

**The Missing Link? Nuclear  
Proliferation and the  
International Mobility of  
Russian Nuclear Experts**

UNIDIR  
United Nations Institute for Disarmament Research  
Geneva

RESEARCH PAPER  
NE 35

August 1995

**The Missing Link?  
Nuclear Proliferation and  
the International Mobility  
of Russian Nuclear Experts\***

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UNITED NATIONS  
New York and Geneva, 1995

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UNIDIR/95/27
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UNITED NATIONS PUBLICATION
<i>Sales No.</i> GV.E.95.0.18
ISBN 92-9045-104-1 ISSN 1014-4013

# Preface

The United Nations Institute for Disarmament Research (UNIDIR), which has been in existence since 1 October 1980, was established by the General Assembly as an autonomous institution within the framework of the United Nations to carry out independent research on disarmament and related international security issues.

The Institute's work, which is based on the provisions of the Final Document of the Tenth Session of the General Assembly, aims at:

1. Providing the international community with more diversified and complete data on problems relating to international security, the armaments race and disarmament in all fields, particularly in the nuclear field, so as to facilitate progress, through negotiations, towards greater security for all States, and towards the economic and social development of all peoples;
2. Promoting informed participation by all States in disarmament efforts;
3. Assisting on-going negotiations on disarmament and continuing efforts being made to ensure greater international security at a progressively lower level of armaments, particularly nuclear armaments, by means of objective and factual studies and analyses;
4. Carrying out more in-depth, forward looking and long-term research on disarmament so as to provide a general insight to the problems involved, and stimulating new initiatives for new negotiations.

In publishing this series of research papers, UNIDIR wishes to make available to the international diplomatic as well as scientific community analyses prepared by the staff of the Institute or persons working within its framework who express their personal points of view on current questions. The papers will deal with a very broad range of subjects and will vary in scope, depending on the evolution of security, disarmament and arms limitation problems, as well as on the specialization of the authors, although it will invariably be related to the Institute's programme of work.

UNIDIR takes no position on the views and conclusions expressed in these papers which are those of their authors. Nevertheless, UNIDIR considers that such papers merit publication and recommends them to the attention of its readers.

*Sverre Lodgaard*  
Director, UNIDIR

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## Introduction

The Nuclear Non-Proliferation-Treaty (NPT) review and extension conference held at the United Nations in May 1995, proclaimed by acclamation, after much political wrangling, that the treaty negotiated 25 years ago, "shall continue in force indefinitely." (NPT Article X-2.) The overall provisions of the treaty allow the United States and the former Soviet Union, along with Britain, France and China to keep their nuclear arsenals.

In many respects the treaty has been a great success.<sup>1</sup> Predictions in the 1960s of some future 25 nuclear weapons states has not materialized, although several states, especially Israel, India, and Pakistan, are presumed to have nuclear weapons. Except for India's "peaceful nuclear explosion" in 1974, there have been no confirmed reports of other tests. More recently, the countries of the Former Soviet Union (FSU) that possessed nuclear weapons - Belarus, Kazakhstan, and Ukraine - have promised to relinquish all such weapons in their territory. South Africa covertly assembled six nuclear weapons, but then dismantled them and belatedly signed on to the NPT. The Treaty has been signed by 170 countries.<sup>2</sup>

But Israel, India, and Pakistan still refuse to sign the agreement. If the Gulf War had not intervened, Iraq would undoubtedly have acquired nuclear weapons even though it had signed the NPT. North Korea, despite having signed the NPT, "worked to develop nuclear weapons while a member and then openly defied the demands of international inspectors".<sup>3</sup> Its recent promise to forego building a bomb does not inspire confidence. Iran was estimated to be some 10 years away from developing nuclear weapons, but according to 1995 CIA reports, it appears to be significantly closer.

Much of the proliferation that has occurred was, if not precisely predicted, at least envisioned as a possibility at the time the NPT was negotiated. The dramatic breakup of the former Soviet Union, however, was not anticipated. The radical changes that have overtaken these countries since 1989 - the fall of the Berlin Wall, and the forced end to Soviet Union domination of Eastern Europe as the

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<sup>1</sup> For a full evaluation see "Nuclear Proliferation: Confronting the New Challenges", *New York 1995 Task Force Report*, Chair, Stephen J. Hadley; Project Director, Mitchell B. Reiss, Council on Foreign Relations, NY 1995.

<sup>2</sup> Official vote taken at the United Nations, 11 May 1995.

<sup>3</sup> Gary Milhollin, director of the Wisconsin Project on Nuclear Arms Control, in Michael R. Gordon, "Iraq Played Catch Me if You Can North Korea Says, What if You Do?", *New York Times*, 5 June 1994, Section 4, p.1.

secession of the near-abroad states began - have contributed new, dangerous problems to an already-heated proliferation fray. With the end of Soviet domination over its satellites in Eastern Europe, and shortly afterwards, over its member states, political reality was dramatically reconfigured.

On the positive side, the potential for nuclear stability has vastly increased. Long-range nuclear weapons have been retargeted and serious denuclearization has begun in the US and Russia. Both countries have agreed to halt all further production of plutonium for weapons purposes and to allow reciprocal inspection of their nuclear facilities.<sup>4</sup>

When the NPT treaty was drafted, there was little thought that several decades later, Soviet scientists, engineers and technologists (SE&Ts) would be able to move so freely around the world. Travel had been tightly controlled, and was often used as a reward for loyalty to the party. Even at international scientific meetings, the KGB member of the delegation was easily discerned.

Neither had the corollary of this vast mobility been anticipated - the potential for scientists to disseminate their knowledge and technical skills, and the possibility of the complicity of SE&Ts, either in the direct sale of fissile materials, or in the facilitation of access to nuclear and other critical materials by criminals.

Freedom of international travel and emigration is to some extent a result of the FSU's new openness. But it is also a consequence of the decline of the economy that entails large-scale cutbacks in employment, devastating inflation that penalizes those on government salaries, a sharp drop in the funding of military SE&T, and a virtual shut-down in the design and production of new nuclear weapons. The results have brought about a movement of SE&Ts away from science as well as out of the country. Many new entrepreneurs in chemical start-up companies and software industries, or employees of foreign firms with recently-established research institutes in Russia, had been employed in government institutes and military establishments. In some instances, they have remained in place but have entered into business using the research institute as a base. Many of those individuals are flourishing. Others are less fortunate. From an admittedly bloated workforce that numbered in the millions, many former SE&Ts now work at menial jobs and barely eke out a living. The SE&Ts from military research institutes have been particularly hard hit with declining salaries and limited reemployment opportunities. Now that the government no longer wants to

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<sup>4</sup> John Holdren, Lecture at Center for Science and International Affairs, Harvard University, 14 February 1995.



produce weapons, they are often not paid for months at a time and their skills are of little value.

The USSR as an authoritarian state had long kept the movement of its citizens, particularly its scientists, under tight control. At the present time the whereabouts of only several hundred nuclear scientists are being monitored according to an agreement between the US and the FSU. The scale and the significance of the mobility of individuals who possess skills from the most theoretical to the nuts and bolts of weapon assembly are not known. Estimates vary from 2,000 to 6,000, but rise sharply if weapons-assembly engineering is included.

Increasing international mobility has advantages as well as drawbacks. It provides opportunities for the growth of science as well as for the careers of underemployed scientists and engineers. With open borders and increased communication facilities, emigration does not have to be permanent. For example, physicists from Moscow's Landau Institute who have become professors at the University of Minnesota, keep in touch with the Institute through e-mail and fax. They can return to Moscow to participate in seminars and graduate student examinations, and were the political and economic climate to change, might return permanently.

Nevertheless, the relationship between this mobility and nuclear proliferation, particularly where applied physics and weapons design are involved, merits attention since any potential threat to nuclear stability should not go unexamined.

In addition to the availability of a skilled SE&T workforce, knowledge about nuclear weapons production has become more accessible to non-nuclear countries. National boundaries are more easily traversed, and education abroad has become more readily available. Revolutionary developments in electronic communications as well as increased access to recently unclassified publications have added to the ease of acquiring weapons design and engineering skills.

Roald Sagdeev, the former director of the Soviet Space Research Institute, wrote that plasma (electrically charged gases involved in nuclear physics) created "incurable instabilities".<sup>5</sup> These gloomy words easily apply to the conditions brought about by the radical changes in the FSU. There are few, if any, realistic policy options that could reduce the risks of nuclear proliferation to zero. The challenge is to identify the root causes and to minimize the possibilities that the

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<sup>5</sup> Roald Z. Sagdeev, *The Making of A Soviet Scientist: My Adventures in Nuclear Fusion and Space from Stalin to Star Wars*, John Wiley and Sons, 1994, p.105.

"incurable instabilities" lead to the destabilization of Russia and - because of the destructive power of nuclear weapons, or even the threat of their use - destabilize all nations.

