Sharing the Challenges of Nonproliferation

The changes brought about by the end of the Cold War have created a surprising turn of events. Once unthinkable collaborations and partnerships to reduce the threat of proliferation are now happening with increasing frequency.

IN these post–Cold War days, the secret cities that contain Russia's weapons complex remain closed, still surrounded by fences patrolled by armed guards. But changes are going on within them. Scientists and engineers from Lawrence Livermore can now be found inside, engaged in meetings with their Russian counterparts. This change has occurred largely because of the convergence of two events: the shift from an arms race to arms reduction, and the dissolution of the Soviet Union, with its attendant economic upheaval.

One of the many risks introduced by the first event is that of increased nuclear proliferation if the disposition of nuclear weapons technology and materials is not managed carefully. Russia has, for example, large amounts of surplus weapons-grade nuclear materials in various forms. These materials are highly desirable to potential proliferators and terrorists. They have become more vulnerable to theft or diversion because Russia now has fewer resources to apply to safeguarding its nuclear materials. U.S. and Russian scientists and engineers are working together to reduce such risks.

U.S. policy makers recognize that Russian nuclear scientists have essential roles to play in global arms reduction and nonproliferation causes. Alleviating the scientists' economic hardships and uncertainty would greatly aid the stabilization of Russian nuclear weapons complex. To these ends, the U.S. Department of Defense has formulated a policy to aid Russian scientists through stimulating commercial economic development in the closed cities. One large component of the policy is the Nunn–Lugar Cooperative Threat Reduction bill, passed in 1991, which initiated collaborations between the U.S. and the newly independent states (NIS), principally Russia. The effectiveness and positive reception of Nunn–Lugar initiatives led to similar and complementary initiatives by the Energy and State departments.

Dubbed "defense by other means" by former Secretary of Defense William Perry, this policy depends as much on scientific capabilities as on political expertise. Thus, Lawrence Livermore staff have found themselves traveling thousands of miles between Livermore and various parts of the NIS to collaborate with NIS scientists on worthwhile, non-weapons-related projects as well as to monitor and assist the progress of arms reduction.

Livermore technician Lori Switzer (foreground) works with Russian scientists Dmitri Semonov (left) and Mikhail Chernov to evaluate candidate neutron and gamma-ray measurement techniques for mutual reciprocal inspection purposes.

Progress in Arms Reduction

The arms reduction taking place in the U.S. and Russia is an important step for global nuclear security. Because verification activities for the strategic arms reduction treaties (START) are concerned with the destruction of weapons launchers and do not deal with the warheads, the Biden Condition was appended to START I during the ratification process to ensure that warheads would be verifiably dismantled in future arms reduction.

Developing transparency measures to deal with the fissile materials derived from dismantled weapons is the task of the Safeguards, Transparency, and Irreversibility Working Group, a joint effort between the U.S. and Russia. Formed as a result of agreements made between Presidents Clinton and Yeltsin over several summit meetings, the group is chartered with developing mutually acceptable ways to keep fissile materials derived from dismantled nuclear weapons secure, account for and control their quantities, and prevent them from ever being used again in nuclear weapons.

Jim Morgan is one of the Livermore scientists working with this group to implement its complex task. He has been involved in discussions about sharing information on fissile materials. The most difficult negotiations involve key proposals brought to the table by the U.S.:

- Regular exchanges of detailed information about weapons and fissile materials stockpiles.
- Reciprocal inspections at storage facilities to confirm the amounts of plutonium and highly enriched uranium removed from weapons.
- Various arrangements to monitor fissile material stockpiles.

These have been difficult proposals from the beginning, starting with fundamentally differing views on information sensitivity. Russia classifies its information differently than the U.S. In addition, because of former Energy Secretary Hazel O'Leary's openness initiatives, the U.S. has already published some general information about U.S.

