STEWARDS AND CUSTODIANS: TOMORROW'S CRISIS FOR THE RUSSIAN NUCLEAR WEAPONS COMPLEX?

by Oleg Bukharin

Oleg Bukharin is a Research Staff Member at Princeton University's Center for Energy and Environmental Studies.

For years to come, the Russian nuclear weapons production complex will remain responsible for missions that are central to international security and nonproliferation, including:

- dismantlement of retired nuclear weapons;
- support to Russia's operational nuclear warhead stockpile to assure its safety, security, and reliability;
- safe and secure storage, management, and disposition of hundreds of tons of fissile materials; and
- support to Russian and international arms control and nonproliferation efforts.

These missions cannot be accomplished without a cadre of qualified workers, scientists, engineers, and managers with skills and knowledge in the following two overlapping but distinct areas: (a) nuclear weapons and fissile material management, and (b) nuclear material protection, control, and accounting (MPC&A). This report focuses on human resource issues in the weapons complex that may affect its ability to achieve the above missions.

At present, the Russian nuclear weapons complex is oversized and large personnel cuts are needed to bring it in line with reduced defense requirements and limited budgets. In the longer term, however, the complex could be facing a different human resources challenge: retirements, a continuing outflow of young specialists, and an absence of new high-quality hires could disrupt the continuity of Russia's nuclear weapons competence, undermine stability of the complex, and, eventually, jeopardize its core missions.

The nonproliferation implications could be serious. Instability in the complex would heighten the danger of proliferation of nuclear materials, expertise, and technologies. The safety and security of nuclear weapons could suffer. Efforts to dismantle obsolete warheads and dispose of resulting fissile materials could be stalled. Decreased confidence in stockpile reliability would increase pressure in Russia to resume full-scale nuclear testing and, thus, undermine the Comprehensive Test Ban Treaty (CTBT) regime. And a shortage of qualified technical experts could complicate negotiation and implementation of warhead transparency and other arms control measures.

A personnel crisis in the Russian nuclear complex would also affect US cooperative nuclear security efforts in Russia. It is therefore essential for the US government to assess the potential implications of these demographic shifts for US national security, to formulate appropriate policies, and to direct the national laboratories, the Department of Energy (DOE), and other governmental agencies to address the problem through US-Russian cooperative programs.

This report will describe current approaches in the United States and in Russia to managing human resources in their post-Cold War weapons complexes. It will then address the potential dangers stemming from an aging pool of Russian weapons and scientists, and discuss some of the measures Russia is currently taking to minimize the problem. Finally, it will emphasize the significance of this issue to US nonproliferation and arms control efforts, and suggest some ways that the United States could help.

HUMAN RESOURCES MANAGEMENT IN THE US WEAPONS COMPLEX

Before discussing human resources issues in the Russian nuclear weapons complex, it is useful to overview briefly the situation in the United States. The Department of Energy's weapons production complex is currently guided by the Stockpile Stewardship and Management Program. A process of reconfiguring and downsizing the DOE complex began in the late 1980s. Since then, three warhead component manufacturing plants and two plutonium and tritium production facilities have been shut down, and all stockpile management functions have been consolidated at eight facilities.[1] The defense program workforce has declined from its mid-1980s level of 55,000 (not including workers in the plutonium production complex) to approximately 25,000.[2] This level of staffing is expected to remain largely unchanged for the foreseeable future.

The situation in the Sandia National Laboratories (SNL) is indicative of the human resources challenges faced by the DOE weapons complex:

> Demographic analyses since 1990 show that a generation of the most experienced engineers have left Sandia or are leaving, the current generation has less experience and practice [because no full-scale weapon systems development has occurred for ten years], and the next generation has not been hired. It also shows that fewer recent college graduates are being hired, and our attrition rates have increased from the past.[3]

The DOE defense program must compete for scientific and engineering talent with private industries (particularly in the fields of computer applications and material sciences). Hiring and retaining capable personnel could become even more difficult as stricter security and counterintelligence measures are implemented at the nuclear weapons facilities in the wake of the 1998-1999 allegations about Chinese espionage activities in the national weapons laboratories.

To address the human resources problem, the national weapons laboratories and DOE have initiated a coordinated effort to attract and train capable scientists and workers, and to consolidate and manage the complex's accumulated nuclear weapons knowledge and experience.[4]

One of the basic premises of this effort is that the future stockpile stewardship objectives cannot be met without qualified experts in every scientific and technical specialty in the area of nuclear weapons technologies. To provide a basis for decisions about recruiting and training, the national laboratories and DOE have developed a tentative list of these functional areas.[5] The list includes such narrow areas of expertise as nuclear warhead arming and safing, cables and connectors, detonators, explosives, firing sets, fuses, gas systems, n-generators, nuclear systems, permissive action link (PAL) devices, parachute systems, radiation hardening, and others.

It is hoped that the Stockpile Stewardship program will attract new scientific and engineering talent by providing challenging work assignments, promising career development paths, and state-of-the-art experimental and computing infrastructure. As in the past, new specialists would be trained on the job. In addition, however, they would receive a considerably more extensive formal instruction, which would include a range of basic, intermediate, and advanced courses on various aspects of nuclear weapons technologies and operations.

