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## Research and Development in Russia: An Important Factor for the Future

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## **ABSTRACT**

The Russian government reduced its research and development (R&D) funding by about 76% in real dollars from 1990 to 1996 as part of the restructuring and downsizing of Russia's R&D system and its reorientation toward civilian research and development following the collapse of the Soviet Union in 1991. The report assesses a number of recent changes in the Russian R&D system, including the large funding and personnel decreases, the evolving structure of a new Russian R&D system, and Russian R&D priorities under the new system. The report identifies issues for Congress, including whether U.S. cooperative R&D programs, recently established to assist Russia's peaceful transition to a market economy, are contributing to that goal and whether such programs should be continued in light of Russia's uncertain future and possible U.S. national security concerns. This report will be updated as circumstances warrant.

# Research and Development in Russia: An Important Factor for the Future

## Summary

If the U.S. government had reduced its research and development (R&D) funding by about 76% in real dollars from 1990 to 1996, the U.S. national R&D system would be in crisis. But even then, the situation in the United States probably would not have been as severe as is now the case in Russia, where that percentage of reduction in governmental R&D funding has occurred, because the United States has a large private-sector R&D system.

The leadership under President Yeltsin continues to move Russia from the Soviet-era command economy toward a free-market system. This involves a restructuring and downsizing of Russia's R&D system and its reorientation toward civilian R&D. This restructuring, however, also has been driven to a significant extent by the nation's deep economic recession. Although large decreases in R&D funding and personnel and a deterioration of R&D facilities have occurred since 1991, recent R&D budget figures (questioned by some experts) might indicate a reversal of this trend. The most recent changes in the government's top-level R&D policy leaders also suggest that R&D, despite its budget decreases, still is considered important in Yeltsin's reform government. Among several recent important R&D reforms was the establishment of the Russian Foundation for Basic Research in 1993, an important innovation in Russian R&D policy because it funds individual researchers directly rather than their research institutes, on the model of the U.S. National Science Foundation. A number of international financing schemes and structures to bolster the Russian R&D system also have been created.

U.S. policy issues parallel ongoing U.S. and international programs to more fully integrate Russia peacefully into the community of nations, thereby reducing the potential for future conflict and increasing Russia's contribution to world economic development. Major federal programs in support of Russian R&D accounted for about \$1.5 billion during the period from 1992 through 1998, with NASA contributing over \$900 million and DOD, DOE, and other federal agencies the rest. One of the several new organizations established to cooperate with Russia in R&D activities by providing research grants to Russian scientists is the U.S. Civilian Research and Development Foundation, created by Congress in 1992. Supporting all U.S. cooperative R&D programs with Russia is the U.S.-Russian Joint Commission on Economic and Technological Cooperation, established in April 1993.

It appears that the U.S. cooperative R&D programs are contributing to Russia's peaceful transition to a market economy and are successfully addressing scientific and technological problems and opportunities of mutual concern to the United States, Russia, and other countries. Several years of experience with U.S.-Russia cooperative R&D programs suggest that it is both worthwhile and practicable for the United States to identify and promote cooperative R&D programs which are mutually beneficial to the two nations, while carefully restricting R&D and dual-use technologies that may contribute to near-term or long-term military threats to U.S. national security.

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# Research and Development in Russia: An Important Factor for the Future

## Introduction

A healthy research and development (R&D) establishment is important for the future of Russia's economy and national security. Research and development has the potential to contribute just as significantly to Russia's economic strength in the long term as it does in the United States, other western industrialized nations, and the newly industrialized countries of Asia (the "Asian tigers": Singapore, South Korea, and Taiwan). The Russian economy, however, is undergoing a great upheaval during its transition from a centrally planned to a market economy. An important aspect of that economic transition is the proposed conversion of much of its defense industry to civilian goods production. Russia's economic problems in general, and its defense industry conversion in particular, have resulted in large decreases in the government's funding of research and development. Before 1991, about three-fourths of Russia's R&D funding was supported by the defense ministries.<sup>1</sup> Some estimates indicate that, by 1992, Russian defense spending had dropped by one-third to two-thirds of its 1991 level.<sup>2</sup> By now, it may have fallen to one-tenth of its 1991 level.<sup>3</sup> That large loss of financial support for the Russian R&D establishment, beginning in 1991 and continuing to the present, has not been replaced by other R&D funding sources to any significant extent.<sup>4</sup>

If the U.S. government had reduced its research and development funding by about 76% in real dollars from 1990 to 1996, the U.S. national R&D system would be in crisis. But even then, the situation in the United States probably would not have been as severe as is now the case in Russia, where that percentage of reduction in governmental R&D funding has occurred. About 58% of Russia's internal R&D funding in 1996 came from the government. In the United States in 1996, by contrast, only about 34% of national R&D funding came from the federal government, and that decreased to about 31% in 1997.<sup>5</sup> The remaining U.S. R&D

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<sup>1</sup> Carol Matlack, "Up From the Wreckage of Russian Science," *Business Week*, 27 October 1997: 152-153; and "Science in Russia: The Diamonds in the Rubble," *The Economist*, 8 November 1997: 25.

<sup>2</sup> Mark P. Poncy, "The Need for Greater U.S. Assistance in Promoting Russian Defense Conversion," *Law and Policy in International Business*, v. 28, Winter 1997: 513-514.

<sup>3</sup> Based on informal estimates of some Russian experts.

<sup>4</sup> For Russian R&D data, see the section on "R&D Funding," below, especially Table 1.

<sup>5</sup> National Science Foundation, *National Patterns of R&D Resources: 1966* (NSF 96-333) (continued...)

funds come from industry and other sources. The Russian R&D funding problem has caused a number of structural changes in the Russian R&D system and the creation of a number of international financing schemes and structures to bolster the Russian R&D system.

The Soviet R&D establishment contributed significantly to the status of the Soviet Union as a military super power before 1991. After 1991, in spite of the many negative aspects of downsizing the Russian R&D establishment (such as the loss of many scientific jobs and some R&D capabilities), several positive developments may be occurring. The Soviet R&D establishment, then the largest in the world and respected for high achievements in some areas, particularly military R&D, was bloated and wasteful according to many accounts. A smaller, more efficient R&D system focused on developing commercial products would be of more benefit to the evolving Russian market economy than the old R&D system. Even with the large decrease in R&D personnel since 1991, the Russian R&D establishment still may not have reached such an optimal size. In addition, a decrease in military R&D, as Russia converts its defense industry to civilian goods production, could contribute to Russia being less of a military threat to the national security of the United States in the years ahead than it has been in the past.

The period of transition from the well-financed, but inefficient, Soviet R&D system to a significantly changed Russian R&D system probably will continue for another 10 to 15 years, according to many experts on Russian science and technology (S&T) policy. The United States may have an important role to play during this period. It, along with other nations, could continue to contribute in major ways to the stabilization of a smaller, more efficient Russian R&D system geared more to civilian market goals than to the predominantly military orientation of the past. Alternatively, the United States could reduce its support of, and cooperation with, some Russian R&D projects if this is determined to be in long-term U.S. interests.