(a)

(b)

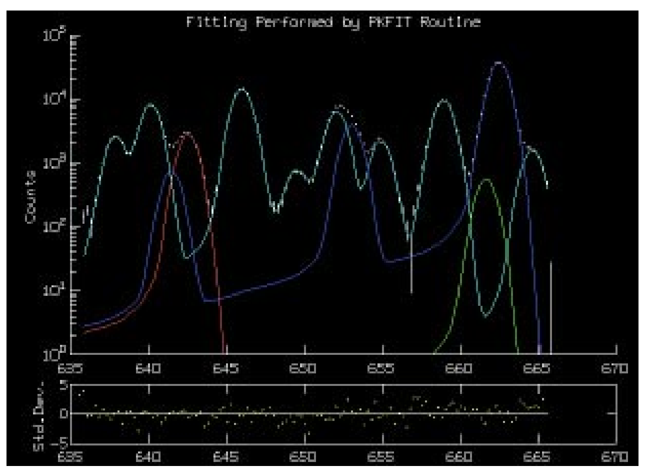

Figure 1. (a) Technician Vern Rekow (left) assists Zachary Koenig in setting up a portable, battery-operated germanium gamma-ray spectrometer. Koenig, a physicist in the Nonproliferation, Arms Control, and International Security Directorate at Livermore, was instrumental in developing this means of determining whether plutonium stored inside containers is consistent with material that may have been plutonium that has been removed from dismantled nuclear weapons. This spectrometer has undergone joint testing with the Russians. (b) Typical results of the spectrometer's reading. The upper plot is a reconstruction of gamma-ray activity, with dots indicating the measured data. Standardized residuals from the gamma-ray activity are plotted below the reconstruction.

fissile materials stockpiles, which goes well beyond the type of information the Russians are willing to share.

The progress of the negotiations has been slow. The U.S. delegation has been trying to maintain some momentum in the talks by suggesting negotiating patterns to keep negotiations moving.

Whatever the course of action, these negotiations will not end when agreements on information exchanges and monitoring procedures have been made. There must also be U.S.–Russian agreements on what measuring devices and instrumentation are allowable for deriving specific information during reciprocal inspections at nuclear facilities.

In parallel to Morgan's work in negotiations, scientists and engineers at Livermore are designing special measuring technologies for use inside U.S. and Russian facilities. One candidate device that has been demonstrated to Russian scientists is a portable, battery-operated, germanium gamma-ray spectrometer. This instrument can determine whether plutonium stored inside containers is consistent with material that may have been removed from dismantled nuclear weapons (Figure 1a). The spectrometer measures the plutonium's gamma-ray intensities in a narrow band of energy (630 to 670 thousand electron-volts) to reveal whether its ratio of plutonium-240 to plutonium-239 is consistent with weapons-grade material; it also estimates what minimum mass of plutonium is necessary to produce the observed intensities (Figure 1b).

The narrow band of energy measured by the spectrometer intentionally leaves some details of the material being measured unknown to satisfy Russian security concerns and make the spectrometer acceptable to the Russians. Tools used for transparency measurements must observe a careful balance between yielding enough to

confirm crucial verification requirements but not revealing so much as to threaten the security interests of either side.

Reducing HEU Holdings

Even as the negotiations for safeguards, transparency, and irreversibility continue, the U.S. has found another way to safeguard some Russian weapons uranium—by buying it. In 1994, the U.S. signed a 20-year, $12-billion deal to purchase 500 metric tons of highly enriched uranium (HEU) recovered from Russian weapons. The contract calls for this uranium to be blended down to low-enriched uranium (LEU) and then shipped to the U.S. to be used for making commercial reactor fuel.

The transparency protocols for the HEU purchase are those that strive, on the one hand, to confirm for the U.S. that the shipped material has indeed been derived from Russian weapons material and, on the other hand, to confirm to Russian satisfaction that the LEU is not going to end up in the U.S. weapons program. These confirmations require access to the uranium processing facilities of both sides. The negotiations for such access, normally complex and difficult, were made even more so when they became subsumed by a host of other issues surrounding the deal, including pricing and LEU market competition.