In particular, DOE and laboratory exports have in part justified the Science-Based Stockpile Stewardship (SBSS) Program, the most controversial part of the US stockpile stewardship effort, because of its importance in attracting capable scientists and maintaining the intellectual vitality, scientific excellence, and warhead design expertise in the US nuclear weapons laboratories. (The other two components of the stewardship program relate to stockpile surveillance and management, and new tritium production.) However, the SBSS program has been criticized as unnecessary, excessively expensive, and economically and politically motivated. In particular, according to the program's opponents, the policy of maintaining the warhead design capability is misguided and dangerous from the arms control and nonproliferation standpoint.[6]

Russia lacks resources to afford anything even remotely resembling the US stewardship program. However, it might not need such a program. While the US stockpile stewardship plan emphasizes science-based surveillance and evaluation of warheads to detect potential defects due to aging, "the Russians ensured stockpile reliability through conservative warhead designs that included lavish use of fissile material and high-explosives and by re-manufacturing nuclear weapons before age-related problems appeared."[7] If so, the Russian stewardship program depends more on good engineers and qualified workers then on brilliant scientists and warhead designers. As in the United States, however, the Russian nuclear complex would not be able to fulfill its core missions without competent specialists in every narrow specialty in the area of nuclear weapons and fissile materials.

To maintain its core competencies, the Russian nuclear complex needs a system of training, a program to systematize and transfer weapons knowledge and past experiences, and an ability to offer salaries and benefits that are competitive with those offered by local commercial enterprises.

THE RUSSIAN NUCLEAR WEAPONS COMPLEX

The Russian weapons production complex is managed by the Ministry of Atomic Energy (Minatom) and consists of 17 facilities, many of which are duplicative. Its core capabilities are located in ten closed nuclear cities (see Table 1). (A number of research and production

Table 1: Russia's Closed Nuclear Cities

TRADITIONAL NAME	NEW NAME	NUCLEAR WEAPONS ACTIVITIES
Arzamas-16	Sarov	• nuclear weapons R&D • serial production of nuclear weapons
Chelyabinsk-70	Snezhinsk	• nuclear weapons R&D
Sverdlovsk-45	Lesnoy	• serial production of nuclear weapons
Penza-19	Zarechny	• serial production of nuclear weapons
Zlatoust-36	Trekhgorny	• serial production of nuclear weapons
Chelyabinsk-65	Ozersk	• plutonium production • production of HEU, plutonium, and tritium components of nuclear warheads
Tomsk-7	Seversk	• plutonium production • HEU production • production of HEU and plutonium components of nuclear warheads
Krasnoyarsk-26	Zheleznogorsk	• plutonium production
Krasnoyarsk-45	Zelenogorsk	• HEU production
Sverdlovsk-44	Novouralsk	• HEU production

facilities, which are involved mainly in the design and fabrication of non-nuclear components of nuclear warheads and support equipment, are located in open cities, including Moscow.) These cities were established in the 1940s to 1960s to produce and process highly enriched uranium (HEU) and plutonium for the defense program, and to design and mass-produce nuclear weapons. Some fissile material production cities are no longer involved in the defense program. They remain, however, central to the mission of storing and disposing of large quantities of HEU and plutonium. Approximately 130,000 people currently work at the nuclear facilities in the closed cities. Of them, approximately 75,000 are part of the defense program.[8] The rest are involved in support activities, nuclear material management, environmental cleanup, and a variety of nuclear and non-nuclear commercial projects.

The Russian nuclear weapons program has been cut substantially since the end of the Cold War. The production of HEU and plutonium for weapons ceased in 1988 and 1994, respectively.[9] The level of weapons research and development (R&D) has declined sharply due to funding shortages, deterioration of the experimental infrastructure, and CTBT-imposed constraints on nuclear testing. As of 1998, the production of new and replacement warheads had decreased by a factor of 10-12 from its past levels.[10] It should be noted, however, that in some cases, state defense orders are well below technical and operational requirements because of minimal budget allocations.

In summer 1998, the government adopted the Program of Consolidation of the Nuclear Weapons Complex, which calls for a reduction of the defense program workforce in the closed cities to 40,000 by 2005.[11] For example, the warhead design centers in Arzamas-16 (the Institute of Experimental Physics, VNIIEF) and Chelyabinsk-70 (the Institute of Technical Physics, VNIITF), which in 1998 employed 18,000-20,000 and 11,000 people, respectively, are expected to cut approximately 8,000 and 5,000 workers. The serial warhead production facilities in Arzamas-16 and Penza-19 and one of the two fissile material component manufacturing facilities (in Chelyabinsk-65 and Tomsk-7), employing thousands of workers each, are to phase out nuclear weapons-related activities by 2003. Employment at the warhead component manufacturing and assembly facilities is to decrease from more than 40,000 at present to approximately 15,000 over the next few years.[12]

These reductions are likely to be only the first step in the downsizing of the complex, and even deeper personnel reductions could occur in the future. For example, some Minatom experts have reportedly discussed the possibility of consolidating major warhead assembly and disassembly operations at a single facility. Some serial production functions will be transferred to the pilot production facilities associated with the warhead R&D centers in Chelyabinsk-70 and Arzamas-16.[13] (This consolidation process is likely to increase the relative significance of the warhead design centers, especially Arzamas-16, in the Russian nuclear weapons program.) Top Minatom managers have also indicated on numerous occasions that no duplication of functions and efforts will occur in the future.