Since the beginning of this project in 1994, new developments have altered the course of the investigation:

- \* What was once hypothetical became reality as nuclear weapons-grade material began to appear outside of Russia. Between May and August 1994, German authorities made four seizures of nuclear material. Many experts believe this is but the tip of the iceberg. If only one-hundredth of one-percent of Russia's plutonium stockpile were to be made available, a Third World country could develop a nuclear arsenal.
- \* Fears of nuclear terrorism have begun to occupy a major position under the proliferation umbrella. It is no longer only the would-be nuclear nations who pose a threat. Well-funded radical terrorist organizations have the potential to wreak havoc, and have begun to join other would-be proliferators for international concern.
- \* The Russians, at the present time, intent on preventing the separation of Chechnya, have become increasingly anxious about the security of their own nuclear power plants and stocks of nuclear material as the Chechens vow to wage a terrorist war on Russia.<sup>6</sup> Fears about political instability and social anomy in Russia have risen as President Yeltsin's influence has seriously diminished. The attack on Chechnya has revealed the Russian army as ill-prepared and demoralized; the President has been portrayed as not-in-control; and the public's ire has been aroused both because of the loss of young Russian soldiers' lives, and the revulsion at the carnage relayed daily by Russian TV. The Russian government fears that poorly-protected military and civilian nuclear installations could readily become targets for Chechen militants.
- \* Many SE&Ts have left the FSU. Whether the emigration could be described as "brain drain", which connotes permanent emigration, is controversial. Even more problematic is the relationship between "brain drain" and nuclear proliferation. If 100,000 SE&Ts emigrate and five of them go to work for Iran or Libya, or if 100 leave and the same number work for would-be nuclear weapons states, the scale of the emigration is of little significance. There is no

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<sup>6</sup> William C. Potter and Leonard S. Spector, "Nuclear Terrorism - The Next Wave?", *The New York Times*, 19 December 1994, p.A19.

fixed ratio of rogue scientists to emigration statistics. However, as a senior scientist at Los Alamos observed, "A certain fraction of one million (SE&Ts), will have to prove ~~un~~non-patriotic".<sup>7</sup>

- \* Emigration - sometimes forced and sometimes for the promise of higher salaries - of Russian ethnics from the former Soviet empire to Russia has escalated to almost three million people, a significant number of whom are SE&Ts who worked at military and civilian installations. Their emigration at once weakens nuclear security, particularly at unsafe civilian nuclear power plants in their former countries, and swells the already-burgeoning ranks of unemployed SE&Ts in Russia which accepts them now only reluctantly.
- \* The NPT has encountered serious opposition from a number of developing countries that believe the treaty is discriminatory. Many non-nuclear members object to restricting their opportunities to acquire nuclear technology for peaceful uses. Critics have demanded the conclusion of a comprehensive test ban treaty; a negotiated halt in the production of fissile material for weapons purposes; more effective security assurances; and nuclear disarmament beyond START II. Contrary to the expectations of some, the nuclear disarmament agreements between the US and Russia have done surprisingly little to alleviate concerns about the imbalance in rights and obligations between the "have" and "have not" nations.
- \* Inflation has further reduced the salaries of FSU SE&Ts as the currency has collapsed to a ratio of 5,000 rubles to \$1, thereby increasing the likelihood of emigration and blackmarket transactions.
- \* Russia is now thought of as the crime capital of the world - some 5,600 criminal groups are in operation according to the Interior Ministry. In July 1994, the FBI opened an office in Moscow because, as its director stated, the potential diversion of nuclear material poses "the greatest long-term threat to the security of the United States".<sup>8</sup>
- \* In January 1995, a document leaked from the Federal Counterintelligence Service (FCS), the successor to the KGB, revealed the growing antipathy, if not paranoia, among Russian conservatives, about American support of scientists in Russia.<sup>9</sup> Claiming that the International Science Foundation -

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<sup>7</sup> Interview with Dr John Shaner, Los Alamos, 18 August 1994.

<sup>8</sup> Quote in John Auerbach, "In Sign of New World Disorder, FBI Opens Moscow Office", *The Boston Globe*, 3 July 1994, p.13.

<sup>9</sup> "Federal Counterintelligence Service Concerned over American Researchers Activity in Russia", translated from *The Independent Newspaper*, Moscow, 10 January 1995. Also see report in *Nature* by Carl Levitin, "Soros Foundation is Defended against Charges of Spying", Vol. 373,

established by George Soros, the international financier - to provide research funds for Russian scientists, was actually enabling American scientists to steal ideas, discoveries, and inventions, the report accused the Americans of "espionage and subversion on the territory of Russia". The memo was denounced by Minister of Science and Technology Boris Saltykov and by many leading scientists. Despite their protests, the Duma held hearings in February 1995, but refrained from any further recriminations.

- \* After a hiatus of some six months of media attention to nuclear theft, a Western European intelligence report revealed a jump in nuclear smuggling activities.<sup>10</sup> According to the report, during 1994, 124 actual or attempted cases of nuclear material from former Communist countries were received compared with 56 in 1993 and 53 in 1992. In more than half, the material contained uranium or plutonium.
- \* In February 1995, Russia, desperate for hard currency, announced that it was selling two or perhaps four nuclear power plants to Iran. Russian technologists are already working in Iran, and 150 Iranians were scheduled to travel to Russia to study nuclear engineering. Albeit difficult to extract plutonium from light water reactors, the acquisition of the reactors brings this unstable country and its militants one step closer to a nuclear weapons capability. The proliferation implications are very serious. As two experts in plutonium wrote recently: "Peaceful Plutonium? There's No Such Thing".<sup>11</sup>

This rapid flow of events suggests that the following text should not be produced in a bound version but rather in a loose-leaf notebook so that observations and events can be revised and updated, rejected or established as fact.

## Background

This paper has its origins in a 1992 study prepared for OECD meetings on the East-West Mobility of Scientists and Engineers. Entitled, "Brain Drain, Brain Bank, and Brain Wall: The International Mobility of Former Soviet Union

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26 January 1995, p.274.

<sup>10</sup> Craig Whitney, "Smuggling of Radioactive Material Said to Double in a Year", *The New York Times*, 18 February 1995, p.2.

<sup>11</sup> Paul Leventhal and Daniel Horner, "Peaceful Plutonium? There's No Such Thing", *The New York Times*, 25 January 1995, p.20.

Scientists, Engineers, and Technologists", it attempted to identify the ways in which political, national security, economic and personal goals collide with each other as well as with traditional scientific norms and practices that are based on openness and sharing - perforce less evident in military and commercial endeavors.<sup>12</sup>

The boundaries between science and engineering and the institutions within which they are carried out - military, commercial, and academic - have become increasingly permeable, further complicating what used to be more clearly delineated arenas. Engineers know basic science, basic scientists with experience in weapons development often know assembly technology, and technologists who have worked at Russian weapons laboratories such as Arzamas or Chelyabinsk understand the engineering of plutonium conversion, or similar techniques. Most would know the market value of their expertise to outsiders. Therefore, the skills of emigrating academic or "available" SE&Ts are valuable not only to universities, but also to foreign military and industrial endeavors.

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<sup>12</sup> Dorothy S. Zinberg, "Brain Drain, Brain Bank, and Brain Wall: The International Mobility of Former Soviet Union Scientists, Engineers, and Technologists", presented at OECD Meetings, "East-West Mobility of Scientists and Engineers: Maintaining the Scientific and Technological Potential of Central and East European Countries", Vienna-Laxenburg conference, 18-19 February 1993.

## Scale of Emigration

Using data generated by the European Commission, Russian officials and academics, as well as by the C.I.A., the OECD paper characterized the emigration as large-scale.<sup>13</sup> Russian economists, Valiukov and Simonovsky, estimated that between 1986 and 1990, the scale of emigration of S&Es had been equivalent to the total of the past 40 years. In addition, the new laws, they predicted, would enable another 1.5-1.8 million highly-skilled individuals to emigrate by the year 2000.<sup>14</sup> The Federated Russian Ministry for Science, Higher Education, and Technical Policy estimated that some 90,000 scientists had left Russia in 1991.<sup>15</sup> Of these, approximately 45 percent went to Israel, 38 percent to Germany, 12 percent to the US, and one percent to Central and Eastern Europe.<sup>16</sup>

According to the vice-president of the Russian Academy of Sciences, 12 percent of all researchers had gone abroad between 1990-93, including 40 percent of all the country's theoretical physicists.<sup>17</sup> In 1993 a thermonuclear physicist from the prestigious Kurchatov Institute observed: "What took decades to build up is now taking months to destroy".<sup>18</sup> After weapons-grade material appeared in Germany, scientists from this Institute reported that 60 scientists had access to nuclear materials which had not been checked for more than eight months.<sup>19</sup> In addition, the Ministry of Atomic Power of the Russian Federation (Minatom) had predicted almost one year previous to the appearance of nuclear material in Germany that security at the Kurchatov Institute was not tight enough to prevent theft. The report, quoted in the *Moscow News (Moskovski Novosti)*, stated ominously that "No quantitative measurements are carried out on the actual availability of nuclear materials (kept at Kurchatov). Thus, there can be no

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<sup>13</sup> Copy # 5 Ministry for Science, Higher Education and Technical Policy of the Russian Federation, V. Valiukov and S. Simanovsky "Brain Drain from Russia: Problems, Prospects and Ways of Regulation", presented at OECD Meetings on East-West Mobility of Scientists and Engineers, Vienna-Laxenburg Conference, 18-19 February 1993. Also Barbara Rhode, "Mobility of Scientists and Engineers between The PECO and CIS Countries and EC", Commission of the European Communities, DG XII-F, February 1993.