The final agreement allows Russian monitors access to the U.S. Enrichment Corporation's Portsmouth Gaseous Diffusion Plant in Piketon, Ohio, and to the five U.S. fuel fabrication facilities receiving the Russian uranium. In turn, U.S. monitors are allowed access to the three principal Russian plants involved in the conversion of HEU to LEU. Lawrence Livermore is taking a lead role in support of DOE program activities related to monitoring activities at those three plants.

What the agreement has meant for Livermore's Doug Leich, HEU transparency technical leader and a member of the U.S. monitoring team, is several long trips to Russia each year, to the cities of Seversk, Zelenogorsk, and Novouralsk (Figure 2). At the plant in Seversk, HEU metal is processed into an HEU oxide before being shipped to the electrochemical plants in Novouralsk or Zelenogorsk. In these facilities, the oxide is fluorinated and combined with a slightly enriched blending material to turn it into LEU suitable for making civilian power reactor fuel.

Monitoring Activities

Describing the monitoring tasks at Seversk, Leich says that monitors can observe the whole oxidation procedure, from the beginning when the uranium metal is analyzed by portable gamma-ray spectrometry to confirm its weapons-grade status, through its feed into and withdrawal from oxidation process equipment, to the final analysis of the withdrawn oxides. Leich and the other monitors apply U.S. tags and seals to some containers of the oxides before their shipment to Novouralsk or Zelenogorsk.

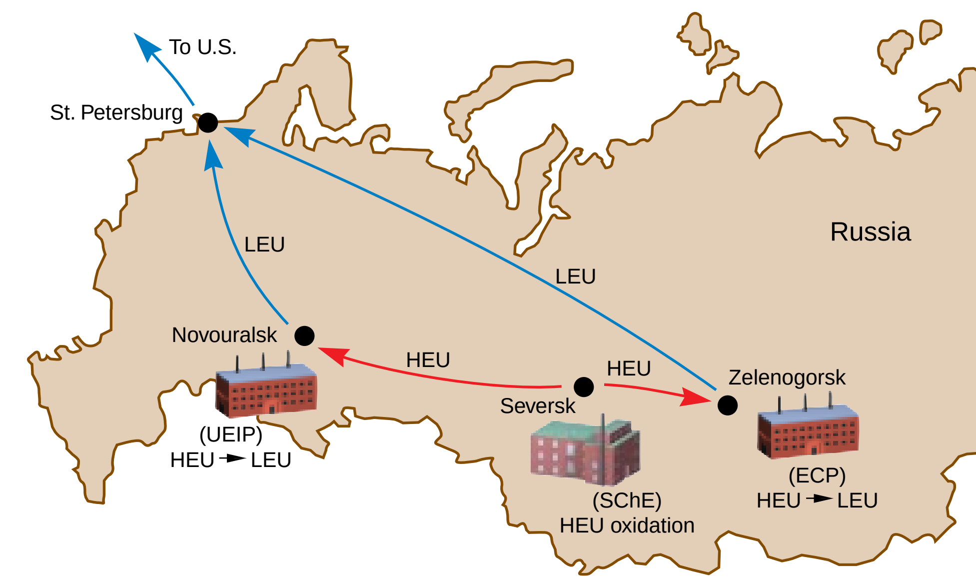

Figure 2. The U.S. is permitted to monitor highly enriched uranium (HEU) processing at the three locations shown. At the Siberian Chemical Enterprises (SChE) in Seversk, HEU metal is converted to HEU oxide and then shipped by train to the Ural Electrochemical Integrated Plant (UEIP) in Novouralsk or the Electrochemical Plant (ECP) in Zelenogorsk, where it is fluorinated and blended to produce low-enriched uranium (LEU). The LEU is shipped via St. Petersburg to the U.S., where it is made into commercial nuclear reactor fuel.

Figure 3. Principal investigators T. G. Nieh (left) and Donald Lesuer (center) join Bradley Tuvey of Lawrence Livermore's Procurement Department in examining samples of the automobile wheels made in Russia using a superplastic deformation technology previously used to make weapons components.