The weapons complex has sufficient manpower (if not resources) to fulfill its core missions at present. In fact, it is facing a difficult problem of redirecting excess workers to non-military activities.

Minatom's internal key position analysis has also found the current situation satisfactory. For the purpose of this analysis, Minatom's specialists identified over 100 key positions and areas of expertise (including those of "critical knowledge carriers") that must be maintained for the complex to fulfill its tasks.[14] These areas, which are much broader than those on the US DOE list, include production and processing of fissile materials, warhead R&D and weapon engineering, special purpose electronic and automatic systems, computational physics, material science, mining and chemical processing, and power generating systems. Tens of civilian and defense nuclear facilities were then surveyed. Minatom's analysis indicated that the staffing levels for key positions and primary specialties were over 90 percent. It was determined that the average age was 52-56 for facility managers, 45-50 for project leaders, and 40-45 for technical experts. It is, however, possible that the demographic situation in the weapons complex is worse than in the civilian nuclear energy complex, and that the average age indicators derived from the survey do not reflect the true situation in the weapons complex.

THE DEMOGRAPHIC PROBLEM

Current personnel redundancy and the large pool of scientists and workers being made excess by defense program reductions might not be sufficient to insulate the Russian weapons complex from human resources problems in the longer term. The demographic situation in the Russian nuclear weapons complex is deteriorating.

Those workers who joined the complex during the program boom years of the 1960s and 1970s are reaching retirement age (55 for women and 60 for men in Russia). However, because of the meager and irregular pensions currently paid by the local governments, most continue working past retirement.[15] Retirement-age workers, for example, account for approximately 20 percent of VNIIEF's workforce in Arzamas-16.[16] It is hoped that the newly signed Federal Law "On the Development, Management, Elimination, and Assurance of Safety and Security of Nuclear Weapons" will empower the federal government and nuclear facilities to provide supplemental payments to nuclear veterans. According to VNIIEF's Director R. Ilkayev, providing each retiree with $500 annually could solve the problem.[17] The budget crisis, however, makes implementation of this measure difficult.

Another serious problem, according to weapons institute directors, is that "there is a massive outflow of highly qualified specialists whereas the flow of young personnel to nuclear weapons facilities has virtually ceased."[18] Younger specialists, those who began their careers in the late 1970s and 1980s, are leaving the complex for commercial jobs (presumably in the local service, banking, and manufacturing sectors). For example, the Avangard warhead production facility in Arzamas-16 has lost approximately 30 percent of its workforce during the past several years.[19] Some basic reasons include the lack of prospects and decreased prestige of the nuclear weapons profession, relatively low salaries, deterioration of the research and production infrastructure, and a decreased level of social services including housing shortages and deteriorating health care benefits.

There has been very little hiring of new workers since the late 1980s. In part, this de facto hiring freeze is due to the lack of applicants. Another contributing factor is that nuclear facilities, which are under pressure to cut personnel levels, have cut back on new hiring to avoid the traumatic process of displacing retirement-age veterans. The problem was summed up at a recent meeting of the Association of the Unions of the Nuclear Weapons Complex:

> The [personnel] situation is aggravated by a large number of pensioners working in the weapons complex. Taking away from them jobs and salaries, especially in the closed cities, would be a crime and could lead to unforeseen social consequences. Naturally, under these circumstances, hiring new specialists is problematic. Eventually, this could result in a serious problem for the nuclear weapons complex.[20]

These demographic trends at weapons facilities could affect the capabilities of the complex in several interrelated ways:

- The flight of younger specialists, the retirement of senior experts, and reductions in defense orders and operations erode the existing small expert teams that have been formed over many years to address critical technical problems. The integrity of these teams has been essential for both on-the-job training of new specialists and executing technical tasks.
- The lack of new hiring has likely already resulted in a generation gap in the Russian weapons complex. As senior experts retire in the next five to ten years, a good measure of the competence and experience of the complex could be lost.
- Eventually, the Russian complex might find itself in a situation where certain functional areas are completely depopulated. The complex, as a result, might fail to accomplish its core missions.