<sup>14</sup> Valiukov and Simanovsky, *op. cit.*

<sup>15</sup> Barbara Rhode, *op. cit.*

<sup>16</sup> Rhode, *op. cit.*, p.3.

<sup>17</sup> Justin Burke, "Exodus of Researchers Stirs Fears Over Fate of Science in the Former Soviet Union", *The Chronicle of Higher Education*, 4 March 1992, p.A41.

<sup>18</sup> Tim Beardsley, "Selling to Survive: Trends in Russian Science", *Scientific American*, February 1993, pp.92-100.

<sup>19</sup> ABC Broadcast, 8 August 1994.

guarantee against unsanctioned removal, theft or substitution of articles containing nuclear materials".<sup>20</sup> It is easy to envision the involvement of an employee, whether administrator, researcher, technician, or janitor, in the theft of dangerous materials under these conditions.

In May 1994, a member of the external branch of the former KGB, Igor Marakovsky, stated forcefully that there was "massive danger for the proliferation of nuclear as well as chemical and biological weapons, because of the elimination of the single nuclear state. In addition, the existence of the Commonwealth of Independent States (CIS) with their nuclear weapons combined with the brain drain are making the process [of stemming nuclear proliferation] slower". He added that the problem of brain drain was being viewed in Russia from the perspective of "a top priority - guaranteeing control over radioactive material".<sup>21</sup>

By September of 1994, a Russian science journalist reporting in *Nature*, stated dramatically that the scientific brain drain had been converted into an exodus, "a phenomenon without any historical precedent".<sup>22</sup>

This assessment is not accepted by a number of western experts who contend that the magnitude of the brain drain has been exaggerated. Because there is no substantiated report on the defection of a nuclear scientist to a hostile country, and because Russian scientists may also return to Russia, those who believe the issue has been exaggerated interpret the anxiety as a political ploy. One American, writing in an unsigned peer review, argued that such speculation is "self-serving misinformation orchestrated by FSU scientists (and westerners) who are in favor of granting large subsidies to FSU nuclear countries in order to regain their former prominence and financial status". This diagnosis would provide cool comfort to Ukraine where the majority of scientists were ethnic Russians, many of whom have migrated to Russia. Social scientists report that the "erosion of intellectual potential is fraught with the danger of national degradation".<sup>23</sup>

The consequences of the (re)migration of ethnic Russian scientists to Russia (for example, some 20 percent of the staff of Chernobyl) led the International Atomic Energy Agency (IAEA) and the managers of civilian nuclear power plants

<sup>20</sup> Fred Kaplan, "Russian Report Cites Lax Security at Top Nuclear Weapons Lab", *The Boston Globe*, 27 August 1994, p.2.

<sup>21</sup> Yuri Marakovsky, UNIDIR Workshop on Brain Drain and Nuclear Proliferation, 5 May 1994, Geneva.

<sup>22</sup> Vladimir Pokrovsky, "Russian Science in the Balance", *Nature*, Vol. 371, 15 September 1994, pp.195-196.

<sup>23</sup> Yuri Klochko and Nina Issakova, "Intellectual Migration: A View from Ukraine", *Science and Public Policy*, December 1993, pp.405-409.

to attempt to create ways in which to slow the "brain drain" that is further endangering the sites. When employment is available (at least, previous to the last inflationary spiral), salaries were five to six times higher in Russia. To stem the outflow, the Ukrainian Nuclear Society is offering monetary awards to outstanding students in nuclear energy. Nevertheless, the exodus of Ukrainian nuclear scientists to Russia continues.<sup>24</sup>

The scale of the emigration is probably more closely related to the future of science and engineering in Russia than to proliferation. If the country loses not only its best scientists but also its most promising younger generation of engineers and scientists, the likelihood of Russia being able to develop a science, technology, and economic base on which to grow economically will be seriously diminished, thereby producing one more "incurable instability".

Despite the disclaimers from those who believe the "brain drain" to be an illusory phenomenon, many Western political, intelligence, and military leaders, along with their counterparts in the Former Soviet Union, have expressed apprehension about the brain drain and its consequences for nuclear proliferation. Testifying before the Senate Governmental Affairs Committee, then director of the CIA Robert Gates warned that a serious threat of nuclear proliferation came from the potential of the approximately 1,000 to 2,000 nuclear scientists from the former Soviet Union to emigrate or trade their know-how for cash. He stated that the circumstance that caused the US the greatest concern, "more than a loss of materials or weapons, is this so-called brain drain problem".<sup>25</sup>

In 1994, the Office of Technology Assessment (OTA), the advisory arm to the US Congress on science and technology policy issues, echoed Gates's concerns in its study, "Proliferation and the Former Soviet Union".<sup>26</sup> The report warns that "brain drain", particularly from nuclear weapons laboratories to foreign states, could be exacerbated by the poor conditions of the laboratories that have been "greatly neglected" since the chaos of 1992-93.

The report catalogues a number of disquieting incidents such as the following:

- \* Two active Russian nuclear physicists appeared on a French television program in 1993 and stated that they saw nothing inherently wrong in

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<sup>24</sup> William Potter (ed.), *CIS/Soviet Nuclear Brain Drain Chronology*, Program for Nonproliferation Studies, Monterey Institute for International Studies, 1994.

<sup>25</sup> Robert Gates (former) Director of CIA, "Testimony before the Senate Governmental Affairs Committee, 15 January 1992", *Washington Times*, 16 January 1992, p.A3.

<sup>26</sup> US Congress, OTA, *Proliferation and the Former Soviet Union*, OTA-ISS-605, Washington, DC: US Government Printing Office, September 1994.



helping Iraq and Libya or other nuclear aspirants acquire nuclear weapons.<sup>27</sup> Their actions (in contrast to their words) are unknown, and so are any responses by their employers or the Russian government.

- \* The Scientific Director of Arzamas-16, a major Russian nuclear research establishment, following a protest rally staged by an angry staff that had not been paid in two months, declared that Iraq had offered Arzamas \$2 billion for a warhead. His claim was never substantiated and might well have been uttered partially out of fury -the laboratories have deteriorated economically and in status - or to remind the government of the laboratories' potential to create havoc.

Rumors about the emigration of scientists to Third World countries can also have a secondary effect. As social scientists Stanley and Lock postulate, the rumors themselves alarm other non-nuclear nations that consequently believe they must maintain a competitive edge. If Libya, for example, is perceived to be acquiring nuclear weapons, other Third World countries, particularly Libya's adversaries, may believe that they too must possess a comparable arsenal and are likely to redouble their efforts to gain weapons-grade material or the weapons themselves. In short, as Stanley and Lock suggest, "Proliferation produces proliferation".<sup>28</sup>

Arguments proposing that NATO retain its nuclear capacity to counterbalance the possible proliferation to Third World countries could also induce such states to continue their nuclear programs. This action, in turn, further embitters those non-nuclear states that are troubled by the inequitable conditions of the NPT. Consequently, allegations of a mass exodus of nuclear technology and know-how serves to justify the retention of nuclear arsenals by nuclear powers, and the feedback effect continues.

## Developments Between December 1993 and 1994

The year was marked by reports of increased emigration, tempered by retractions from some who had recently written of the crisis of the brain drain. A seeming willingness of the Russian government to stem the tide combined with a

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<sup>27</sup> *Op. cit.*, p.63.

<sup>28</sup> Ruth Stanley and Peter Lock, "The Migration of Scientists and Engineers from the Former Soviet Union: Will it Lead to Weapons Proliferation?", *Arbeitspapiers*, Berlin: Berghof-Stiftung Fur Konfliktforschung, 1992, p.1.

shortage of jobs abroad might have slowed the outward flow. The figures are inconclusive, particularly as the numbers relevant to the long-term travel or emigration of Russian nuclear experts to North Korea, China, and now Iran, are impossible to verify. Fissile material reputed to have originated in the Former Soviet Union made its first appearance on the black market and growing concerns about nuclear terrorism marked the year. The Monterey Institute of International Studies, publishers of the chronology *The CIS/Soviet Nuclear Braindrain*, reported:<sup>29</sup>

12/9/93 A high-ranking North Korean delegate in Moscow who was accused of recruiting Russian nuclear scientists to work on nuclear energy and technology projects was expelled.

12/10/93 US Intelligence reports that they suspect nuclear scientists from the FSU have "allegedly been heading to Iran, Iraq and North Korea in order to assist with the development of nuclear and other arms there".

1/10/94 Reuter reports that the director of the Federal Counterintelligence Service (the former KGB) expressed his concerns about "cases involving a number of diplomatic missions and other foreign intelligence services in the area of leaking vital scientific, technological, defense, nuclear and other information". He added that there have been increased efforts to recruit Russian officials.