When the containers of oxide arrive at those sites, monitors first check the tags and seals on them. Then, says Leich, "We can request nondestructive assay of containers of HEU oxide, observe the feeding of oxide into a process that chemically converts the HEU to a hexafluoride form, and perform an assay of the HEU hexafluoride withdrawn from the conversion process. During the blending-down process, we can request random samples of the HEU hexafluorides, the blending materials, and the resulting LEU right out of the process piping and put them through an analysis procedure." U.S. and Russian monitors also have the right to measure the total flow of uranium at the blending point. Before the LEU is put on railcars to start its journey to the U.S., the monitors observe the application of Russian and U.S. tags and seals.

Monitoring at Seversk and Zelenogorsk is confined to periodic visits, but monitors have continuous access to the Novouralsk plant through the U.S. Permanent Presence Office there, which Lawrence Livermore manages for DOE. At all three plants, U.S. monitors have access to relevant documentation and accountability records.

Toward Peaceful Enterprises

Lawrence Livermore is currently active in several programs that provide collaborative project opportunities for scientists from the newly independent states, principally Russia, Ukraine, Belarus, and Kazakhstan. The goal of these programs is to direct the scientists toward work that will help develop free-market economies in their home states.

The first of these programs is the laboratory-to-laboratory program, which began in 1992 shortly after the directors of the Russian and American nuclear weapons design laboratories exchanged visits. Supported and monitored but not directly funded by DOE, the lab-to-lab program involves interactions between NIS institutes and DOE laboratories for the purpose of "encouraging exchanges of information between U.S. and NIS scientists, thereby building confidence and openness between the two sides," according to Janet Hauber, Group Leader for Cooperative R&D and facilitator of Livermore's laboratory-to-laboratory efforts. Funding for projects that result from these collaborations comes from the sponsoring DOE laboratory with the stipulation that the work is neither related to weapons development nor enhances weapons capability.

Hauber reviews the work between the NIS and U.S. scientists to assess the benefits derived by the participants. Although DOE is kept informed about lab-to-lab projects, the technical contacts are made directly by the scientists and involve only the laboratories and institutes. Thus, scientific collaborations are both informal and easy to initiate.

The laboratory-to-laboratory model for doing business has been so successful that it has been adopted by the Initiatives for Proliferation Prevention (IPP) program, another source of cooperative work for NIS scientists. Hauber is a member of the Interlaboratory Advisory Board of the IPP, her primary project responsibility. Sponsored and directly funded by DOE, the IPP program supports collaborations between NIS and DOE national laboratory scientists. The objectives of the IPP, like those of the lab-to-lab program, are to strengthen nonproliferation and keep NIS scientists employed in their current institutions, but unlike the lab-to-lab program, the focus of IPP-sponsored projects is clearly on their commercial potential.

Although projects must be mutually beneficial and not related to weapons, the major emphasis of IPP projects is on promoting economic recovery in the NIS. To that end, a large effort is expended on developing NIS know-how in the areas of intellectual property rights, entrepreneurship, and commercialization. To facilitate these collaborations, DOE has simplified the project review and approval process and promoted uniform administrative procedures, such as uniform contracts and general patents, which make it easier to protect intellectual property.

Projects done under the IPP program are carried out in three stages. In the first stage, the collaborating laboratories and institutes perform a feasibility study. Since the beginning of the program in 1994, some 200 projects in technical areas such as materials manufacturing, biotechnology, energy, and waste management have been initiated. Projects considered to be feasible move into a second stage, one in which private industry can participate through cost-sharing (by matching government funding) and by assisting in prototype development. A number of projects are currently in this second stage.