## Background

The Russian Academy of Sciences was created by Peter the Great in 1725. Following the establishment of the Soviet Union in 1922, it became the Soviet Academy of Sciences. In November 1991, it was reestablished as the Russian Academy of Sciences. During the Soviet era, it was the central scientific organization of the Soviet Union, with R&D capabilities in Russia and the other 14 Soviet republics. Its mission was to conduct research in support of the techno-economic and, later, military needs of the state. The prestigious research institutes of the Academy were responsible mainly for conducting fundamental research. The R&D organizations of the government's military and industrial branch ministries were responsible mainly for applied research and development related to the missions of those ministries. The institutes of higher education were responsible mainly for the

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<sup>5</sup> (...continued)

(Arlington, VA, 1996): 78; and Steven Payson, "R&D Exceeds Expectations Again, Growing Faster than the U.S. Economy during the Last Three Years," (NSF) *Data Brief*, 5 November 1997: 2.

education of future scientists, although they also conducted limited research. During the Cold War, the majority of these large R&D capabilities were devoted to military R&D. Even today, about one-half may be devoted to military R&D.<sup>6</sup>

Toward the end of the Soviet era and the Cold War, the Soviet Union, particularly Russia, was comparable to the United States in some areas of science, especially in several areas of theoretical science and a few areas of experimental science. It was weaker than the United States in most other scientific areas, including most areas of experimental science. This was due largely to the prestige historically associated with theoretical science and mathematics in the Soviet Union, but also because of the lack of adequate scientific equipment. The Soviet Union also was competitive with the United States in several areas of military research, an elite area of its R&D establishment.<sup>7</sup> This elite status was achieved, however,

not because of a separate system but because of higher standards; and the higher standards [were] achieved through a massive inspection system at enormous cost. No civilian consumer could afford the real costs of the products produced by and for the Soviet military.<sup>8</sup>

The Russian R&D system, in its economically inefficient “Soviet” configuration, has not contributed significantly to the market system reforms instituted in the post-Soviet era under President Boris Yeltsin. In contrast, in the United States and other industrialized nations, civilian applied research has contributed significantly to economic development.

One factor in Russia's favor, however, is that most of the R&D capabilities of the former Soviet Union at the time of dissolution were in Russia. Russia had about two-thirds of the researchers and major research institutes, and almost 60% of all research organizations, of the former Soviet Union. These R&D capabilities are concentrated in Moscow, St. Petersburg, and Novosibirsk.<sup>9</sup>

## Post-1991 Changes in Russia

Many of the current problems in Russian research and development, especially its financial problems, were caused by the dissolution of the Soviet Union in December 1991. At the end of the Cold War, Russia underwent many changes. It began a movement toward democratization of its political structure and the Communist Party lost control of the government. Russia now is governed under a

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<sup>6</sup> See the section on “R&D Funding,” below.

<sup>7</sup> William C. Boesman, *Science and Technology in the Former Soviet Union: Capabilities and Needs*, Joint Economic Committee, *The Former Soviet Union in Transition*, Vol. 2: *Study Papers*, S. Print 103-11, v. 2, 103d Cong., 1<sup>st</sup> sess., Washington, D.C.: GPO, 1993: 610-628.

<sup>8</sup> Harley D. Balzer, *Soviet Science on the Edge of Reform* (Boulder: Westview Press, 1989): 135.

<sup>9</sup> *Science and Technology in the Former Soviet Union: Capabilities and Needs*: 612-613.

constitutional system of law, rather than by the Communist Party, and has a functioning parliament. It would appear, however, that the former internal security services, although reorganized and renamed, have retained much of their secret police powers.<sup>10</sup> Some of the old power structure, formerly called the *nomenklatura*, also appears to have been retained.<sup>11</sup> However, while the government still has more control over the nation's science and technology (and other sectors) than do governments of other industrialized countries, it has much less control than previously. This is due in part to R&D funding difficulties and the related decentralization of R&D, and the establishment of alternatives to governmental R&D support, including foreign partners and nongovernmental commercial organizations.

The Russian leadership under President Yeltsin, especially after the government's organizational reforms of early 1998, continues to move toward a free-market system for Russia. This involves a considerable degree of demilitarization of the nation. In 1996, for example, production of major weapons systems was about 13% of the 1991 level according to Russian statistics.<sup>12</sup> During the Soviet period, the military was the major funder of research and development. Because military R&D often was the best R&D performed in Russia, defense budget cuts have affected adversely some of Russia's best R&D capabilities, even if they were inefficient in economic terms. Another goal of the transition to a market economy is the conversion of much defense industry production to civilian production but, apparently, very little defense conversion has occurred thus far. This limits the amount of existing top quality defense-related R&D that might otherwise be converted to civilian ends. There also are concerns about "reconversion" to military ends and that some cases of "conversion" may be only "diversification."<sup>13</sup>

The shift from the Soviet-era command economy toward a free-market system requires a restructuring and downsizing of Russia's R&D system and its reorientation toward civilian R&D, a process that began in the early 1990s.<sup>14</sup> This restructuring of the Russian R&D system, however, has been driven to a significant extent by the nation's deep economic recession. Financial support for Russian R&D, the majority of which is still funded by the government, has fallen dramatically since 1991. This

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<sup>10</sup> Amy Knight, "Is the Old KGB Still in Power?" *The Washington Quarterly*, v. 20, Winter 1997: 59-74.

<sup>11</sup> Olga Kryzhanovskaya and Stephen White, "From Soviet *Nomenklatura* to Russian Elite," *Europe-Asia Studies*, v. 48, July 1996: 711-733.

<sup>12</sup> Senate, Select Committee on Intelligence, *Current and Projected National Security Threats to the United States*, Hearing, 105<sup>th</sup> Cong., 1<sup>st</sup> sess. Washington, D.C., GPO, 1997: 61.

<sup>13</sup> Glenn E. Schweitzer, "Conversion Activities in the Russian Weapons Laboratories," *Technology in Society*, v. 17, no. 3, 1995: 239-260; and Glenn E. Schweitzer, *Moscow DMZ* (Armonk, NY: M. E. Sharpe, 1996): 139-158.

<sup>14</sup> See, for example, Centre for Co-operation With the Economies in Transition, *Science, Technology and Innovation Policies: Federation of Russia, Volume I: Evaluation Report* (Paris: OECD, 7 September 1993): 115 p.; and Peter Kneen, "Science in Shock: Russian Science Policy in Transition," *Europe-Asia Studies*, v. 47, March 1995: 281-303.



financial crisis in itself has contributed to a large decrease in Russia's R&D funding and personnel since then.