1/27/94 The Japanese weekly *Shukan Bunshun* stated that beginning in the 1980s some 160 Russian nuclear scientists and missile specialists had allegedly gone to work in North Korean laboratories. Some of the scientists had changed their names and others had become North Korean citizens. The paper added that North Korea now possesses "one or two nuclear warheads" (medium range missiles) which have been developed with Russian assistance.

2/16/94 *Rossiiskie Vesti* #27 alleged that 50 Russian specialists had been paid \$5000 a month to assemble nuclear warheads; Kurchatov Institute staff were paid "\$100,000 to work on a project near the Gulf of Sidra, and Algeria sought out Ukrainian engineers to help design their nuclear power plants".

3/16/94 A Greek newspaper reported that Turkey had been hiring unemployed Russian scientists for \$2300 a month in an attempt to acquire nuclear

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<sup>29</sup> *Op. cit.*, Potter.

weapons. Kazakh nuclear weapons experts were reported to be teaching at Istanbul University.

8/22/94 Professor Anatolii Dyakov of the Moscow Physical-Technical Institute, quoted in *Der Spiegel*, stated that because of a lack of funds, "Principled people with a long work record at the Institute are now leaving it. They have to live. Their places are being taken by people devoid of principles, who realize they are practically rolling in money".

8/29/94 A Russian newspaper reported that the issue of Russian nuclear scientists going to Pakistan was on the agenda of the Indian Home Minister's visit to Moscow.

11/21/94 A Los Alamos technical staff member who was on assignment at 14 various Moscow research institutes, was quoted in *Nuclear Fuel* stating that Russian nuclear specialists were working on projects for foreign countries. "Moscow is full of foreign trade offices. The representatives submit projects... to the institutes and get their nuclear program projects done one piece at a time".

11/29/94 Reuter reports that a Sino-Russian nuclear project worth US\$10 million will entail importing "super clean" isotopes and cobalt-60 into China from Russia.

The Monterey Institute cautioned that these were unsubstantiated reports. However, the black market nuclear material that has turned up in Germany, Hungary and the Czech Republic bears the "fingerprints" of Russian research institutes (as opposed to military installations), thereby lending credence to the media reports and quotes from US government officials.

## The Long Hot Summer

Before the appearance of stolen nuclear material in May 1994, a Russian journalist had explored the possibility of purchasing nuclear material on the Russian black market. Six months of undercover investigative reporting led to many aborted attempts to sell and purchase fissile material. Nonetheless, his efforts uncovered one major fact: operators in the black market are aware of a demand for nuclear materials and will attempt to satisfy it if the request sounds serious.<sup>30</sup>

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<sup>30</sup> Kirill Belyaninov, "Nuclear Nonsense, Black Market Bombs, and Fissile Flim Flam", *Bulletin of Atomic Scientists*, May/June 1994.

The sequence of detections began 10 May 1994 when German police in a search for counterfeit material came upon six grams of plutonium-239 in the home of a German businessman, Adolf Jaekle. Philip Williams, a political scientist, argues convincingly that a sophisticated Bulgarian-Iraqi "professional supply chain" was involved. Not only did Jaekle name five potential Iraqi buyers, one of whom was a close associate of Jafar Dhia Jafar, Iraq's chief nuclear scientist, but he was also found to have been carrying business cards that belonged to two scientists at the Kurchatov Institute - circumstantial evidence, but nevertheless unsettling. In addition, Jaekle implicated former Stasi (East German security) agents, and intimated that the sample was part of a 150kg shipment.<sup>31</sup> Since a nuclear weapon requires approximately four to five kgs of plutonium-239, the planned shipment could have fuelled a substantial nuclear arsenal.

During 1994, perhaps to raise consciousness about the inherent dangers of proliferation, German undercover agents encouraged three men to acquire nuclear material in Moscow, and arrested them when they arrived in Munich, August 1994, with 330 grams of plutonium, and one kg of Lithium-6. The case caused significant controversy because it raised the question as to whether nuclear trafficking is "a fabricated issue rather than a security threat".<sup>32</sup> In June 1995, the Bundestag, which has set up a formal committee of inquiry, began an open debate on whether the federal secret service actually staged the plutonium scare in order to strengthen its credibility as an intelligence force. The Russians are accusing the Germans of fraud; and *Der Spiegel*, the weekly-news magazine, is accusing the secret service of committing a criminal offence by allowing radioactive material to be placed on an airplane flying over Germany. Had the plane crash landed over Munich, *Der Spiegel* contended, more than half the city would have been contaminated. Not surprisingly, the case has provided a political battleground for the Social Democrats eager to embarrass Helmut Kohl's government. Adamant about its actions and success, the secret service argues that Germany has succeeded in demonstrating that they have the problem under control and consequently, "Operation Hades" would deter future trafficking.<sup>33</sup> Unfortunately, they lost track of the smugglers in Moscow.

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<sup>31</sup> I want to thank Professor Philip Williams, Director of the Ridgeway Center for International Studies, University of Pittsburgh (US) for making available a draft of his paper, *Nuclear Material Trafficking*, 1994.

<sup>32</sup> Philip Williams, *op. cit.*

<sup>33</sup> "Back from Hades", *The Economist*, 29 April 1995, p.59.

Williams believes the problem is real and serious, and proposes that the models used to study drug trafficking be applied to tracking the illegal movement of nuclear materials and their purveyors.<sup>34</sup> The comparisons demonstrate the difficulties of interdiction:

Only approximately fifty percent of smuggled drugs are interdicted in the US. Even assuming that radioactivity makes the task of detection somewhat easier, the absence of monitoring equipment at many borders makes it unlikely that smugglers will be detected. In drug arrests, it is usually the less expert criminals who are caught - a likelihood that concerns West European officials who have intercepted what they estimate to be only a small percentage of what is being stolen and sold. Increased police surveillance of known drug routes leads to their being established elsewhere, not obliterated. For instance, because Germany increased its surveillance, the Czech Republic has become the new gateway to the west.

Williams presents evidence that both the quantity and the quality of nuclear material discovered have increased since May 1994.<sup>35</sup> In addition, he believes that because the first interdiction occurred by accident, it demonstrated that the police are not on top of the problem. This observation was reenforced by Anthony Fainberg, a senior analyst with the US Office of Technology Assessment, who reported that the nuclear material that has been appearing since the first wave six months ago is even more dangerous because it contains greater amounts of plutonium and highly enriched uranium, and there is evidence that only five to 10 per cent of what is leaking through the "highly porous borders" of the FSU is being intercepted.<sup>36</sup> The estimate is highly speculative as there is no way of assessing the total supply of illegal material in the hands of smugglers.

The arrest of a Czech scientist in Prague, 19 December 1994, in conjunction with a confiscated shipment of 6.6 pounds of highly-enriched uranium 235 has sharpened these inquiries. In addition, questions about who provided access to plutonium that originated in the FSU, and was for sale in Germany several months earlier, have intensified international concern.

Although media reports of the appearance of additional fissile material have diminished, reports from intelligence agencies and informal conversations with

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<sup>34</sup> Philip Williams, *op. cit.*

<sup>35</sup> Philip Williams, *op. cit.*

<sup>36</sup> Anthony Fainberg, participant AAAS Panel on "The Impact of the Collapse of the Soviet Union on Nonproliferation", 18 February 1995, Atlanta, Georgia.

Pentagon officials suggest that the proliferation has grown markedly.<sup>37</sup> Regrettably, what has diminished is public attention to this very serious problem.

## Intimations of the Complicity of Scientists

For several years, non-nuclear materials have been selling at a brisk pace at former off-limits, closed military research centres in Russia. Even many of the scientists are for hire. As Tim Beardsley wrote in 1993, the Kurchatov Institute which employs about 10,000 scientists and engineers "resembled nothing so much as a flea market".<sup>38</sup> Salaries were not being paid, and many scientists were leaving. On the positive side, collaborative projects with overseas industries and universities were being initiated, but since then inflation has demolished the value of the ruble, and the situation of the SE&T community not involved in commercial activities has worsened.

The report of a politician hinting that a Russian scientist might be involved in proliferation activities was in August 1994. The Bavarian Minister of the Interior claimed that "It might be that underpaid Russian scientists are the people who are selling the material; it might be the people from the security of the former KGB, or Russian security authorities might be involved". People previously involved in smuggling were not from the government, but according to the Soviets, were thought to be drivers, various workers, and shift foremen.<sup>39</sup>

The cumulative effect of numerous reports detailing the lack of security at Russian research institutes (as opposed to military installations), combined with the desperate plight of those working there, has sharply increased suspicion about the involvement of all levels of employees, not just unskilled laborers.

## Making Inquiries about Scientists and Nuclear Proliferation

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<sup>37</sup> Craig Whitney, *op. cit.* Also informal comments made at the Proliferation Panel at the AAAS meetings, Atlanta, Georgia, 18 February 1995, reenforce findings from Western European intelligence documents.