For example, assuming that the 1994 data in Table 2 are correct and that there is no new hiring, less than half of today's personnel will be left in the Institute of Technical Physics in Chelyabinsk-70 by 2005, virtually all of them between 40 and 60 years old.[21] In another ten years, the institute will practically cease to exist. In fact, Chelyabinsk-70 is already experiencing a shortage of computational and theoretical research specialists.[22] Also, according to Chelyabinsk-70's local newspaper:

> VNIITF is experiencing significant difficulties because of the outflow of personnel, in particular, of qualified workers. Massive resignations could render the institute incapable of fulfilling state defense orders. This would be a downfall of the facility: in the environment of minimal financing, its customers de-

> mand practical results, not paper studies about the future. The VNIITF management is also troubled by the lack of new hiring. This personnel situation could in the future lead to a self-destruction of the institute.[23]

Concern regarding personnel trends was also recently articulated by the deputy secretary of Russia's Security Council, A. Moskovskikh:

> [T]he decreased status of the [nuclear weapons] profession, relatively low and delayed salaries, reductions in defense orders and personnel cuts lead to a real threat of Russia's losing its human potential. There is also a threat to international security as nuclear experts could 'leak' from Russia to politically unstable countries."[24]

Nuclear Experts from Non-Russian Republics

Minatom is conducting a recruitment campaign to encourage nuclear specialists to return to Russia from Lithuania, Latvia, Kazakhstan, and other former Soviet republics. Few, if any, of these specialists, however, have skills and knowledge in nuclear weapons science and technologies. Indeed, so far, most of them have joined civilian research centers, such as the Institute of Physics and Power Engineering in Obninsk and the Institute of Atomic Reactors in Dimitrovgrad.

ISTC and IPP Funding

Minatom has been an active participant in activities of the International Science and Technology Center (ISTC) and the DOE-sponsored Initiative for Proliferation Prevention (IPP). These programs have had an important nonproliferation impact, as they help to stabilize and support researchers in the nuclear complex. Approximately 7,000 leading research experts complex-wide were involved in ISTC projects in 1998. These programs, however, focus mainly on senior scientists, not on younger specialists. They also do not target engineers and workers at manufacturing facilities.

Table 2: Age Distribution at the Warhead R&D Centers in Arzamas-16 and Chelyabinsk-70

	AGE OF RESEARCHERS	1985	1990	1994
	(years)	(percent)	(percent)	(percent)
Institute of Technical Physics (VNIITF)/ Chelyabinsk-70	Under 30	3.6	2.6	1.3
	30 to 50	67.1	50.9	44.0
	Over 50	29.3	46.5	54.7
Institute of Experimental Physics (VNIIEF)/ Arzamas-16	Under 30	10.4	5.2	0.8
	30 to 50	69.5	67.1	64.7
	Over 50	20.1	27.7	34.5

Based on data in Ksenis Gonchar, Research and Development (R&D) in Conversion in Russia, *BICC Report No. 10 (Bonn: Bonn International Center for Conversion, May 1997), p. 86.*

ADDRESSING THE PROBLEM: MINATOM'S INTERNAL POLICIES

Minatom managers recognize that while the nuclear complex is currently facing the problems of low productivity and large numbers of excess workers, there is an erosion of the human resource base due to personnel aging, decline in personnel quality, and losses of "carriers of critical knowledge" (depopulation of certain technical areas). Steps have been taken to counter these negative developments. The effectiveness of these measures, however, is uncertain.

College Education

The Minatom complex operates a network of educational and training institutions, which includes seven colleges, 18 technical schools, and six qualification-enhancement centers. The system continues to produce nuclear specialists at a rate of approximately 2,000 per year. To attract the best students, Minatom has established special fellowships.[25] The quality of education, however, has been adversely affected by funding shortfalls: only 25 percent of the amount requested by Minatom's colleges and technical schools was provided in 1992-97.

More importantly, there has been a fundamental shift in how new specialists are recruited. In the past, although much of the new workforce was drawn from the closed cities themselves—branches of the Moscow Engineering and Physics Institute (MEPhI) were established in seven closed cities (see Table 3)[26] —the primary objective of these institutions was to train engineers, not scientists. To bring in fresh scientific talent, essential for advancing nuclear weapons science and technologies, nuclear facilities annually submitted a list of specialties to the Ministry of Education. Requested positions were then filled with the best graduates from top technical universities in Moscow (Moscow Engineering and Physics Institute, Moscow Institute of Physics and Technology, Moscow State University, etc.), St. Petersburg (Leningrad State University), and regional centers. Young specialists were "distributed" to nuclear weapons facilities with an obligation to work there for at least several years.

By the early 1990s, this centralized planning system had collapsed and the stream of young specialists dried up. To compensate, the weapons complex has begun to rely on the local populations for recruits, and on its own schools for training. For example, in 1991, the college in Arzamas-16 established a special department, which currently consists of six divisions: applied mathematics, experimental physics, radio-physics and electronics, theoretical and experimental mechanics, theoretical physics, and general engineering.[27] Courses are taught by senior scientists from the Institute of Experimental Physics. Starting in the third year, students have access to VNIIEF's experimental facilities, computers, and technical libraries. The department produced its first graduates in 1995-96. (Approximately 180 young specialists joined VNIIEF in 1998, a dramatic improvement over the previous years.[28]) The colleges in Chelyabinsk-70 and Zlatoust-36 have established similar departments.