Even though the former Soviet R&D model did not have a great deal to contribute to the evolving market economy, the R&D establishment then was held in high esteem and received many perquisites. The current R&D establishment has suffered a loss of national prestige, mainly because of the decreases in R&D funding, personnel, and capabilities since 1991. Recent top-level changes in the government's R&D policy structure, however, discussed below, indicate that R&D still is considered to be important by the leadership, although there appears to be no unified view on national S&T goals.

## **Research and Development in Russia**

Political and economic problems such as those discussed above have caused significant changes in Russia's civilian and military R&D funding, personnel, structure, and priorities. Reportedly, "[t]he processes of transition threaten the very survival of the Russian S&T system."<sup>15</sup>

### **R&D Funding**

The major problem, aside perhaps from the nonquantifiable loss of prestige of Russian R&D, is decreasing funding. Since the government provides a large portion of R&D funding, this decrease has a significant impact on S&T activities. In 1995, about 74% of Russia's internal R&D funding came from the government; this decreased to about 58% in 1996.<sup>16</sup>

Table 1 shows Russian R&D funding and personnel since 1990. Although some analysts knowledgeable about Russian R&D and R&D statistics question the accuracy of the official statistics, especially in regard to military R&D, large decreases in both R&D funding and personnel since 1991 are apparent. The decrease in R&D funding was due to decreasing percentages of gross domestic product (GDP) being devoted to research and development at the same time that GDP itself was decreasing. Given these caveats about the data, Table 1 indicates that:

- From 1990 to 1996, gross domestic expenditures on civilian and military R&D decreased about 76% in constant 1989 rubles and about 57% as a percentage of gross domestic product. The latter indicates not only a decrease in real R&D funding, but a trend of overall national financial resources away from research and development since 1990. The small increases in these figures in 1996 might indicate a reversal of this trend.

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<sup>15</sup> *Science, Technology and Innovation Policies: Federation of Russia, Volume I: Evaluation Report*, 16.

<sup>16</sup> Centre for Science Research and Statistics, *Russian Science and Technology at a Glance: 1997* (Moscow: Ministry of Science and Technological Policy of the Russian Federation and Russian Academy of Sciences, 1998): 40-41.

- From 1991 to 1996, governmental civilian and military R&D appropriations as a percentage of the total governmental budget decreased from 7.43% to 3.2%. However, there was a significant increase to 5.06% in 1997, which is about 68% of the 1991 level. This might indicate a shifting of governmental priorities back toward R&D funding.

**Table 1. Selected Russian Science and Technology Indicators, 1990-1996**

Years	Gross Domestic Expenditures on R&D			Govt'l R&D Approps as a % of Total Govt'l Budget	Scientific Degrees Awarded (Doctoral Degrees)	National R&D Personnel (Researchers <sup>c</sup> / Technicians)
	Constant 1989 Rubles <sup>a</sup>	Current Rubles <sup>a</sup>	Percent of GDP <sup>b</sup>			
	billions		%	%		thousands
1990	10.9	13	2.03	n.a.	35,117 (5,067)	1,943.3 (1,227.4)
1991	7.3	20	1.43	7.43	35,040 (6,326)	1,677.8 (1,079.1)
1992	3.2	141	0.74	4.47	29,612 (5,491)	1,532.6 (984.7)
1993	3.1	1,317	0.77	4.58	19,790 (4,111)	1,315.0 (778.8)
1994	2.9	5,146	0.84	2.83	16,149 (3,185)	1,106.3 (640.8)
1995	2.4	12,149	0.73	3.25	14,313 (2,760)	1,061.0 (620.1)
1996	2.6	19,394	0.86	3.2	15,054 (3,022)	990.7 (572.6)

<sup>a</sup> These are "old" rubles. In early 1998, "new" rubles were issued with a face value of one-thousandth of the old rubles.

<sup>b</sup> GDP = gross domestic product.

<sup>c</sup> Scientists and engineers engaged in R&D and usually having higher education (university or equivalent) degrees. From the glossary in the Source.

**Source:** Centre for Science Research and Statistics, *Russian Science and Technology at a Glance: 1997*, Moscow, Ministry of Science and Technological Policy of the Russian Federation and Russian Academy of Science, 1998: 23, 26, 40, 42.

As in previous years, not all of these appropriated funds actually may be allocated due to sequestrations which have occurred because government revenues have failed to meet budget targets. Moreover, not all Russia R&D organizations share equally in the actual allocations of the R&D budget. In 1996, for example, the Russian Academy of Sciences received about 78%, and the Russian Federation for Basic Research about 37%, of their budget allocations. Many other R&D organizations received significantly less than their allocations.<sup>17</sup> The Ministry of Science and Technology, for example, received about 50% of its budget.<sup>18</sup> The Russian Space Agency received about 80%.<sup>19</sup>

In addition to the amounts shown in Table 1, large amounts of R&D funds were received from foreign nations, including the United States. It is unclear, however, how much of the foreign funds actually went into the Russian R&D system. In 1993, for example, OECD estimated that about \$200-\$300 million reached Russia from OECD countries, but a Russian official thought that this was an inflated figure.<sup>20</sup> During the worst years of the Russian R&D funding crisis, 1994 to 1996, foreign support might have reached 30% to 50% of total Russian civilian basic research funding.<sup>21</sup>

Table 1 indicates the extreme inflation that occurred in Russia from 1990 through 1996. Gross Domestic Expenditures on R&D (GERD) was about 19.4 trillion rubles (current prices) in 1996. Most of Russia's GERD still is provided by the government. In 1996 and 1997, the federal R&D budgets were about 11.3 trillion and 26.8 trillion rubles, respectively.<sup>22</sup> The amount for 1996 slightly exceeded the 4% of total federal budget required by the new federal science and technology policy law.<sup>23</sup> In dollars, the planned Russian R&D budget for 1997 was to have been about \$6.0

<sup>17</sup> Irina Dezhina, *Russian Science: Transformation and Adaption* (Paper delivered at the Georgetown University conference on Russian Science and Industrial Policy: Moscow and the Regions, 25 March 1997): 6-7; and Irina Dezhina, "Russian Science in the Transition Period (1991-1996)," *Russian Science and Industrial Policy: Moscow and the Regions, Conference Report* (Washington, D. C.: Georgetown University, 24-25 March 1997, 68-69.

<sup>18</sup> Personal communication with Dr. Richard J. Brody, Department of Commerce, 11 September 1997, Also see Andrey Allakhverdov and Vladimir Pokrovsky, "Science Agency Hit with 55% Cut," *Science*, v. 276, 13 June 1997: 1639.

<sup>19</sup> Nicolay Novichkov, "Russian Space Chief Voices Dire Warnings," *Aviation Week & Space Technology*, v. 146, 6 January 1997: 26.

<sup>20</sup> *Ibid.*, 38, 111.