<sup>38</sup> Tim Beardsley, "Selling to Survive", trends in Russian Science, *Scientific American*, February 1993, pp.92-100.

<sup>39</sup> Quote from Interior Minister of Bavaria, Craig Whitney, "Germans Suspect Russian Military in Plutonium Sale", *The New York Times*, 16 August 1994, p.1.

Unprejudiced questions on the topic of possible ties between nuclear theft and FSU scientists and engineers are often enough to elicit irritated and sometimes angry responses from Russians. The title of an article by the Russian physicist Sergei Kapitza, stated the outrage succinctly: "Soviet Scientists: Low Pay, No Pay, Now Insults".<sup>40</sup> Angered at the thought that distinguished scientists, who had found their livelihoods destroyed as the government abandoned most nuclear research and development, would be subjected to charges of theft and lack of concern for national security, Kapitza railed at the attack. Unfortunately, his image was of the tiny fraction of any profession that exists at the very pinnacle of the field. The thousands of other scientists and engineers working in research institutes and large sprawling bureaucracies such as Minatom's production and storage facilities, although not any less patriotic than the more accomplished, are likely (if only statistically) to harbour a few whose motives and behavior are suspect.

In August of 1994, during an interview, Sergei Karaganov, the director of the Moscow Institute for International Relations, asked with some annoyance, "Why do you concentrate on Russians (who might be selling nuclear knowledge)? Americans are stealing our ideas. Hundreds of thousands of our defense experts are working for the US military".<sup>41</sup> He remonstrated that the money did not accrue to Russia - even Russian-owned companies were being set up off-shore - so that the net capital movements were out of the country. He added that nuclear experts were being tightly controlled, but that others just beneath them could easily leave or have fled. Outlining a route that involved permeable borders and few, if any, visa requirements, Karaganov described a journey that could begin in Russia, move across Ukraine to Moldova, Romania, and finally Hungary. He added that if a foreign power wanted weapons or security information, the scientist would not have to go to the particular country. Rather the foreign agent could set up a laboratory for the scientist in Switzerland. Even without weapons-grade material, the laboratory could greatly increase the knowledge of the would-be procurer.

## **Iran and China: Working Closely with Russia**

In February 1995, Russia announced that it had completed a deal to sell two light water reactors to Iran. Russian engineers and technicians were already

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<sup>40</sup> Sergei Kapitza, *The Bulletin of the Atomic Scientists*, April 1992.

<sup>41</sup> Interview with Sergei Karaganov, Aspen, CO, 15 August 1994.

working there and 150 Iranian engineers will be moving to Russia for an extended period of training. The links to potential nuclear proliferation are clear, particularly as Iran has made little secret of its intention not simply to possess a nuclear weapon but to become a full-fledged nuclear state.

China already possesses nuclear capability and has been eager to enhance the sophistication of its weaponry by employing FSU scientists with advanced knowledge. Dr. Karaganov reported that there are 2 million Chinese currently working in Machuria and who are greatly facilitating the interchange of information about weapons. The Chinese have bought many Scud missiles manufactured by Germans and resold them to Third World countries. Like Russia, they are eager to sell nuclear power plants to Iran, and have supplied M-11 missile technology to Pakistan.

In addition, Karaganov stated, hundreds of Russian scientists and engineers are already working for North and South Korea as well as for China, but only Russian counter-intelligence would have the exact numbers. The BBC has reported that an unspecified number of Russian scientists and engineers have moved to North Korea, taken Korean names, and faded from sight.

Other scientists also balked at the suggestion that the theft of nuclear material be linked with the scientists working with them. Professor Sagdeev insisted that the Russians are still in control of emigration. "There is an international law covering people who hold state secrets, and they can leave only if sent to institutes or conferences. They could defect but would have no incentive to defect to Iraq or Iran. The cultures are hostile to the Russian way of life". He added, "Of course, there could always be an exception".

Andrei Gagarinsky, Deputy Head of the Kurchatov Nuclear Institute, holds another position. He maintains that rumors of Middle Eastern headhunters swarming over Russia are unfounded, largely propagated by Russians themselves to call attention to their problems - a thinly veiled threat about the damage they might inflict if they are not appropriately employed at home.<sup>42</sup>

Sagdeev believes the real loss to science lies in the internal emigration out of the profession. "There is great pressure to shrink the size of the scientific community but the scientists will say "no" to smuggling. They are not a great

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<sup>42</sup> Sarah Helmstadter, *The Russian Brain Drain in Perspective*, RFE/RL Research Institute, 18 August 1992.



source of proliferation risk".<sup>43</sup> Between January 1991 and June 1992 more than 600,000 scientists left their employment.<sup>44</sup>

Hundreds of thousands of engineers, professors, scientists, government officials and other highly-skilled professionals have been forced to accept menial jobs in the post-communist downsizing.<sup>45</sup> A more recent, ominous warning came in March 1995 from Natalya Nikitina, co-director of MetaSynthesis in Moscow, a consulting firm for Russia's science cities (Naukograds) which include the nuclear institutes.<sup>46</sup> Describing the fate of many of these cities - "without means of subsistence, falling into decay, a state of crisis" - Nikitina reported that "Mass unemployment will begin in the next few months" and she warned that criminal activity will increase.<sup>47</sup>

Not all SE&Ts have suffered. For those who have become entrepreneurs or joined western companies for collaborative or contract work, the benefits accrue both to them and Russia: they will maintain their skills, work at the forefront of innovative enterprises, and be able to contribute the experience to the greater good of Russian science and its economy. It is the newly-disenfranchised and impoverished whose anger and downward spiral cause them to pose a greater threat than the distinguished theoretical physicists about whom so much has been written.

## The Mafia

The main suspect in nuclear smuggling has been the Russian mafia. Writing about post-Soviet organized crime, Stephen Handelman reported that the mafia has "undermined reform, spawned violence, and helped fuel an ultranationalist backlash".<sup>48</sup> In 1993, 100,000 gang members controlled 40 per cent of the turnover in goods and services and were deeply involved in banking, real estate, and trade

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<sup>43</sup> Telephone interview with Dr Roald Sagdeev, 7 August 1994.

<sup>44</sup> Report from the Analytical Center for Problems of Socio-Economic and Scientific Development, quoted in Helmstadter, *op. cit.*

<sup>45</sup> Vincent Schodolski, "Thousands of Russian Professionals Taking Menial Jobs to Survive", *Chicago Tribune*, 25 May 1992.

<sup>46</sup> Unpublished lecture, "Naukograds in Russia", delivered at the NATO Advanced Research Workshop, *Science Cities: A Comparative Exploration of the Structure and Function of Scientific-Technical Growth Centers*, 23-25 March 1995, Nice, France.

<sup>47</sup> *Op. cit.*

<sup>48</sup> S. Handelman, "The Russian Mafia", *Foreign Affairs*, March/April 1994.

of Red Army weapons. In addition, the mafia is tied to the government because the "nomenklatura capitalists" are able to use the mafia in a fierce struggle over the spoils of the FSU - industry, banks, defense facilities, and airports. Perestroika only strengthened criminal associations; and grey and black market money continues to penetrate much business activity. Handleman reports that at the present time smuggling profits form the foundation of mafia wealth. Mafia ties to the government have created a crisis of governance: military officials have been caught in smuggling rings, and the criminal syndicates have been eager (and reportedly successful) in turning their affluence into political influence.

The mafia has begun to expand its syndicate overseas, into Europe and the United States, thus further heightening tensions about the possibilities for the sale of illegally-obtained fissile materials. The FBI has opened a branch office in Moscow to collaborate more closely with Russian intelligence services, and the Russian authorities have stepped up their own efforts to curtail nuclear thefts.

## Responses to the Availability of Nuclear Material

The repercussions of the appearance of fissile materials were momentarily electrifying. *Time* magazine's August 1994 cover with the picture of an eerily irradiated skull, proclaimed: "Nuclear Terror for Sale: Once We Feared Thugs Like Carlos the Jackal. Now No One Knows Who Might Buy Smuggled Plutonium - and Hold The World Hostage".<sup>49</sup> The article stated that "The first symptoms of the nuclear plague are spreading into Europe".<sup>50</sup> Senior scientists at Los Alamos, although less incendiary, were no less concerned in expressing their agreement that the threat of nuclear terrorism has skyrocketed. One scientist stated matter-of-factly that the destruction of New York by terrorists was not inconceivable.<sup>51</sup>

The discourse on this issue has been emotionally charged, with Russian experts claiming that stories of nuclear materials "leaking" across Russian borders is an attempt by Western agencies to discredit Russian nuclear science and potential and to gain control over the former Soviet nuclear arsenal.<sup>52</sup> Although

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<sup>49</sup> *Time Magazine*, 29 August 1994.

<sup>50</sup> *Op. cit.*

<sup>51</sup> Dorothy S. Zinberg, interviews at Los Alamos, 18 August 1994.

<sup>52</sup> Andrey Ishchenko, "Atomic Energy Minister: West Trying to Discredit Russia", *Novaya Yezhnednaya Gazeta*, 16 June 1994.