It is not clear, however, if the closed cities will be able to supply sufficient numbers of quality workers. There is a nationwide de-emphasis on technical educa-

Table 3: Educational Institutions in the Closed Nuclear Cities

CLOSED NUCLEAR CITY	EDUCATIONAL INSTITUTION
Sverdlovsk-44 (Novouralsk)	Novouralsk Polytechnical Institute of the Moscow Institute of Physics and Engineering (MEPhI)
Chelyabinsk-65 (Ozersk)	Ozersk Technological Institute of MEPhI
Sverdlovsk-45 (Lesnoy)	Polytechnical Institute of MEPhI
Arzamas-16 (Sarov)	Sarov Institute of Physics and Technology of MEPhI
Tomsk-7 (Seversk)	Seversk Technological Institute of the Tomsk Polytechnical University
Chelyabinsk-70 (Snezhinsk)	Snezhinsk Institute of Physics and Technology of MEPhI
Zlatoust-36 (Trekhgorny)	Trekhgorny Polytechnical Institute of MEPhI

Based on data in "The Government Equates Good Work at Minatom Facilities with Fulfillment of the Military Service Obligation," Atompressa *(Electrostal), No. 6 (337), February 1999, p. 3.*

tion and training. Furthermore, working at a secret facility is a disincentive: according to a US DOE official, a recent poll of high-school students in Chelyabinsk-70 indicated that none of them saw their future inside the closed city.[29] According to Minatom experts, the personnel departments at individual facilities also have not been successful in adopting new approaches to attract and keep young specialists. In the longer term, cutting off the supply of outside talent might undermine intellectual vitality and result in technical stagnation in the weapons complex. Whether this would undermine the Russian stewardship of fissile material management programs, however, is not known.

Draft Relief

Minatom has negotiated with the government a military service draft relief for young specialists who join the weapons complex facilities for full-time positions immediately after college graduation.[30] This draft relief is a strong incentive for potential young recruits to work at nuclear facilities. The weapons complex, however, does not offer additional protection compared to civilian nuclear facilities: 69 Minatom facilities (including nuclear power plants) offer the draft relief benefit.[31]

Management Reserve: Restoring *Nomenclatura*

The nuclear complex experiences shortages of managers at both individual facilities and its headquarters in Moscow. There is a lack of people with leadership skills. Minatom is therefore seeking to re-establish the system of "nomenclatura" that existed during the Soviet period. The system would include approximately 3,000 managers, scientists, and designers, who would enjoy very high salaries and other benefits. These people would form the complex's managerial and scientific elite. Potential candidates are sought out during a licensing process for senior managers at nuclear facilities. There is also an effort to recruit displaced managers from non-Minatom parts of the Russian governmental bureaucracy.

Minatom is also participating in the State Program for Training Managers for the National Economy.[32] For the 1998-99 and 1999-2000 academic years, Minatom was allocated 50 slots per year. Training is conducted by a "Management-Technology" consortium, formed by the Moscow Atomenergo Institute of Qualification Enhancement and MEPhI. The program targets young managers from nuclear facilities, and includes training in general economics and management disciplines (for example, marketing finances), information and management technologies, and languages. The program also envisages an internship in a foreign country. The first 20 trainees finished the program in February 1999. It appears, however, that out of the ten closed cities only Tomsk-7 has been active in the program. Most trainees come from civilian nuclear facilities.

Other Measures

Minatom has resolved to develop facility-level programs of monitoring demographic processes, to provide social security measures for young specialists, to improve the education infrastructure and increase funding for education and training, and to strengthen human resources departments at nuclear facilities. There is an internal effort to archive nuclear test and experimental data and knowledge. Special commissions have been set up at individual facilities and are working to identify technologies critical to their future missions. The effectiveness of many of these measures, however, will depend on the availability of funding and sustained attention from Minatom headquarters and facility managers.

IMPLICATIONS FOR US NONPROLIFERATION POLICIES

How Should US Programs Respond?

Workforce dynamics in the Russian nuclear weapons complex are of strategic significance to the United States for nonproliferation reasons and because of the potential impact on the Russian nuclear weapons program. These dynamics also directly affect existing US-Russian cooperative nonproliferation programs, particularly the Nuclear Cities Initiative (NCI).

The NCI program was launched by DOE and Minatom in 1998, and is currently the only US-Russian cooperative program with a focus on a comprehensive set of human issues in Russia's closed nuclear cities. According to the program's plan:

> [T]he goals of the Initiative are as follows:
> - Assist the Russian Federation in its announced intention of reducing the size of its nuclear weapons establishment to better match its post-Cold War budgeting plans and smaller nuclear arsenal.
> - Promote nonproliferation goals through redirecting the work of nuclear weapons scien-

> tists, engineers, and technicians in the ten closed Russian nuclear cities to alternative, non-military scientific or commercial activities.[33]

Consistent with Minatom's plans for personnel reductions, NCI's main specific objective is to create 30,000 to 50,000 commercial jobs in the next five to seven years.[34] This goal, however, might have to be adjusted because a considerable fraction of the projected reductions will occur due to natural attrition. Indeed, assuming that the age distribution data for Chelyabinsk-70 (Table 2) are correct, approximately 5,000 people currently employed by VNIITF will be over 60 by 2005. Most of these people will not be looking for new jobs. (The life-expectancy of 58.61 years for men in Russia in 1998 suggests that many of them may be dead.[35]) The risk of these retired weapons scientists and engineers being tempted to share their knowledge with potential proliferators could be reduced by a set of social security measures, including health care and timely pensions. Although by improving the economic and social climate in the closed cities, the NCI program contributes to the well-being of nuclear weapons veterans, none of the existing US programs are designed to deal with the demographic problem directly.