A typical project—an analysis of the use of superplastic deformation technology to make automobile wheels—is being performed by a consortium made up of Lawrence Livermore, the All Russian Institute of Technical Physics, the (Russian) Institute of Metals Superplasticity Problems, Kaiser Aluminum, and Rockwell International. Lawrence Livermore's specific role at this juncture is to characterize wheel design and material for compliance with U.S. Department of Transportation standards and to determine whether the wheel will be able to meet U.S. requirements (Figure 3). Once the superplastic technology has been fully developed, it has potentially many more uses than for making car wheels. Because it uses nearly all of its starting materials to form the final product, it is a beneficial technology that produces few industrial waste byproducts. Also, because it is a technology previously used to make weapons components, it will be a true swords-to-plowshares project.

The third stage of IPP projects involves production of the developed products in the context of a purely commercial agreement between the Russian entity and a U.S. industrial firm.

While the progress of IPP projects is sometimes slow, Hauber is enthusiastic about the program, believing that it will be an important factor in developing strong economies for the NIS. She says that "we just need to continue this work a little longer. The Russians are determined, and that determination will go a long way toward a successful outcome."

International Support

A third program provides project opportunities to NIS scientists through the International Science and Technology Center (ISTC) in Moscow and the Science and Technology Center of the Ukraine in Kiev. Established by agreements among participating governments, the centers develop and fund nonproliferation projects whose primary objective is to provide peaceful, non-weapons-related opportunities to weapons scientists and engineers from the NIS, particularly those with knowledge and skill in the development of weapons of mass destruction (nuclear, chemical, and biological).

Although headquartered in Moscow, the ISTC is available to other states of the former Soviet Union—so far, scientists from Russia, Armenia, Belarus, Georgia, Kazakstan, and Kirgizia have submitted proposals. The ISTC is supported by the U.S., the European Union (EU),* Norway, and Japan. The EU, Japan, and U.S. each place a deputy director at the Center and provide staff support for Center operations such as finance and program management. The parties rotate the Center directorship as well as the chair of its governing board. The current chairperson of the governing board is Ron Lehman, Director of the Center for Global Security Research at Lawrence Livermore.

The ISTC sponsors projects focused on developing scientific and technical solutions for national and international problems, reinforcing the transition to a market economy, developing basic science and technology, and promoting the further integration of NIS scientists into the international scientific community. Project proposals submitted to the ISTC are evaluated for scientific

* The member nations of the European Union are: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

MINATOM
Civilian Complex

1. Dmitrovgrad, Scientific Research Institute of Atomic Reactors (NIIAR)
2. Elektrostal Production Association Machine Building Plant (POMZ)
3. Obninsk, Physics & Power Engineering Institute (FEI)
4. Podolsk, Scientific Production Association Luch
5. Novosibirsk Chemical Concentrates Plant
6. Beloyarsk Nuclear Power Plant
7. Sverdlovsk Branch of Scientific Research and Design Institute of Power Technology (NIKIET)
8. Scientific Research and Design Institute of Power Technology (NIKIET)
9. Khlopin Radium Institute
10. Moscow Institute of Theoretical and Experimental Physics
11. St. Petersburg Central Design Bureau of Machine Building

MINATOM
Defense Complex

12. Arzamas-16/Sarov, All-Russian Scientific Research Institute of Experimental Physics (VNIIEF)
13. Krasnoyarsk-26/*Zheleznogorsk**, Mining and Chemical Combine
14. Krasnoyarsk-45/*Zelenogorsk*, Electrochemical Plant
15. Chelyabinsk-65/*Ozersk*, Mayak Production Association
16. Chelyabinsk-70/*Snezhinsk*, All-Russian Scientific Research Institute of Technical Physics (VNIITF)
17. Sverdlovsk-44/*Novouralsk*, Urals Electrochemical Integrated Plant
18. Tomsk-7/*Seversk*, Siberian Chemical Combine
19. ELERON (Special Scientific and Production State Establishment)
20. All-Russian Scientific Research Institute of Automatics (VNIIA)
21. Bochvar All-Russian Scientific Research Institute of Inorganic Materials (VNIINM)

*Italics indicate new Russian place names.