<sup>21</sup> Personal communications with Gerson Sher, U.S. Civilian Research and Development Foundation, July 22, 1998 and August 18, 1998. Varying estimates of foreign funding are discussed in Glenn E. Schweitzer, *Experiments in Cooperation* (New York: The Twentieth Century Fund, 1997): 4 and footnote 9 on p. 156-157 (quote); and Glenn E. Schweitzer, "Can R&D Recover in Russia?" *Technology in Society*, v. 17, no. 2, 1995: 124 and footnote 10 on p. 141.

<sup>22</sup> *Russian Science and Technology at a Glance: 1997*, 41.

<sup>23</sup> *Russian S&T at a Glance: 1997*, 41; and Article 15, Financing of Scientific and (or) Scientific-Technical Activity, of "On Science and State Science and Technology Policy," approved by President Yeltsin 23 August 1996.

billion (about \$4.0 billion for civilian and \$2.0 billion for military R&D). However, the civilian portion was slashed about 55%, to \$2.2 billion, because of the government's large deficit.<sup>24</sup> Total R&D funding for 1997 thus was roughly one-half civilian and one-half military.<sup>25</sup> For 1998, the planned civilian R&D budget is about \$2.2 billion, the same as the actual funding level in 1997.<sup>26</sup> If military R&D funding for 1998 also is about the same as last year, total R&D funding would remain about one-half military and one-half civilian.

The R&D funding difficulties of the past several years could have been made significantly worse by a draft tax code approved by the Russian Cabinet in February 1997 and planned to be submitted to the Duma in April 1997. The then-existing tax laws were in need of reform because they were contradictory and confiscatory. The draft code, although it would have increased governmental revenues, which Russia desperately needs, also would have eliminated almost all of the tax exemptions and concessions that applied to the Russian R&D establishment, including universities. It was estimated that it would have deprived Russian R&D of funds amounting to about one-half of the 1997 budget.<sup>27</sup> This threat to R&D funding was eliminated in 1997.<sup>28</sup> The new tax code passed by the Duma in July 1998 favors enterprises, including R&D organizations, by reducing their tax burdens while increasing the tax burden on consumers through increased sales, value added, and personal income taxes.

## R&D Personnel

Related to the significant decreases in R&D funding are similar decreases in the number of R&D personnel and scientific degrees awarded. Table 1 shows that, from 1990 to 1996, the number of scientific degrees awarded decreased about 57% and the number of researchers and technicians fell about 53%. Although endangered, mathematics and scientific education in Russia is still world class. The dramatic decreases in the numbers of scientific degrees awarded and R&D personnel may not be entirely unfortunate because it is generally conceded that the Russian scientific and engineering work force was bloated in comparison with most other countries. A 1993 analysis reported:

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<sup>24</sup> Richard Stone, "Reformer Named Science Minister," *Science*, v. 280, 8 May 1998: 821; and Sheila Foote, "Russia Focuses Funding on R&D; Production at Record Low," *Defense Daily*, v. 197, 9 December 1997: 2-3.

<sup>25</sup> Also see Mikhail K. Glubokovskii, Chairman, Subcommittee on Science, Russian State Duma Committee on Education, Culture, and Science, Presentation at the Georgetown University conference on Russian Science and Industrial Policy: Moscow and the Regions, 24 March 1997; and Mikhail K. Glubokovsky, "The Formulation of the National Science Budget," *Science and Technology Legislation in Russia* (Paris: OECD, 1996): 24.

<sup>26</sup> Stone, "Reformer Named Science Minister," op. cit.

<sup>27</sup> Andrey Allakhverdov and Vladimir Pokrovsky, "New Tax Code Threatens Science Funds," *Science*, v. 275, March 1997: 1411.

<sup>28</sup> "Russian Grants to Remain Duty Free," *Science*, v. 276, 16 May 1997: 1019.

The United States employed in the late 1980s some 1 million research scientists and engineers (RSE) in full-time equivalent (FTE) for an economy which, in real terms, seemed three times bigger than Russia's. Japan, whose science system is more labour-intensive, employed some 450,000 RSE for an economy which seemed equivalent, in real terms, to Russia's. These data give some benchmarks for the size that seems reasonable for Russia. The latter still employed 950,000 RSE in head count in 1991 -- the corresponding number in FTE would be somewhat smaller. The reduction that has already occurred concerns possibly 200,000 to 300,000 persons, so that large cuts are still to come.<sup>29</sup>

Table 1 shows that the number of Russian researchers and technicians decreased to about 573,000 in 1996. Allowing for some differences in statistics from different sources, the Russian R&D work force still might not have reached its optimal size, given the evolving Russian R&D structure and priorities.

Aside from the personal hardships imposed on the unemployed scientists and engineers involved, and the ripple effect of reduced wages throughout the economy, the reduction in the work force has caused several other problems, but also opportunities, for Russia.

- External brain drain. The first and greatest wave of expatriates, in 1992 and 1993, included many of Russia's scientific and engineering elite. However, some of these persons may return. A brain drain of nuclear weapons scientists, a potentially dangerous situation, probably is minimal because of laws restricting the travel of such scientists and because of international programs to encourage them to stay. The overall external brain drain has been relatively small.<sup>30</sup> In addition, many Russian students studying abroad probably will return, although not until after they are 28 years old, in order to avoid the military draft.
- Internal brain drain. Of the approximately 500,000 to 600,000 scientists and engineers who left their professions from 1990 to 1995, possibly more than half of them have found new careers in Russia, many in the emerging market economy in non-scientific and non-engineering capacities.<sup>31</sup> These intelligent, well-educated, and motivated individuals probably have contributed significantly to the evolving market economy. "Banking, for instance, has recently become a prestigious and desirable career (ex-physicists and

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<sup>29</sup> *Science, Technology and Innovation Policies: Federation of Russia. Volume I: Evaluation Report*, 17.

<sup>30</sup> About 11,000 to 12,000 scientists and engineers are reported to have emigrated and another 11,000 to 12,000 are working outside Russia on contracts, according to Boris G. Saltykov, former Russian Minister of Science and Technology Policy at the Georgetown University conference on Russian Science and Industrial Policy: Moscow and the Regions, 24 March 1997.

<sup>31</sup> See Table 1 and Jocelyn Kaiser (ed.), "Russian Research on the Ropes," *Science*, v. 274, 13 December 1996: 1827.

mathematicians are its most successful practitioners).”<sup>32</sup> Boris Nemtsov, former First Deputy Prime Minister, is a former nuclear physicist.

- Remaining scientists and engineers. Although many of the best Russian scientists and engineers have retained their jobs in the institutes of the Academy of Sciences and other elite institutions, the average age of these remaining R&D personnel has been increasing. This has negative implications for the future of Russian R&D.

The decrease in R&D funding has not only caused a decrease in R&D employment, but a deterioration of R&D facilities. Old equipment cannot be maintained or replaced, new equipment and supplies cannot be purchased, and many facilities are closed part of the time because utility bills, no longer subsidized, cannot be paid. Parts of some facilities have been rented for non-scientific use to raise funds. Other facilities have been closed entirely.