Generally, the human resources issue has not been on the US-Russian cooperative agenda. One notable exception is the human resources workshops organized by Sandia experts, in Chelyabinsk-70 and the Institute of Automatics in Moscow in 1998 and in Arzamas-16 in 1999.[36] The workshops covered such areas as staffing planning and recruitment, training, and student internship programs. An agreement was signed at the end of each workshop to continue exchanges in the future.

The significance of the problem for US national security and American nonproliferation programs in Russia warrants additional cooperative activities in the area of human resources management.

There is no reliable data outside (and, possibly, inside) Minatom on the workforce composition and demographics in the Russian weapons complex. It therefore would be useful to develop a comprehensive database that would include for every worker such data as his/her age, skill sets, and operational experience. Minatom and facility managers could then use the database to plan personnel management and activities related to re-configuration of the weapons complex.

The tasks of developing a polling methodology, interfacing with human resources services at individual facilities (which would presumably conduct polling), and interpreting collected data could be assigned to the newly established analytical nonproliferation centers in Arzamas-16 and Chelyabinsk-70 and sponsored by the NCI initiative.[37] The database in its entirety would be classified and not available to the US government. However, I would propose that the NCI contract to support this work could grant US officials access to aggregated data for each targeted facility, such as age distribution, skill sets, etc.

The Arzamas-16 and Chelyabinsk-70 nonproliferation centers, or other entities within the weapons complex, could also be tasked to compare the US DOE and Russian lists of functional areas, and to determine the staffing levels that would be required for the Russian complex to fulfill its core missions under realistic assumptions about the future size and composition of the nuclear warhead and fissile material stockpiles and about levels of funding. A related project could involve building an analytical model of Russia's future nuclear complex. This work could be supported by a lab-to-lab or NCI contract.

Some other useful initiatives could include an expansion of technical exchanges along the lines of the SNL-sponsored workshop in Chelyabinsk-70 and Arzamas-16, and a program of internships (for a period of several months) for human resources specialists from Russian facilities at DOE facilities in the United States.

Finally, every US cooperative program (MPC&A, fissile material disposition, basic and applied research, warhead dismantlement transparency) should be directed to identify and support young specialists who in five to ten years will assume the principal responsibility for the complex's core missions. The possibility of interactions with US counterparts, prospects for professional growth, and modest financial support could provide an incentive for young people to pursue careers in critical nuclear areas.

US Policy Dilemma

A larger policy question, which is central to a range of US cooperative efforts in Russia, is whether and to what extent the United States should be engaged in cooperation with Russia on nuclear weapons-related issues. The primary objective of the United States in this area is to reduce the danger from nuclear weapons by downsizing Russia's nuclear weapons production infrastructure. It is also in the US interest that the Russian nuclear weapons complex remains stable and that it has technical competence and organizational integrity to provide for safe and secure management and disposition of nuclear weapons without reverting to nuclear testing. Supporting Russian activities to develop new weapons or enhance the performance of its existing stockpile, of course, is not a US goal.

Designing and conducting a policy that balances these conflicting objectives could be a delicate and challenging task. Facilities, technologies, and skills required for warhead dismantlement and stockpile stewardship, including warhead surveillance and re-manufacturing, for example, are also essential for designing new warheads. Moreover, ensuring that no US funding or technical assistance is diverted to warhead development work is in many cases virtually impossible without unacceptably intrusive verification arrangements.

At present, US-Russian cooperative activities in weapons-related areas take place under the warhead safety and security agreement, the laboratory-to-laboratory warhead dismantlement transparency program, and the protocol on scientific and technical exchanges to assure the safety and security of nuclear weapons under the CTBT. Some progress has been made on warhead safety, security, and dismantlement transparency. (The warhead dismantlement transparency work has recently slowed down because of security concerns in Russia.) Less cooperation has occurred in the area of scientific and technical exchanges, mainly because of concerns in the United States that such cooperation would help Russia to advance its weapons capabilities. The political fallout of illegal supercomputer exports to Chelyabinsk-70 and Arzamas-16 in 1996, the General Accounting Office's allegations that some scientists who receive funding from the DOE-sponsored IPP program continue to work part-time on weapons projects, and the 1999 Chinese spying scandal all send a strong message to DOE and national laboratory officials to stay away from sensitive and potentially controversial cooperative initiatives. A reported April 1999 decision by the Russian Security Council to develop a new low-yield warhead for tactical applications does little to alleviate these concerns.[38]

The domestic political environment in the United States and the overall crisis in US-Russian relations make any new initiative in the weapons area unlikely. This is unfortunate because an unclassified (at least initially) technical dialogue on nuclear weapons technologies and operations could be of benefit to both countries. It would increase the transparency of the Russian nuclear complex and its stockpile stewardship program. It would facilitate progress in the areas of warhead security and dismantlement transparency. It also would help the two countries to address cooperatively other critical nonproliferation issues, including the human resources situation in the Russian weapons complex.