Independent
Civilian Sector

22. Russian Scientific Research Center– Kurchatov Institute
23. Karpov Institute of Physical Chemistry, Obninsk
24. Tomsk, Scientific Research Institute of Nuclear Physics
25. Norilsk, Nikel Plant
26. St. Petersburg Institute of Nuclear Physics
27. Joint Institute of Nuclear Research, Dubna
28. Moscow Institute of Physical Engineering (MIFI)

Naval Nuclear
Fuel Sector

29. Northern Fleet
30. Pacific Fleet
31. Icebreaker Fleet (Murmansk Shipping Company)

Non-Russian NIS
and Baltic Sector

32. Sosny Institute of Nuclear Power Engineering, Minsk, Belarus
33. Tbilisi, Institute of Physics, Georgia
34. Aktau, BN-350 Breeder Reactor, Kazakstan
35. Almaty, Research Reactor, Kazakstan
36. Semipalatinsk, Complex 21, Kazakstan
37. Ulba Fuel Fabrication Plant, Ust'Kamenogorsk, Kazakstan
38. Salispals Institute of Nuclear Physics, Latvia
39. Ignalina Nuclear Power Plant (INPP), Lithuania
40. Kharkiv Institute for Physics and Technology (KIPT), Ukraine
41. Kiev Institute of Nuclear Research (KINR), Ukraine
42. Sevastopol Naval Institute, Ukraine
43. South Ukraine Nuclear Power Plant (SUNPP), Konstantinovsk, Ukraine
44. Tashkent, Institute of Nuclear Physics, Uzbekistan