R&D funding decreases also have caused some problems in maintaining Russia's international S&T commitments. Perhaps most importantly for the United States, Russia may not be able to fulfill its financial commitments in support of the International Space Station (ISS).<sup>33</sup> According to Rep. Sensenbrenner, chairman of the House Committee on Science, this raises serious concerns about Russia's continued participation in the project.<sup>34</sup> In a letter to President Clinton on June 24, 1998, Rep. Sensenbrenner and Rep. Brown, ranking minority member of the House Science Committee, “requested a plan from the President within thirty days detailing how the Administration expects to resolve the dire problems surrounding the International Space Station.”<sup>35</sup> The letter requested the President’s personal intervention with President Yeltsin to ensure Russia’s full compliance with its ISS commitments. The recent troubles with the Mir space station also may lead to Russia scaling back its planned experiments on that station.<sup>36</sup> Russia also plans to decrease its contribution to the International Thermonuclear Experimental Reactor (ITER), although it appears to be maintaining its participation in the Large Hadron Collider (LHC) project of CERN (European Laboratory for Particle Physics).<sup>37</sup>

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<sup>32</sup> Richard Layard and John Parker, “The Coming Russian Boom,” *The American Enterprise*, v. 7, July/August 1996: 61.

<sup>33</sup> Congressional Research Service, *Space Stations*, by Marcia S. Smith, CRS Issue Brief 93017, updated regularly, 16 p.

<sup>34</sup> David Mulholland, “Sensenbrenner Urges ‘Produce or Else’ Stance On Space Station,” *New Technology Week*, v. 11, 3 March 1997: 1, 11; and David Mulholland, “Goldin Expects ISS Schedule Will Hold Up,” *New Technology Week*, v. 11, 10 March 1997: 1, 7.

<sup>35</sup> Committee on Science, *Committee Asks Clinton for Space Station Plan*, press release, 24 June 1998: 1.

<sup>36</sup> Tony Reichhardt, “Mir’s Problems Could Mean Scale-Down for Science,” *Nature*, v. 388, 28 August 1997: 818.

<sup>37</sup> Alison Abbott, “Funding Forces Fusion Project Out of Europe,” and “Russian Contribution for CERN Collider,” *Nature*, v. 382, 25 July 1996: 288.

The ongoing governmental R&D funding decreases give added importance to Russia's technology development programs conducted in support of its market reform policies. If such programs are successful, the still small nongovernmental S&T sector may contribute more to the nation's research and technology development activities than it has in the past.

A loss of prestige of Russian R&D is both a cause and an effect of the R&D funding and personnel problems discussed above. Russian R&D is not as valued in the evolving market economy as it was in the Soviet era.<sup>38</sup> In addition, scientists and engineers have lost much of the leadership role that they had in that era. This, perhaps more than the continuous decreases in R&D funds, which might ultimately level off and maybe even turn into increases, and the loss of R&D personnel, which has some positive as well as negative aspects, might be the most serious factors in the long-term health of Russian R&D.

## **R&D Structure**

The Russian R&D structure also has undergone a number of changes since the end of the Soviet era. In the Soviet era, the State Committee for Science and Technology, in conjunction with the Soviet Academy of Sciences, had principal responsibility for formulating policy for, and conducting, basic research. The Ministry of Higher and Specialized Secondary Education was responsible for the institutes of higher education. Immediately after the Soviet era, the Ministry of Science, Higher Education, and Technology Policy, headed by Boris Saltykov, was established as the principal R&D organization, responsible for policy direction and the funding of much R&D and science education. In early 1993, it lost its responsibility for higher education policy and became the Ministry of Science and Technology Policy. In August 1996, it became the State Committee on Science and Technology, headed by Vladimir Fortov, who also was a Vice Premier. On March 10, 1997, it became again the Ministry of Science and Technology (now "Science and Technologies") under Fortov, but he no longer was a Vice Premier. The new deputy prime minister with responsibility for science and technology was Vladimir Bulgak, a seasoned bureaucrat who was the former minister of communications.<sup>39</sup> In a cabinet reshuffle in April 1998, Bulgak was appointed Minister of Science and Technologies to replace Fortov.<sup>40</sup> Although he lost his position as deputy prime minister, Bulgak subsequently was appointed to a seat in the newly created Presidium, a select subset of the Cabinet. This was an indication of the importance placed on science and technology in the reform-minded government of President Yeltsin and the new Prime Minister, Sergei Kiriyenko. After about five months in office, Kiriyenko was fired on August 23, 1998 and replaced by the former prime minister, Viktor Chernomyrdin. These changes are an indication of the governmental uncertainty that still affects the Russian R&D system.

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<sup>38</sup> Salaries of scientists, for example, have fallen from about 110% to about 80% of other salaries, according to Boris G. Saltykov.

<sup>39</sup> Information on these recent developments was obtained in a personal communication with Dr. Irina Dezhina on 28 March 1997.

<sup>40</sup> Carl Levin, "Russian Reshuffle Places Bulgak at Helm," *Nature*, v. 393, 7 May 1998: 3.

Those changes indicate continuing rivalry among the current Russian S&T policy leadership as to the proper level and focus of research and development. That rivalry includes a continuing competition for scarce R&D funds between, for example, the Ministry of Science and Technology and the Russian Academy of Sciences. In some ways, though, the R&D structure has not changed much since the breakup of the Soviet Union. The Russian Academy of Sciences is basically the same organization as the former Soviet Academy of Sciences and is still the most influential and prestigious R&D organization in Russia. It remains hostile to R&D reform. The Ministry of Science and Technology, especially under former minister Saltykov, has been the principal agent of reform in Russian S&T policy. Saltykov, for example, attempted to identify Russia's best research institutes and fund them on a priority basis as Federal Research Centers (also referred to as State Science Centers). These centers, now numbering about 60, about twice the number originally envisioned, are particularly favored in the R&D budget. The program, however, has been seriously diluted by the inclusion of the additional institutes, given the government's limited financial resources. After he was appointed deputy prime minister, Bulgak promoted a reform of Russian science, including a radical restructuring of the Russian Academy of Sciences and a substantial reduction in the number of state-supported research institutions. His reform plan was published in October 1997. Because it lacked detail, a time schedule, and deadlines, however, it has been criticized by other reform-minded individuals as being too vague.<sup>41</sup>

Another important R&D reform was the establishment of the Russian Foundation for Basic Research (RFBR) in 1993, headed, until recently, by the former Minister of Science and Technology, Vladimir Fortov. It has provided Western-style merit-based, peer-reviewed grants for about 54,000 research scientists. Although the Foundation accounted for only about 4 to 6% of the federal budget allocation in 1995-97 (and actually received only about one-third of that),<sup>42</sup> it may have contributed roughly one-third to one-half of salary support for Russian scientists conducting basic research.<sup>43</sup> This is mainly because the much larger budget of the Russian Academy of Sciences has been going principally for maintenance of its physical plant, rather than for salaries or scientific equipment. The RFBR is an important innovation in Russian R&D policy with potentially long-reaching ramifications because it funds individual researchers directly rather than their research institutes, on the model of the U.S. National Science Foundation.