CONCLUSION

The available information regarding the demographic situation in the warhead production complex in Russia is not sufficient to conclude definitely that it will compromise the core missions of the complex. The redundancy of the complex, the large pool of excess specialists, and Minatom's extensive system of education and training suggest that the human resources situation, at least in the near term, will remain adequate. The lack of new hiring, outflow of young specialists, and aging of senior workers, however, could eventually erode the personnel base of the nuclear complex. Dealing with this problem is the responsibility of the Russian government. A human resources crisis in the Russian nuclear complex, however, would also have a strong impact on US national security and nonproliferation policies. There is therefore a need to understand and address at least those parts of the problem by using cooperative nuclear security programs.

[1] Plutonium production was stopped at the Savannah River Plant (where tritium production also stopped) and Hanford Reservation. Component manufacturing and other weapons-related activities ceased at the Rocky Flats Plant (CO), Pinnellas Plant (FL), and Mound Laboratory (OH). At present, the weapons complex comprises the Los Alamos (Los Alamos, NM), Lawrence Livermore (Livermore, CA), and Sandia (Albuquerque, NM and Livermore, CA) national laboratories, Pantex Plant (Amarillo, TX), Kansas City Plant (Kansas City, MO), Nevada Test Site (NV), Savannah River Plant (Aiken, SC), and Y-12 Plant (Oak Ridge, TN).

[2] The 1985 personnel levels are from T. Cochran, W. Arkin, R. S. Norris, and M. Hoenig, *US Nuclear Warhead Facility Profiles*, Nuclear Weapons Databook Vol. III (Cambridge, MA: Ballinger Publishing Co., 1987), p. 132. (Some personnel is not associated with the defense program.) The 1998 personnel levels are from House of Representatives, Committee on Appro-

priations, *Hearings before the Subcommittee on Energy and Water Development, Part 6*, 105th Cong., 2nd sess. (Washington, DC: GPO, March 17, 1998), p. 635.

[3] *A Sandia Nuclear Weapon Knowledge Management Program Plan for FY 1998-2003, Volume 1*, SAND97-3083/1 (Sandia National Laboratories, February 1998), p. 11.

[4] DOE has launched a complex-wide effort to capture and systematize nuclear weapons information. This work is being carried out by the Nuclear Weapons Information Group, which was established in 1994 and currently includes participants from DOE weapons facilities, Defense Special Weapons Agency, and the UK Atomic Weapons Establishment. The primary objectives of this Lawrence Livermore National Laboratories (LLNL)-led group are to identify information, archive it in standard formats (typically, as HTML and PDF files), and develop a classified network infrastructure to access the data. In addition to standard documents, blueprints, and computer codes, the program also seeks to capture anecdotal technical information and best practices by videotaping interviews with retired warhead designers and assembly workers, facility tours, panel discussions, and other undocumented information. "Preserving Nuclear Weapons Information," *Science and Technology Review*, (May 1997), pp. 18-19.

[5] "*A Sandia Nuclear Weapon Knowledge Management Program Plan*," p. 8.

[6] SBSS critics point out that the program would (a) undermine the Non-Proliferation Treaty and the Comprehensive Test Ban Treaty by advancing weapons capabilities, (b) describe accurate models of physics processes in nuclear weapons in unclassified publications, thereby increasing proliferation capabilities of other nations, and, possibly, (c) facilitate development of proliferation-prone pure-fusion weapons. For example, see Christopher E. Paine and Matthew G. McKinzie, *Does the US Science-Based Stockpile Stewardship Program Pose a Proliferation Threat?* (Washington, DC: Natural Resources Defense Council, November 1998).

[7] Harold Smith, Jr. and Richard Soll, "Challenges of Nuclear Stockpile Stewardship under a Comprehensive Test Ban," *Arms Control Today* 28 (March 1998), pp. 3-6.

[8] Remarks by Minatom's Deputy Minister Lev Ryabev at the 7th Carnegie Endowment Nonproliferation Conference, January 11-13, 1999, Washington, DC.

[9] Two plutonium-production reactors in Tomsk-7 and one in Krasnoyarsk-26 continue to operate to provide heat and electricity to the local populations. As a byproduct, they also produce weapons-grade plutonium. This plutonium, however, is not used in the weapons program. Instead, it is converted to plutonium oxide and is placed in storage.

[10] "We Must Save the Best (Press Conference with L. Ryabev)," *Gorodskoy Kuryer* (Sarov), March 5, 1998. [All Russian titles are given in English translation.]