Russian political leaders continue to deny that the material originated in Russia,<sup>53</sup> Germany's Dr. Wolfgang Stoll, a leading expert on plutonium, reported in carefully-weighted words that the "fingerprints" on the plutonium confiscated in Munich identified the material as originating in the FSU - Russia not excluded.

The likelihood that Russia is the source has increased as reports leaked from the Pentagon and elsewhere reenforcing Dr. Stoll's suspicions. The majority of serious rumors (most of the material is classified) continues to identify the material as having originated in non-military research institutes, and, more recently, from the fuel rods of a nuclear submarine in Murmansk. Russian authorities reported that they had apprehended Russian naval officers with stolen fissile material.

A chilling incident was reported by the Russian Ministry of Atomic Energy when a deputy director at a top-secret nuclear-fuel manufacturing plant in the closed city of Ozersk was found dead with a crushed skull. Formerly known as Chelyabinsk-65, the plant had been one of Russia's major nuclear weapons research and development installations and had come under suspicion when western specialists alleged that the material seized in Germany could have originated there.<sup>54</sup> The official's brutal death intensified the suspicions of mafia involvement and illegal nuclear trade activities, although as in most instances, no definitive proof was forthcoming.

## Related Problems

The persistent problems about proliferation and the role of FSU scientists remain as Libya, Algeria, North Korea, Iran, and Iraq attempt to become (or are, clandestine) nuclear weapons states, and nuclear powers such as China are eager to upgrade their weapons systems. As Richard Falkenrath reports, Russia boasts large supplies of both - more than one million SE&Ts and another million working in some capacity in civilian and military nuclear facilities. And the country possesses approximately 1,250 metric tons of highly enriched uranium (HEU) and 180 metric tons of weapons-grade plutonium.<sup>55</sup> Two-thirds of the

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<sup>53</sup> Interview with the Deputy Assistant Director of the Duma, Valentin Kovalyov, September 1994.

<sup>54</sup> "Russian Atom Plant Aid is Found Injured, Dies", Reuters Dispatch in *The Boston Globe*, 20 October 1994, p.10.

<sup>55</sup> Figures quoted from Cochran and Norris, *Russian/Soviet Nuclear Warhead Production*, pp.42, 108-109. Richard A. Falkenrath, "The United States, the Former Soviet Republics, and Nuclear Weapons: Problems and Policies of Denuclearization", *CSIA Discussion Paper 94-08*, Kennedy

material exists in nuclear warheads. The remaining third poses a more serious proliferation risk because the precise number of laboratories and storage facilities containing fissile materials is unknown. In a number of installations, neither security systems nor even rudimentary precautions are in place to prevent theft. In many institutes, theft could not be detected as there are no accounting systems.

## A Bright Spot: The Joint Efforts of Los Alamos and Arzamas 16

In 1946, at Stalin's behest, Arzamas-16 was founded as a closed city devoted to the development of nuclear weapons in order to eliminate the US monopoly over nuclear weapons.<sup>56</sup> Known variously as the Laboratory of Measuring Instruments or Moscow Center 300, or what Sakharov, its leading scientist and developer of the hydrogen bomb, called in his memoirs, "The Installation", Arzamas 16 was the Soviet counterpart to Los Alamos.

Within three years of its inception, Arzamas-16 scientists detonated the Soviet Union's first atomic bomb on the Semipalatinsk testing range. Like the other closed city responsible for the development of nuclear weapons, Chelyabinsk-70, Arzamas 16 has been in turmoil since the collapse of the USSR and the corresponding reductions in military spending. Its past status rudely destroyed, Arzamas 16 has had to redefine its mission, and like the nuclear weapons laboratories in the US, it has had to redirect its efforts to economically viable civilian projects.

Sergei Kapitza wrote that the "nuclear labs must redefine priorities and find new ways to employ the talent of scientists and engineers, many of whom are old".<sup>57</sup> As indicated by the report of the staged protest referred to above, the current state of the laboratory is far removed from its origins. For instance, despite the laboratory's being the centerpiece of nuclear research and development, the very success of Sakharov's hydrogen bomb radically changed his life and set him on a new path as an "international hero in search of peace and justice against thermonuclear terror and the totalitarian regime in his own country".<sup>58</sup>

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School of Government, Harvard University, September 1994.

<sup>56</sup> For a history of Arzamas 16 see Roald Sagdeev, *op. cit.* and David Holloway, *op. cit.*

<sup>57</sup> Sergei Kapitza, "Russian Science: Snubbed and Sickly", *The Bulletin of Atomic Scientists*, Vol. 50, No 3, May/June 1994, p.52.

<sup>58</sup> Roald Sagdeev, *op. cit.*, p.49.

It would be inconceivable to the heroes of the early Arzamas 16, although rewarding to Sakharov, who for decades railed against the evils of nuclear weapons, that their government would all but abandon them. In the rush to capitalism, the Russian government has drastically cut expenditures at Arzamas 16 and other similar installations, leaving behind thousands of SE&Ts. One small bright light, and one of many post-Cold War ironies, has been the collaborative effort that Los Alamos, itself reeling from budget cuts, and Arzamas 16 have for several years been engaged in constructing an inventory of and safeguards for fissile materials stored at Arzamas 16. Until recently there has been no certain method for detailing any thefts as the total supply of nuclear material was unknown.

Once fierce antagonists in the race to develop nuclear weapons of ever-greater destruction, they have forged a partnership with the overall goal of reducing nuclear proliferation.<sup>59</sup> This new partnership, still uncertain but growing stronger as the mutual benefits accrue, originated quietly in the early 1990s when the Russians began to send signals that they might be interested in a visit to Los Alamos. In 1992 the first delegation arrived, and by 1994 several American groups had visited Arzamas 16. Together they designed a number of projects to develop control systems for Russian nuclear materials that could be used to stabilize the Russian nuclear stockpile.

Analogous to Arzamas 16, Los Alamos was the star of a Soviet-phobic US federal government. During the Star Wars hysteria of the Reagan administration in 1985, its funding swelled to \$309 million. By 1994 it was cut by more than one third, and the number of personnel in the core nuclear programmes was cut by more than half.

The reasons for Los Alamos-Arzamas-16 collaboration are compelling. Those who have become well acquainted with the scientists (largely male) at Arzamas, report that they are patriotic (although some are Ukrainians), and devoted to their institute which for more than three decades had been at the "top of the feeding chain". They do not want to emigrate. But their wives tell a different story. Like tens of thousands of other Russians they worry about their children - will there be anaesthetics if they are sick? Even aspirins? In winter the children do not have enough to eat.

The future appears grim for these scientists and engineers. The youngest (under 35) and most talented scientists are the most likely to leave, further impoverishing the country. The laboratory has lost several thousand employees.

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<sup>59</sup> This section of the paper is based on an editorial written by the author, "War Plants Make Peace", *The Boston Globe*, 19 November 1994.

However, the scientists whose jobs have been saved are often not getting paid, not even the good ones. The American scientist responsible for the new collaboration remarked that "At one point the director (of Arzamas 16) floated a personal loan to cover the payroll". Although the government is beginning to realize it must protect this national asset, Arzamas scientists and their families are growing potatoes, tending their gardens, and trying to maintain a level of survival."<sup>60</sup>

The project to develop an accounting system for Russian nuclear material is expensive. So far the seed money has come from Los Alamos discretionary funds. With the election of a Republican Congress in the US intent on drastically cutting expenditures, even to defence laboratories, this funding is at risk.

If the project could grow, the payoff would be enormous. Gains would be made in stemming nuclear proliferation to terrorists and nuclear-weapons aspirants. Russian scientists would be able to remain in place working on safeguarding nuclear weapons, as well as the environment. The US would benefit from access to the highly-talented pool of scientists, some of whose laboratories have already begun joint ventures with US industries. Science, in general, would benefit from the basic research findings generated by both laboratories. Further more, the new collaboration could serve as a model for multilateral cooperation for all nuclear-weapons countries.

The project, funded with Los Alamos discretionary funds, is inadequate. Pessimists argue that it is too little, too late. However, the situation in absence of even these pilot-scale efforts would be worse. By providing a model, the project can encourage other countries to engage in similar activities and perhaps stimulate the Russian government to protect the well-being not only of its nuclear security but its experts with nuclear knowledge. The stakes for the rest of the world are enormous.

This is not an easy assignment. The costs for the necessary technology are high, and many Russians are suspicious of American motives and accuse them of trying to gain control of Russian nuclear knowledge. Yet the changes that have come about so rapidly after a half-century of nuclear buildup provide the opportunity to resurrect the goals of the "father of the bomb", J. Robert Oppenheimer, who like his counterpart at Arzamas 16, Andrei Sakharov, a decade later, once envisioned a world where all nuclear materials would be safeguarded by an international organization. These new "lab to lab" collaborations could be the first step toward realizing their utopian dream. Their labs are already being called Los Arzamas.

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<sup>60</sup> Interview with Los Alamos scientists, August 1994.