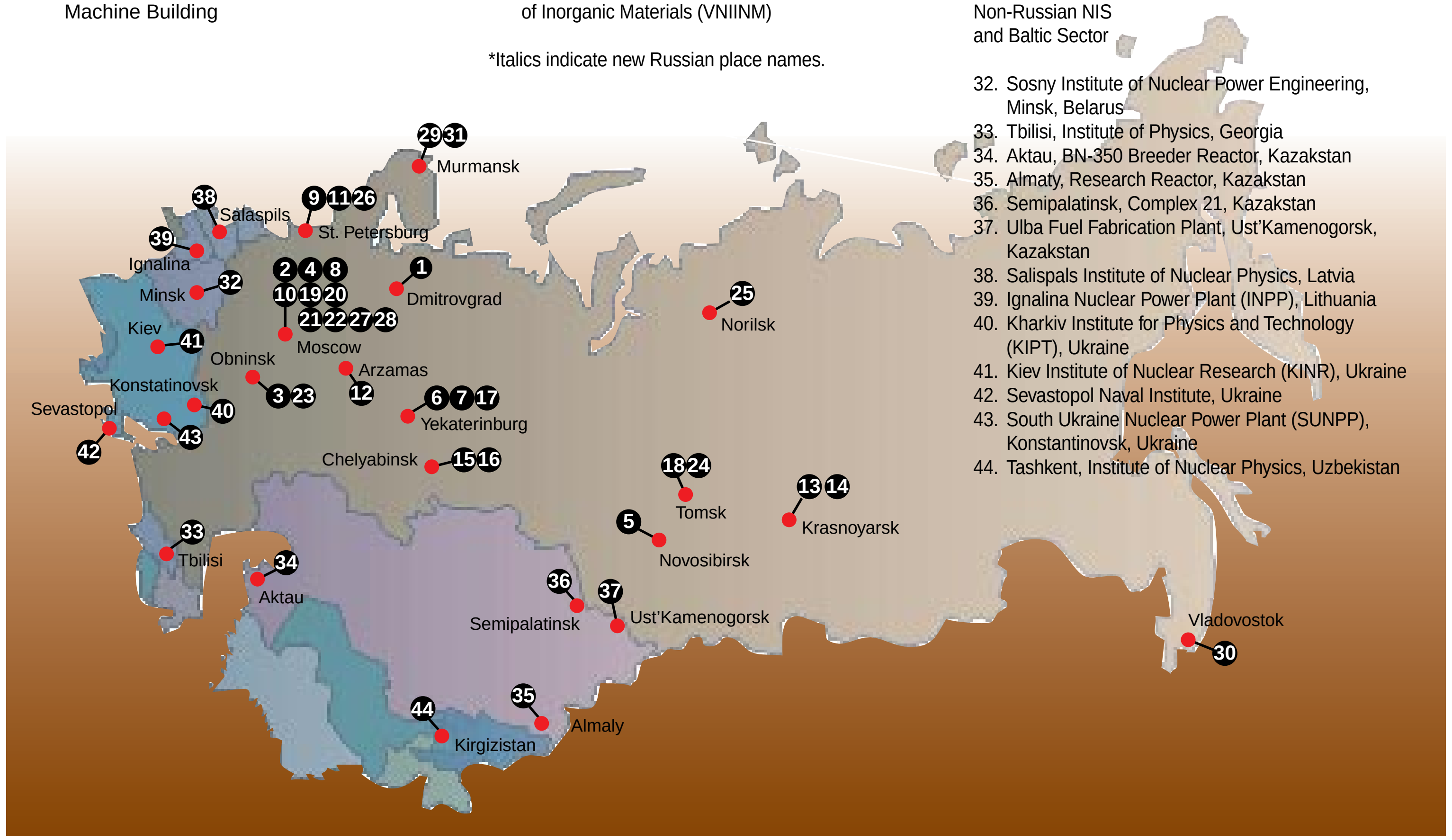

Figure 4. The DOE Materials Protection, Control, and Accounting program currently has projects to improve security and material accountability at 44 sites in the newly independent states where nuclear materials are processed and stored. One of several projects with which Livermore currently is involved is at Chelyabinsk-70 (Snezhinsk), number 16 on the map.

merit by the funding parties. Eileen Vergino, Lawrence Livermore's Program Manager for the ISTC, sits on the U.S. scientific advisory committee and provides technical support to the U.S. State Department, both by finding scientific reviewers for submitted technical proposals and advising them on funding decisions. Proposals are evaluated for technical merit as well as for conformance to ISTC policy. Overall approval is provided by the ISTC governing board, and final funding decisions are made by the funding party.

U.S. scientists, including those at DOE laboratories, are encouraged to express support for or, better yet, collaborate on proposals they find interesting and significant to their area of expertise. A firm commitment by U.S. collaborators to a project will improve its chances for funding. While the U.S. collaborators will not receive any funding, they will play a key role in project development and review. U.S. collaborators often see the ISTC as a means for leveraging funds and enabling collaborations between themselves and NIS scientists on projects ranging from reactor safety to treaty verification to environmental assessment and cleanup.

The Science and Technology Center of Ukraine is modeled after the ISTC. Its main difference is its sponsors, currently composed of the U.S., Canada, and Sweden and soon to include the EU and Japan.

Security and Accountability

Russia's transition toward democracy has changed its state mechanisms for controlling and securing nuclear materials. Because of the economic and social changes in Russia, the borders around weapons complexes are now more permeable; gaining access to weapons materials has become easier. These factors increase the potential for the theft of nuclear materials. Therefore, one of the larger U.S. efforts in Russia is to provide assistance for improving the physical protection, control, and accounting of Russia's nuclear materials.

The DOE Materials Protection, Control, and Accounting (MPC&A) program is a cooperative effort with Russian institutes and enterprises that process or store nuclear materials usable in weapons. Lawrence Livermore is one of seven DOE national laboratories involved in the program and is working directly with Russia's nuclear institutes to provide them with technical support, training, funding, and equipment. The goal is twofold: enhance Russian physical protection and nuclear material accounting capabilities and encourage an overall change of philosophy about physical and material protection. The program is intended to foster support from institutes and scientists for enhanced security concepts and methodologies that will be the foundation for enhanced national standards throughout the newly independent states.

Begun in 1994 with pilot projects at three Russian institutes and modeled, like the IPP program, after the laboratory-to-laboratory program discussed earlier, the MPC&A program has expanded to more than 44 institutes and enterprises (Figure 4). One or more project teams have formed at each institute or enterprise. One of the several project teams led by Lawrence Livermore has responsibility for Chelyabinsk-70.