[11] Remarks by Ryabev at the 7th Carnegie Endowment Nonproliferation Conference.

[12] "Interview with Nikolai Voloshin: Subcritical Tests—an Important Component of Ensuring Stockpile Reliability," *Yaderny Kontrol* (September-October 1999), pp. 29-32.

[13] Olga Zaguskina, "New Work Year Begins (Interview with Radii Il'kayev)," *Gorodskoy Kuryer* (Sarov), February 5, 1998.

[14] "The Slogan 'Personnel is Everything' Remains Valid," *Atompressa* (Electrostal), No. 4 (335), February 1999, p. 3.

[15] Peter Khven, "Once Again About the Law for Bomb-Makers," *Gorodskoy Kuryer* (Sarov), September 3, 1998.

[16] Olga Zaguskina, "E. Adamov: 'The Nuclear Industry Created More Problems Than It Resolved,'" *Gorodskoy Kuryer* (Sarov), September 2, 1999.

[17] Frank von Hippel, Princeton, NJ, conversation with author, July 1999.

[18] Statements made at the December 15, 1998 Duma Hearings on the situation in the nuclear weapons complex. "Members of Parliament Discuss Problems of the Nuclear Weapons Complex," *Atompressa* (Electorstal), No. 46-47 (330-331), 1998, p. 6.

[19] L. Saratova, "There are no crises where cars are built," *Gorodskoy Kuryer* (Sarov), September 24, 1998.

[20] "Problems of the Complex were Discussed in Trekhgorny," *Atompressa* (Electrostal), No. 21 (352), June 1999, p. 3.

[21] Some Russian experts, however, suggest that the average age of the VNIITF's workforce in Chelyabinsk-70 is 45. In contrast, the average age in Arzamas-16's VNIIEF is 55. Meeting of the Russian-American Nuclear Security Advisory Council, Moscow, April 1998.

[22] "The Slogan 'Personnel is Everything' Remains Valid," p. 3.

[23] "From Industry's Papers," *Atompressa* (Electrostal), No. 19 (350), June 1999, p. 4.

[24] "Minatom's Activities are the Basis of National Security," *Atompressa* (Electorstal), No. 6 (337), February 1999, p. 1, 3.

[25] In the 1998-99 academic year, Minatom provided personalized fellowships (stipends) in the amount of one minimal salary to 35 students in Minatom's schools in Chelyabinsk-65, Sverdlovsk-44, Sverdlovsk-45, Zlatoust-36, Tomsk-7, Arzamas-16, and Chelyabinsk-70. *Atompressa* (Electrostal), No. 39, October 1998, p. 1.

[26] For example, the Arzamas-16 branch of MEPhI (MEPhI-4) was established in 1952 as an evening school. It became a true college in 1971. MEPhI was designated a head institute for the development of methodology and training curriculum for other nuclear schools in Russia.

[27] T.Yufereva, "Greenhouse for Scientific 'Greens'," *Sovershenno Otkryto*, 8(3), 1996, p. 31.

[28] "Hope is the Only Thing Left," *Gorodskoy Kuryer* (Sarov), August 27, 1998.

[29] Remarks at Russian-American Nuclear Security Advisory Council's meeting on "Transforming the Russian Nuclear Complex: The Role of Non-Governmental Institutions," Washington, DC, June 23-24, 1999.

[30] "The Government Equates Good Work at Minatom Facilities with Fulfillment of the Military Service Obligation," *Atompressa* (Electrostal), No. 6 (337), February 1999, p. 3.

[31] "The Slogan 'Personnel is Everything' Remains Valid," p. 3.

[32] "Consortium 'Management-Technologies'–First Crop," *Atompressa* (Electrostal), No. 7 (338), February 1999, p. 4.

[33] US Department of Energy, *Nuclear Cities Initiative Program Plan* (Washington, DC: DOE, May 18, 1999), pp. 1-2.

[34] Kenneth Luongo and William Hoehn III, *The Nuclear Cities Initiative: Status and Issues* (Washington DC: RANSAC, January 1999), p. 2.

[35] Central Intelligence Agency, *World Factbook 1998*, <http://www.odci.gov/cia/publications/factbook/rs.html#econ>.

[36] Bill Murphy, "Sandia Human Resources Team Visits Chelyabinsk-70, Moscow to help Russian Labs Address 'People' Issues," *Sandia Lab News*, September 25, 1998; Olga Zaguskina, "Personnel Managers Decide Everything," *Gorodskoy Kuryer* (Sarov), April 29, 1999.

[37] These nonproliferation centers were created in 1998-99 with support from Princeton University's Center for Energy and Environmental Studies and the Russian-American Nuclear Security Advisory Council, and through funding provided by US private foundations and DOE. The establishment of the centers is a part of the effort to make nonproliferation and arms control activities a major core mission of the Russian nuclear weapons complex.

[38] See, for example, David Hoffman, "Kremlin to Bolster Nuclear Stockpile," *Washington Post Foreign Service*, Thursday, April 29, 1999, p. A19.