## Conversion from a Military to a Civilian Economy

The temptation to steal nuclear material would be reduced if secure employment were provided by successful conversion from a military to a civilian economy. Since the late 1980s, the industrial sector in Russia has been attempting to convert from its military base. Thirty per cent of Soviet GNP was geared to military purposes; 80 percent of industrial enterprises belonged to the military-industrial complex.<sup>61</sup> The estimated cost of conversion ranges between 150-300 billion US dollars, according to Russian and foreign consultants.<sup>62</sup>

Many scientists at these nuclear facilities were engaged in basic research financed by the state. There is no certainty that the activities of the closed cities can be converted to mass production of commercially viable goods such as the monitoring devices and environmental protection equipment that Arzamas is trying to develop, but they are making some progress.<sup>63</sup>

In the US a recent report from the blue-ribbon panel appointed by Secretary of Energy Hazel O'Leary to study the 10 major federal laboratories (including Los Alamos) recommended that the labs focus on research rather than increasing their ties to industry. Stating that the labs are not well suited for industrial research and development, the panel, chaired by Robert Galvin, chairman of Motorola, argued that the work "could put them in competition with the private sector (while) some on the panel worry that such an emphasis is more of a fad than a sustainable mission".<sup>64</sup> However, Siegfried Hecker, director of the Los Alamos National Laboratory and one of the architects of the Arzamas 16 collaboration, believes that if the federal laboratories lose touch with industry, they could run the risk of becoming obsolete.<sup>65</sup>

If Los Alamos, which has been involved with industry since the end of World War II, cannot convert to non-military work, there is little hope that Russian nuclear laboratories, which have been closed off from all but military-related industries, could readily convert to non-military activities. Furthermore, the

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<sup>61</sup> Sergei Kapitza, *op. cit.*, p.52.

<sup>62</sup> ITAR-Tass, 28 June 1994.

<sup>63</sup> Brenda Horrigan, "Arzamas-16: Opening onto a New World," Draft Research Paper, RFE/RL Research Institute, p.4, 1992.

<sup>64</sup> Andrew Lawler, "Report to Stress Research over Close Ties to Industry", *Science*, Vol. 267, 27 January 1995, p.446.

<sup>65</sup> *Op. cit.*

conversion is likely to be hindered by the continuing need for some unknown level of military production at Arzamas 16.

Even the style of work is not compatible for the conversion to industry. According to Sergei Kapitza, scientists at the nuclear laboratories worked in a compartmentalized fashion, with each research team having minimal contact with others at the facility. In contrast, industrial research requires rapid exchange of information and flexible work teams that can move with new ideas and plans. During the Soviet regime, cities like Arzamas 16 were cut off from regular communication with the outside world. External telephone lines have been installed only since the early 1990s, but communication has been further impeded by the vastness of the laboratories.<sup>66</sup>

Isolation from the Soviet and post-Soviet politics has left the nuclear facilities stranded in the tug-of-war for funding. These circumstances create material hardship, in pay and equipment as well as in terms of psychological well being, and could induce individuals or teams of scientists to be more receptive to offers from "undesirable" Third World nations, despite their feelings of patriotism or concerns for international security.

Although the nuclear scientists formed a Union of the Developers of Nuclear Warheads, they have not been able to get better representation in the government.<sup>67</sup> The Union's efforts to date have so far failed to secure additional funding and better work conditions. In a 24 June 1994 letter addressed to President Boris Yeltsin, the employees of the Russian Federal Nuclear Center in Chelyabinsk cited the psychologically damaging and morally degrading conditions in which the scientists, engineers, and technicians of Chelyabinsk work to no avail.

More than 7,000 people in the closed research cities signed a letter which stated: "Nuclear weapons are the best means of deterrence and are necessary instruments for the might and independence of the Motherland. This letter clearly indicates their desire for a resurrection of previous work conditions, status, if not the resumption of the Cold War."<sup>68</sup> It also reveals their vulnerability to illicit, remunerative activities.

## Update

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<sup>66</sup> Horrigan, *op. cit.*, p.3.

<sup>67</sup> Horrigan, *op. cit.*, p.7.

<sup>68</sup> *Novaya Yezhednevnyaya Gazeta*, 24 June 1994.



Soon after the *Time* article "Nuclear Terror for Sale" appeared, the topic seemed to disappear from the public eye. Had all the culprits been apprehended? Had the threat receded? Had the Russians and other producers of plutonium in the former Soviet Union, the assumed source of the illicit materials, managed to batten the hatches at their nuclear installations? Or had the media simply turned its attention to other real or potential catastrophes?

Experts at the February meetings of the American Association for the Advancement of Science in Atlanta answered the questions with discouraging words. They agreed that nuclear smuggling had not stopped. Rather, it is on the rise. Anthony Fainberg, a senior analyst with the US Congressional Office of Technology Assessment, reported that the nuclear material appearing since the wave of panic six months ago is even more dangerous. Much of the earlier supply was not weapons-grade material, although it could be used by blackmailers and terrorists. Recent blackmarket nuclear samples, Fainberg said, consisted of greater amounts of plutonium and highly enriched uranium - the *sine qua non* of nuclear weapons - and are more readily available.

Other panellists lengthened the list of potential threats. Nuclear weapons could be seized in the former Soviet Union, particularly Russia, by renegade military units. Civilian nuclear installations could be sabotaged because the security is minimal at most of them. Nuclear facilities could be targeted with conventional arms as the Chechens have threatened to do. And with so much weapons-grade material being transported to presumably safer storage sites, the likelihood of accidents or threats occurring during transit has mounted.

On a more optimistic note, William C. Potter, Director of the *Program for Nonproliferation* at the Monterey Institute of International Studies, outlined the accomplishments of Project Sapphire, in which 1,100 pounds of highly-enriched uranium were secretly airlifted from Kazakhstan to Oak Ridge, Tennessee for safe storage.

To give some idea of what this cache represents, the requirement for one nuclear weapon is approximately 25 pounds or 10kg of enriched uranium or 9 pounds (4.5kg) of plutonium - 239. Not surprisingly, Iran, one of the countries most aggressively pursuing a nuclear capability, had taken note of this motherlode of highly-enriched uranium, and at the time of the transfer was actively attempting to procure some of it. Even though this particular cache was safely disposed of, like the material appearing on the black market, it is but a hint of what lies stored in the irradiated Pandora's Box.

Speaking at a Harvard colloquium, John Holdren, a physicist at the University of California (Berkeley) stated that the planned dismantlement of

existing nuclear weapons in the US and Russia would produce a 50,000kg of surplus plutonium in both countries. What the US and Russians do with this surplus, he added, will determine the likelihood of whether the plutonium could be used by other countries to manufacture nuclear weapons. If the plutonium were not securely disposed of, the rest of the world would not believe that these two superpowers were serious about permanent nuclear disarmament. The perception that they are serious, he noted, will be crucial in order to convince other countries that they should not "go nuclear".

### **Promising Initiatives: The International Science and Technology Committee (ISTC) and the International Science Foundation (ISF)**

Despite the current peril, a number of ameliorating possibilities exist. Slow to get off the ground, the Nunn-Lugar initiative has finally taken off. Three years ago, the US Congress passed the Nunn-Lugar legislation to aid in denuclearizing much of the weapons stockpile in the former Soviet Union. In addition, the International Science and Technology Center, created to provide peace-time employment for nuclear scientists, was finally established in Moscow. Legislation for it was stalled in the Russian Duma by a paranoid faction that perceived the initiative as an attempt to weaken Russia by stealing its secrets. Only when Yeltsin shut down the Parliament by fiat in October 1993, was the agreement implemented. It is funded, in part, by the Nunn-Lugar appropriations.

Its accomplishments to-date are relatively small compared to the extent of the problems, but they are laying a solid base from which to grow. About \$800 million of the authorized \$1.3 billion will have been spent by the end of 1995 on several projects - on the dismantlement of strategic nuclear weapons and construction of storage sites for the plutonium that is being released from the dismantlement of the weapons. Even contracts for building prefabricated housing for workers at the sites are included in the funding. Many of the efforts are collaborations between governments and federal laboratories, while others provide contracts for American private companies. On a smaller scale, other Western countries and Japan are entering into similar arrangements with the former Soviet Union.

The accomplishments of the Nunn-Lugar funds and other proliferation-related projects were alluded to on the AAAS panel by Zhu Mingquan, a scientist from Fudan University, the M.I.T. of China. Noting that four years ago he could not even have mentioned the subject, he persuasively argued that because the US

and the international community had tried to help resolve these difficult problems, world attention was focused on the dangers of proliferation and the need for speedy action. Less persuasively, he argued that perhaps because of this focus, the dangers of proliferation had been overstated. There was little agreement on the last statement as several Russian emigre-scientists in the audience rose to enumerate escalating problems of an increasingly unstable government, the potential for civilian unrest, rising unemployment, and the emigration of the very scientists whose knowledge was needed for the successful dismantlement and storage of nuclear weapons material.

