying the code, a 35.9 percent “social tax” was to be imposed on individual grants. The Soros Foundation had to go through a lengthy appeal process to secure an exemption from the tax, which otherwise would have placed a crippling burden on the science education project.

Even though important grant-making programs for Russian scientists are likely to continue under foreign auspices, and even though a number of closely related activities have been set up, including a program launched by the MacArthur Foundation in 1997 to fund basic research and higher education in Russia (a program subsequently funded as well by the Carnegie Corporation of New York and overseen by the CRDF), these projects have no direct bearing on scientists, engineers, and technicians in the Russian defense complex. Indirectly, a few of the programs may offer a fallback option—albeit only a limited and transitory one—for some of the scientists and engineers who might choose (or be forced) to leave the weapons complex, but the total amount of funding available is much too small to accommodate more than a handful of them over the long term.

Initiatives by American aerospace corporations to collaborate with Russian enterprises could provide an alternative source of employment for a small number of weapons scientists (though not necessarily those working on WMD programs). The Boeing Corporation established a research center in Moscow in 1993 and now employs 500 workers in seven Russian cities. The company recently signed an agreement with the Russian Aerospace Agency to collaborate on space research, rocket launch technologies, and the development of a short-range jetliner. Lockheed Martin has undertaken joint research and development projects with other Russian enterprises such as the Vavilov Institute, the Skobeltsin Nuclear Physics Institute, the Ioffe Physics-and-Technology Institute, Khrunichev Industries, and the Yakovlev Central Design Bureau. The collective impact of private sector collaborations such as these on the employment of former weapons scientists (exclusive of the activities of members of the U.S. Industry Coalition and other corporate participants in U.S. Government programs) is unclear, but at best their role in providing new jobs for WMD experts will be minor.