Other important post-Soviet R&D organizations include the Russian Space Agency and the Ministry of Atomic Energy, which are responsible for the military and civilian nuclear complex. The Ministry of Defense continues to be responsible for much military R&D. Russian R&D also is becoming more decentralized and diversified. A significant amount of science policy is being formulated in various

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<sup>41</sup> Andrey Allakhverdov and Vladimir Pokrovsky, "Bulgak Fails to Deliver on Reform Plans," *Science*, v. 278, 14 November 1997: 1220.

<sup>42</sup> *Russian Science: Transformation and Adaption*, 7-8.

<sup>43</sup> Personal communication with Gerson Sher, U.S. Civilian Research and Development Corporation, August 18, 1998, based on information from V. Fortov, former director of the RFBR and later minister of Science and Technologies, M. Alfimov, current director of the RFBR, and B. Saltykov, former minister of Science and Technology Policy.



regions of Russia because the regions are receiving less funding from, and are being less influenced by, Moscow.

## R&D Priorities

Article 11 of the new Russian S&T policy law<sup>44</sup> sets forth the main goals and principles of Russian R&D policy, which are to:

develop, sensibly locate and effectively use scientific-technical potential, to enlarge the contribution of science and technology to development of the state's economy and to attainment of the most important social objectives, to provide for progressive structural transformations in materials production, to raise its effectiveness and the competitiveness of its products, to improve the ecological situation and protection of the state's information resources, to reinforce the defense capabilities of the state and the security of the individual, the society and the state, and to strengthen interrelationships between science and education.

Like much else in Russia today, however, the medium-range and long-range directions of state S&T policy “shall be determined by the President.” Article 13 states that the President shall make his determination on the basis of a special report to be prepared by the government.

While these activities might seem, and probably are, somewhat chaotic, they have contributed to a number of positive changes in Russian R&D: more flexibility in the R&D system, including increased local, regional, international, and industrial participation; implementation of competitive, peer-reviewed research grants by the new Foundation for Basic Research; selective support of science, for example, of the new Federal Research Centers; support of leading scientific schools; and increased cooperation between academic research and teaching.<sup>45</sup>

Current Russian R&D priorities are a mix of Soviet and post-Soviet priorities as reflected in the nation's 42 federal S&T programs, most of which are from the Soviet period. These programs fall into four major categories: military conversion programs, new technologies, life sciences, and “socio-oriented” programs. Most of the R&D funding in 1995 and 1996, however, went to such programs as the Conversion of the Defense Industry, the Federal Space Program, and the Program of Development of Civil Aviation. At least in those years, according to a Russian analyst familiar with Russian R&D programs, the “hidden priority still [was] defense-related research.”<sup>46</sup> Although Russia is attempting to develop new commercial technologies, about one-half of current Russian R&D funding, as noted above, might be for military R&D. Senior Russian officials have stated that, because of budgetary constraints, the

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<sup>44</sup> *On Science and State Science and Technology Policy.*

<sup>45</sup> Personal communication with Dr. Irina Dezhina on 28 March 1997 and *Russian Science: Transformation and Adaption.*

<sup>46</sup> *Russian Science: Transformation and Adaption*, p. 6.

Russian military has concentrated more on defense-related R&D than weapons production since 1993.<sup>47</sup>

In addition to the de facto priorities reflected in the government's R&D programs, there exist several other lists of R&D priorities. One governmental list includes basic research and seven critical technologies: information technologies and electronics, production technologies, new materials and chemical products, technologies of living systems, transport, fuel and energy, and ecology and rational use of nature. The priorities of the Russian Academy of Sciences coincide to a large extent with this list. Other R&D priority lists include that of the National Technology Basis program and a separate priority list involving dual-use technologies. The establishment and funding of the new Federal Research Centers also is an important priority.<sup>48</sup> This abundance of R&D priorities, some of which may be inconsistent with others, reflects continuing uncertainty as to the relative importance of the various components of Russian science policy, as do the structural changes in the R&D system noted above.

Military and space R&D historically have been two of the most important Russian R&D priorities. Although cloaked in secrecy, Russia presumably is maintaining its R&D capability to service some of its large nuclear weapons force. In addition, selected areas of military R&D appear to be well funded and world class, including advanced fighter aircraft and nuclear submarines.<sup>49</sup> There is, however, a crisis in military funding. Salaries of military officers, for example, have been months in arrears for several years.<sup>50</sup>

Space R&D, however, in which Russia has long played a leading role internationally, especially in areas such as human spaceflight, has suffered several reverses. The loss of its Mars 96 spacecraft, a serious blow to the Russian space program,<sup>51</sup> and the government's problems with funding the International Space Station, noted above, are symptoms of a program in financial and technical trouble.

## Issues for Congress

The policy issues involve mainly problems and opportunities in U.S. and international support of, and cooperation with, the Russian R&D establishment. Overall, these issues parallel ongoing U.S. and international programs to more fully integrate Russia peacefully into the community of nations, thereby reducing the

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<sup>47</sup> *Current and Projected National Security Threats to the United States*, p. 61.

<sup>48</sup> *Ibid.*, 3-7.

<sup>49</sup> Miklos Radvanyi, "A Lack of Democracy is Plaguing Russia," *The Washington Times*, 30 August 1996: A17.

<sup>50</sup> Congressional Research Service, *Russian Conventional Armed Forces: On the Verge of Collapse?* by Stuart Goldman, CRS Report 97-820F, 4 September 1997: 20.

<sup>51</sup> Tony Reichhardt, Carl Levitin, and Ehsan Masood, "Lost Mars Mission Thrusts Russian Space Science Further into Crisis," *Nature*, v. 384, 21 November 1996: 199.

potential for future conflict and increasing Russia's contribution to world economic development. In general, the policy issues can be defined as whether U.S. R&D cooperation with Russia should be increased or decreased in the four major areas of U.S. government support for Russian science and technology; support of Russian efforts to prevent the proliferation of nuclear weapons and materials and the defection of nuclear weapons scientists; support of Russian economic reforms; support of U.S. scientists in establishing research partnerships with Russian scientists; and promotion of technical commercialization by assisting U.S. companies gain access to advanced Russian technologies and highly skilled technicians.<sup>52</sup>

Major federal programs in support of Russian R&D are shown in Table 2. It is estimated that these programs accounted for about \$1.5 billion during the 1992-1997 period, of which over \$900 million was for NASA's Human Space Flight programs and a number of other NASA R&D projects. The U.S. private sector also contributed about \$300 million in R&D funding during this period, about \$200 million of which was provided by George Soros.