Russians themselves have admitted that nuclear materials have been stolen, most recently by a group of officers from a nuclear submarine in Murmansk. At the time of this writing they are on trial, but as Bukharin and Potter report, this is hardly cause for relief.<sup>69</sup> Some Russian submarine fuel is highly-enriched uranium that could be converted for use in nuclear weapons. The safeguards system that allowed naval officers to crawl through a gap in the wall, remains primitive at best. As there are no reliable accounting systems for fissile material in Russia, just how much is missing will continue to be an unsolvable mystery. A recent Western European intelligence report concluded that whereas in 1993 there were reports of 56 attempts to smuggle nuclear material from the former Soviet Union, in 1994, the number rose to 124.

The recently-elected Republican Congress, determined to reduce spending, particularly for American foreign policy, is attempting to cut back on appropriations to work with Russia in this matter. For most other bureaucracies with age-old records of bloated budgets and staff, these efforts are laudable. But cutting out or drastically reducing the current Nunn-Lugar annual appropriations by \$400 million per year would deal a serious blow to national and international security.

In addition to strengthening the ISTC, the International Science Foundation established in 1992 by an initial \$100 million contribution from Hungarian-born international financier George Soros, has provided fellowships for basic scientists (not weapons developers) since 1992. By May 1994, the foundation had received more than 9,000 requests for its first round of long-term grants, each of which was reviewed by four or five scientists to assure a fair reading. In all there were 50,000 review reports. According to a report in *Science*, a total of 2,611 grants was awarded, with an average value of \$15,000 over a period of 18 months.<sup>70</sup> In less

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<sup>69</sup> Oleg Bukharin and William Potter, "Potatoes Were Better Guarded", *The Bulletin of the Atomic Scientists*, May/June 1995, pp.46-50.

<sup>70</sup> "Russian Science Seen from the West", *Science*, Vol. 264, 27 May 1994, p.1260.

than two years time, the NSF will have dispersed \$125 million to approximately 50,000 scientists in the FSU.<sup>71</sup> Sadly, a recent report from the General Accounting Office (GAO) of Congress claimed, "We found that scientists receiving center funds may continue to be employed by institutions engaged in weapons work".<sup>72</sup> With growing Congressional concerns that the Russians are intent on building new nuclear weapons, this report could further jeopardize future Nunn-Lugar appropriations.

Although the grants are not made to the former nuclear institutes, shoring up the scientific community in general makes it possible for nuclear scientists to apply for research awards through universities and to keep the badly-frayed fabric of the scientific enterprise from deteriorating even further.

The dramatic one-time covers of *Time* and other crisis-prone journals and, particularly, TV, do not help sustain awareness of lurking catastrophes. Accordingly, new threats to the safe disposal of nuclear weapons could become real without interference from an informed, insistent public. Worst of all, the experts pointed out, the cost of greatly reducing the numbers of nuclear weapons is not nearly as great as the cost of dismantling chemical weapons, which has not yet begun in earnest.

## Conclusions

At the present time, rumors fly about the attempted purchase of nuclear "brains" by Third World nations eager to acquire nuclear technologies. With few exceptions they have not been substantiated although efforts to document them are met by either denial or the cover of "classified".

The rapid succession of reported findings of radioactive material in Germany, the Czech Republic, and Hungary has heightened speculation about whether scientists, engineers, or other technical personnel, singly or in collusion with mafia members, might have provided access to the material. There does not, however, appear to be any unclassified hard data to demonstrate that a particular scientist or engineer has been responsible for the appearance of nuclear materials either

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<sup>71</sup> Carl Levitin, "Soros Foundation is Defended against Charges of Spying", *Nature*, 26 January 1995, p.274.

<sup>72</sup> Bill Gertz, "Russia Uses Pentagon Funds in Constructing New Nukes", *The Washington Times*, 23 May 1995, p.3.

within the former Soviet Union or in Germany, Hungary, or the Czech Federation, the countries where fissile materials have been interdicted.

Continuing crises in Russia, in particular, heighten concerns about the likelihood that SE&Ts will be actively, passively, or inadvertently involved in nuclear proliferation. The economic, social, and political climates have worsened for many SE&Ts. Many trained in weapons technology, and consequently of limited interest to a government determined to convert from a military to a civilian economy, have lost their jobs and also their position in society. Once admired as heroes of the Soviet Union, they have become victims of their society's turn against science. Psychological demoralization combined with the financial deprivations and anxiety about the future enormously increase the likelihood that a certain percentage of un- or underemployed SE&Ts will succumb to the temptations offered by would-be nuclear nations.

The likelihood that terrorists will acquire nuclear material either for use or as threat has become more real as the supplies of fissile material appear in black markets in Europe. A US scientist who investigated the plutonium discovered in Germany said: "This discovery is extraordinarily significant. It represents a change from hypothetical to proof".<sup>73</sup>

The means by which nuclear knowledge is proliferated throughout the world have grown exponentially since the FSU borders became permeable in 1989. With few exceptions, SE&Ts are able to move more freely around the world. The new mobility also poses a conundrum for the already-thorny issue of the international education of foreign students. Russia is educating Iranian students on the theory and engineering of light water reactors. The United States, long committed to openness in access for foreign students, does not prohibit (usually) Chinese students from studying nuclear physics. A US State Department official, when asked about the involvement of FSU scientists in nuclear proliferation, said flatly, "Real proliferation takes place by educating the Chinese here". The stage is set for increased controversy about a tradition that has benefited the host countries and universities, science and engineering worldwide, as well as the students themselves.

There are strong cultural factors working against the sale of nuclear knowledge - integrity, national pride, and the fear of consequences for international security. But these constraints do not apply to the mafia who have made substantial inroads into the theft and/or sale of technology that can be used for the buildup of military armaments. As yet it is not known whether the cultural

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<sup>73</sup> Jimmy Burns, "Plutonium Find Adds to Nuclear Smuggling Fears", *Financial Times*, 23-24 July 1994, p.3.

constraints have been bridged because of unbearable hardship imposed on so many once-patriotic citizens.

## Recommendations

- \* Encourage international efforts to improve the long-term financial and social welfare of FSU SE&Ts. Only by assuring SE&Ts that they and their families can depend on financial support can they be expected to resist the attempts by would-be nuclear thieves (as well as those interested in procuring missile designs).
- \* Help FSU governments to develop ways in which to restore status and psychological well-being of their once-valued SE&Ts. Now badly demoralized, many pose a threat to the security of their own countries.
- \* Focus on the importance of prevention, not detection, and internationalize all efforts. What is happening in Russia or the FSU today could also happen elsewhere in the world.
- \* In the US, begin a sustained round of talks with key members of Congress to stress the importance of the Nunn-Lugar initiative. Stress the potential threat of the dissemination of nuclear knowledge or material. Also demonstrate the gains that can be obtained by the US and by other nations from cooperative activities with Russian SE&Ts. Develop models for collaboration such as those begun by Los Alamos.
- \* Both national and international legislation are needed for the prevention and interdiction of nuclear materials. As Williams suggests, the IAEA should start a database on nuclear smuggling, but, in addition, national authorities have to share information.<sup>74</sup>
- \* Start an international committee to secure funds for R&D that will help develop adequate accounting systems and secure nuclear stockpiles, an activity that is in the best interests of the international community.
- \* Without impinging on individual liberties, the FSU should monitor the travel of SE&Ts who possess not only nuclear knowledge but also knowledge of advanced weaponry design and development.

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<sup>74</sup> Philip Williams, *op. cit.*

- \* Provide methods for fingerprinting all nuclear material. Set up an international registry, a library of fissile materials, so that leaks can be identified through nuclear "fingerprints".<sup>75</sup>
- \* Stop the production of weapons-grade fissile material.
- \* Strengthen existing programmes on inventories, safeguards and denuclearization.
- \* Support programs that are working to provide alternative civilian employment for SE&Ts who have specialized in nuclear-related fields.
- \* Tighten nuclear security controls internationally, so that Russia is not singled out as the only weak link.
- \* In the absence of hard data, use international consciousness raising to illustrate the potential destructiveness of nuclear proliferation and the moral responsibility of SE&Ts worldwide to diminish the likelihood of illegal activity. It is ironic that the world might be more endangered in the post-Cold War era than previously. Continuous vigilance on the part of the public and the scientific community is essential.

When Sagdeev wrote of plasma's "incurable instabilities", he implied that gaining understanding of the instabilities would point the way to "controllable chaos". The subtle but crucial difference serves us well as a metaphor for what lies ahead.

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<sup>75</sup> Suggested by Jim Walsh in "Combatting Nuclear Smuggling", *The Boston Globe*, 25 August 1994, p.15.

\* I would like to thank the Swedish Ministry of Defense and Sverre Lodgaard, the director of UNIDIR in Geneva, who provided funding for the workshop and research for the paper. I would also like to thank Drs. Siegfried S. Hecker, John Shaner, and Terry Hawkins for their assistance during my visit to Los Alamos, August 1994. Scott Evans, a graduate student at Harvard's Russian Reserach Center, was very helpful in tracking down the many references in the paper. Richard Falkenrath and Owen Cote, postdoctoral Fellows at Harvard's Center for Science and International Affairs, provided insightful advice.



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