NASA's cooperative effort, the largest among the federal programs, draws on Russian know-how to reduce costs in the U.S. manned space program. NASA provided about \$662 million to Russia for the Shuttle-Mir program and the International Space Station project from 1994 through 1998, of which \$190 million was funded through a contract between the Boeing Corporation and Russia's Khrunichev Company. A second major NASA cooperative program is research on global climate change. There also are a number of cooperative efforts in other areas, including aeronautical research and development.

The "Nunn-Lugar" Cooperative Threat Reduction (CTR) program of the Department of Defense (DOD)<sup>53</sup> promotes the national security of the United States by facilitating the reduction of weapons of mass destruction, including nuclear weapons, in the former Soviet Union; expediting their destruction; establishing proliferation safeguards, including the prevention of an external brain drain of weapons scientists and engineers; and expanding defense contacts between the United States and Soviet successor states. Very little of this involves research and development. The program provided about \$50 million in direct support of Russian scientists through the International Science and Technology Center (ISTC) and about \$5 million through the U.S. Civilian Research and Development Foundation (CRDF), discussed below. DOD's "Non-Nunn-Lugar" programs include a number of cooperative projects with DOD and the Department of the Army, Navy, and Air Force and the purchase of Russian technologies.

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<sup>52</sup> Details on the federal R&D cooperative and assistance policies, programs, and activities discussed in this section are taken mainly from a personal communications with Dr. Richard J. Brody, Department of Commerce, 11 September 1997 and 17 July 1998, and Cathleen Campbell, Department of Commerce, 17 July 1998; and *Experiments in Cooperation*, 25-46, 130-131.

<sup>53</sup> Soviet Nuclear Threat Reduction Act of 1991, Title II of P.L. 102-228, 106 Stat. 1693, 12 December 1991, as amended.

**Table 2. Major U.S. Government Programs in Support of Russian R&D-Related Activities**

(\$ millions)

U.S. Government Programs	Estimated R&D Funding, 1992-1997
NASA	912 <sup>a</sup>
Department of Defense “Nunn-Lugar” Cooperative Threat Reduction (CTR) Program “Non-Nunn-Lugar” Programs	(55) <sup>b</sup> 150 <sup>c</sup>
Department of Energy	150 <sup>d</sup>
International Science and Technology Center (ISTC)	135
Civilian Research and Development Foundation (CRDF)	16
Other Federal Programs	127 <sup>e</sup>

<sup>a</sup> Includes \$662 million for the Mir and International Space Station projects, part of NASA's Human Space Flight programs (\$472 million provided directly by NASA and \$190 million funded through Boeing Corp. and spent in Russia); and \$250 million for various R&D programs.

<sup>b</sup> About \$50 million for the International Science and Technology Center (ISTC) and about \$5 million for the Civilian Research and Development Foundation, included in the ISTC and CRDF figures, below.

<sup>c</sup> Includes a number of cooperative projects with DOD and the Departments of the Army, Navy, and Air Force.

<sup>d</sup> Mainly DOE's Initiative for Proliferation Prevention (IPP) and other cooperative projects funded through DOE national laboratories.

<sup>e</sup> Includes a number of research projects involving NSF, NIH, USDA, NIST, and other agencies.

Source: Individual organizations and Glenn E. Schweitzer. *Experiments in Cooperation* (New York, The Twentieth Century Fund, 1997): 130-131.

The Department of Energy programs involve mainly bilateral R&D projects with Russia in the areas of nuclear materials protection and nuclear reactor safety. The Initiative for Proliferation Prevention (IPP) and other R&D projects totaled about \$150 million during this period.

The National Science Foundation, the National Institutes of Health, the U.S. Department of Agriculture, the National Institute of Standards and Technology and about 17 other federal agencies also have cooperative research programs with Russia, which accounted for about \$275 million from 1992 through 1996. The Freedom Support Act (FSA) of the U.S. Agency for International Development (USAID)<sup>54</sup> indirectly funds programs in support of U.S. AID's economic and technical assistance goals in Russia and other former Soviet nations, including energy efficiency projects,

<sup>54</sup> Freedom for Russia and Emerging Eurasian Democracies and Open Markets Support Act of 1992, P.L. 102-511, 106 Stat. 3320, 24 October 1992.

environmental quality demonstration projects, public health services, and the exchange and training of undergraduate and graduate students. Other than providing about \$85 million to the ISTC, only about \$2 million of FSA funding has been for research and development, mainly the International Business Technology Incubation project.

Three new organizations have been established specifically to cooperate with Russia in these types of R&D activities by providing research grants to Russian scientists. The first, the International Science Foundation (ISF), was established by George Soros in 1992. It expended about \$100 million on long-term basic research grants for Russian researchers before it ceased operations by 1996.<sup>55</sup> The second organization, the International Science and Technology Center, is a joint cooperative effort of Russia, the United States, Japan, the European Union, and a few other nations. The ISTC was established in March 1994 after extended negotiations between the parties.<sup>56</sup> The Center has committed about \$135 million<sup>57</sup> to encourage Russian nuclear weapons scientists, who might otherwise wish to emigrate, to stay in Russia and reorient their research to non-military ends. The third organization is the U.S. Civilian Research and Development Foundation for the Independent States of the Former Soviet Union, established under the Freedom Support Act.<sup>58</sup> It began funding in 1996 and has committed about \$16 million for Russia by 1998 to strengthen civilian R&D collaboration, defense conversion, and the emerging market economies of Russia and other former Soviet states.<sup>59</sup>

A recent initiative is the Program for Basic Research and Higher Education (BRHE), a joint effort of the U.S. Civilian Research and Development Foundation and the Russian Ministry of Education. Its purpose is to eliminate the historical separation between the approximately 325 research institutes of the Russian Academy of Sciences and Russian universities, which have never conducted much research. The initiative “would create a cadre of elite research centers at universities that can help attract and train the next generation of scientists.”<sup>60</sup> This initiative apparently has the support of the leadership of the Russian Academy of Sciences. If successful, the initiative would dramatically change the structure of Russian science by creating a research institute-university link with similarities to those existing in France and Germany.

Supporting the cooperative R&D programs with Russia is the U.S.- Russian Joint Commission on Economic and Technological Cooperation, created by President

<sup>55</sup> Based on Irina Dezhina, *The Role of the International Science Foundation (ISF) in Support of Science in the Former Soviet Union* (1997): 29-54, especially pp. 32 and 49.

<sup>56</sup> Schweitzer, “Conversion Activities in the Russian Weapons Laboratories.”

<sup>57</sup> Richard Stone, “The Perils of Partnership,” *Science*, v. 275, 24 January 1997: 470.

<sup>58</sup> Section 511 of Freedom for Russia and Emerging Eurasian Democracies and Open Markets Support Act of 1992.

<sup>59</sup> U.S. Civilian Research and Development Foundation, *Progress Report 1995-1997* (Arlington, VA, 1997): 5, 7.

<sup>60</sup> Richard Stone, “A New Initiative for Russian Science,” *Science*, v. 280, 29 May 1998: 1336.

Clinton and President Yeltsin at their Vancouver summit meeting in April 1993. Chaired by Vice President Gore and the Russian prime minister, the Commission has proven to be exceptionally successful in eliminating obstacles to, and in breaking new ground in, U.S.-Russian R&D cooperation. A number of R&D projects have been brought under the aegis of the Commission and a number of new R&D agreements have been made. The high-level Commission apparently has continued to operate smoothly even during periods of stress in U.S.-Russian relations and thus has been a stabilizing factor and an important channel of official cooperation during such periods.

Improving the success rate of joint Russian-U.S. commercial technology ventures is important to both the U.S. private sector and Russia. At its February 1997 meeting, the Commission agreed to design an initiative to improve the commercialization of Russian technologies. The U.S. government has identified four potential areas of activity that could contribute significantly to overcoming existing difficulties in commercial cooperation between the two countries: resolution of at least some of Russia's systemic legal and regulatory impediments to technology commercialization; increased availability of information for U.S. companies on Russian research institutes, scientists, and specializations; education and training in a host of "transaction" areas (import/export regulations, partnering arrangements, etc.) and intellectual property rights relevant to doing business in Russia; and case studies of successful and unsuccessful joint technology commercialization projects.<sup>61</sup> Also in 1997, CRDF established its Next Steps to the Market Program to "stimulate cooperation in applied R&D through the support of projects designed to facilitate and expedite the commercial utilization of research results."<sup>62</sup>

Even with all these U.S. and other cooperative R&D programs and activities, however, the near-term future of Russia and Russian R&D still appears to be perilous. Some observers, though, believe that the longer-term future, following the transition period, may be rather bright for Russian R&D if a smaller, but more efficient, R&D system is adequately funded.

Now is a time of both danger and opportunity for U.S.-Russian R&D cooperation. The Russian economy still is in financial crisis.<sup>63</sup> Foreign direct investment in Russia, which would ameliorate this situation, is small in comparison to global, and even eastern European, investment patterns.<sup>64</sup> Foreign direct investment in major technological projects, which generally includes both funding and foreign corporate management of research and development, might be crucial to increased R&D funding in Russia because the government probably will continue to find it difficult to allocate more of its constrained budgets for research and development in

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<sup>61</sup> Richard J. Brody, "U.S.-Russian Initiative on Commercializing Russian Technologies Highlights Opportunities and Impediments," *East/West Executive Guide*, v. 7, March 1997: 13-14.

<sup>62</sup> CRDF announcement, 23 June 1997.

<sup>63</sup> Congressional Research Service, *The Russian Financial Crisis: An Analysis of Trends, Causes, and Implications*, by William H. Cooper, CRS Report 98-578E, 26 June 1998, 6 p.

<sup>64</sup> European Bank for Reconstruction and Development, *Transition Report Update April 1998*(London, 1998): 12.

the near future. Russia particularly needs additional foreign direct investment in energy and telecommunications, which typically involve significant R&D components. Privatization and foreign and domestic purchase of ownership shares of, for example, the Russian telecommunications giant, Sviazinvest, and major Russian energy companies are important for sustaining much of Russia's R&D and for increasing its technological competitiveness. Fortunately, prospects for this are good. The economic downward trend was arrested in 1997. Although it recurred with sudden severity in 1998, optimistic forecasts project small increases in growth but only if and when the financial crisis coincident with the governmental changes of August 1998 is resolved, an open question at this moment. If the Russian economic situation, including foreign direct investment and the tax collection process, does not improve, there likely will be continuing serious ramifications for Russian R&D, because adequate R&D funding depends upon an improved economy, a more productive tax base, and direct foreign investments.<sup>65</sup> If the Russian economy does begin to revive and grow, the Russian R&D system, although smaller, may be stronger after the transition period (perhaps 10 to 15 years) than it was in the Soviet era, especially if it continues to receive outside help.

U.S. and other cooperative R&D programs are enhancing Russia's peaceful transition to a market economy and are successfully addressing scientific and technological problems and opportunities of mutual concern to the United States, Russia, and other countries. U.S. R&D cooperation with Russia also is one of the few areas in current U.S.-Russia relations in which both countries can promote mutual goals in a constructive way involving many U.S. government agencies. Some may argue that the contributions already made by these efforts support the case for increased U.S. and international R&D cooperation with Russia.

Others may caution that, with increased cooperation and a relaxation of international tensions, much U.S. and foreign R&D and many dual-use technologies, including computers and telecommunications, may ultimately find their way into Russia's military efforts and be counterproductive in regard to U.S. national security. This Cold War issue surfaced again in early 1997 with the sale of powerful U.S. computers to two Russian nuclear weapons laboratories.<sup>66</sup> Another security issue came to light recently when the U.S. government imposed sanctions against seven Russian entities suspected of contributing to Iran's missile program.<sup>67</sup>

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<sup>65</sup> Personal communication with John P. Hardt, Congressional Research Service, 1 July 1998. Also see John P. Hardt, "Commentary on the IMF Led Russian Assistance Program," presented at a panel discussion of the Heritage Foundation, Washington, D.C., July 23, 1998. 6 pp.; and Congressional Research Service, *Russia's Opportunity to Enter a New Stage in the Transition: Update*, by John P. Hardt, CRS Report 97-977 E, 29 October 1997, 44 p. For the policy positions of the U.S. government, the International Monetary Fund, and the World Bank in regard to foreign investment in Russia, see the various papers of the U.S.-Russia Business Council conference on U.S.-Russian Trade and Investment Forecast '97, 1 April 1997, Washington, D.C.

<sup>66</sup> Daniel Sneider, "Of Supercomputers and National Security: Can U.S. Keep 'War Games' Computers from Russia?" *The Christian Science Monitor*, 4 March 1997: 3.

<sup>67</sup> Richard Stone, "U.S. Blacklists Russian Institutes," *Science*, v. 280, 24 April 1998: 513; (continued...)

The most difficult policy issue in regard to continued U.S. support of Russian R&D might be how to achieve a balance between these two important national concerns. Several years' experience with U.S.-Russian cooperative R&D programs suggests that it is both worthwhile and practicable for the United States to identify and promote the large number of cooperative R&D programs which are mutually beneficial to the two nations, while carefully restricting R&D and dual-use technologies that may contribute to near-term or long-term military threats to U.S. national security.

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<sup>67</sup> (...continued)

and "Russia: Russian Firms Hit by U.S. Iran 'Blacklist,'" *Izvestiya*, 30 July 1998: 1 (translated text from FBIS-SOV-98-210).