T. R. Koncher, leader of Lawrence Livermore's MPC&A work, says, "We think of Chelyabinsk-70 as Russia's equivalent to Lawrence Livermore because it is their second oldest weapons complex, just as we think of Arzamas-16 as their Los Alamos." Chelyabinsk-70, now called Snezhinsk, is east of the Ural Mountains, approximately 1,900 kilometers east of Moscow and about 80 kilometers south of Ekaterinburg. Several other nuclear facilities located nearby have close relationships with it, so it is expected that any security improvement techniques developed at Chelyabinsk-70 will ultimately be beneficial to these other institutes as well.

Security Upgrades

Lawrence Livermore's approach to upgrading safeguards and security at Russian weapons complexes is to work with Russian colleagues to identify areas where upgrades are required and then rapidly install those upgrades. The MPC&A program first installed safeguards such as barriers, alarms, communications systems, and portal monitoring systems. Subsequently, pedestrian and vehicle portals were installed to improve entry and exit systems (Figure 5). Older Russian manual systems are being replaced with automated control systems that will incorporate nuclear material monitors, metal detectors, and ballistically hardened booths for the guards. The new systems can detect nuclear materials being smuggled out, improve the capability to discover anyone trying to sneak inside, and offer better protection for guards in the event of an attack.

Lawrence Livermore is also working to enhance Russian transportation systems for nuclear materials. The Automatic Transportation Security System (ATSS) is an ongoing project to use readily available technologies to make rail systems more secure. The three-phase project, scheduled to be completed in the year 2000, covers some 375 development tasks. The first phase, now under way, includes installing intrusion and environmental sensors, security seals, on-train data communications and display, voice communications, physical barriers, locks, active delays such as high-intensity explosive sound generators and smoke generators, and off-train data

Figure 5. With the help of Livermore and other DOE laboratories, the Materials Protection, Control, and Accounting program has upgraded the safeguards and security at Russian weapons complexes. Shown here are (right) a pedestrian portal monitor and (below) a drive-through vehicle portal monitor.

communications and tracking. In parallel to the physical controls, U.S. and Russian scientists are developing safety methodologies—for example, procedures for coordinating emergency response from a central command post.

Improvements for the ATSS were designed at Moscow's Eleron Institute, which is devoted to the development, manufacture, and implementation of security equipment and systems. Actual implementation of the improvements will be done in conjunction with seven other Russian institutions, which will assure that the system has been incorporated into the Russian transportation infrastructure.

Efforts are also under way to obtain an accurate measure of nuclear material inventories and to establish procedures for checking and evaluating material balances regularly throughout all operations. This work requires the use of nondestructive assay methods to measure or verify nuclear inventories efficiently. U.S. scientists, for instance, are providing a gamma-ray spectrometer that can measure plutonium isotopes or uranium enrichment and thus determine and verify nuclear inventories (Figure 6). Lawrence Livermore scientists developed the codes required to interpret the gamma-ray measurements. The codes analyze the complex gamma-ray spectra of plutonium or uranium to determine the actinide isotopic distribution for samples of any physical form, size, shape, or chemical formula. The system is easy to use: it does not require calibration of the instrumentation, and its measurement and analysis times are short.

Long-Term Assessments

In addition to upgrading security weaknesses, U.S. scientists are helping Russian scientists assess long-term security infrastructure needs and establish priorities for implementation. Lawrence Livermore, in conjunction with Sandia National Laboratories, has been working with Russian institutes to conduct vulnerability analyses. This work, which generally begins with a training workshop, teaches quantitative probabilistic risk analysis, the technique that DOE uses to evaluate protection systems for special nuclear materials. The focus of these workshops is on using a computer-based analysis tool called ASSESS (Analytical System and Software for Evaluating Safeguards and Security) to quantify the detection, delay, and neutralization probabilities of various protection systems. The quantitative values depend on the objectives of the protection system. These objectives, in turn, are defined through an analysis that asks: What needs protection? What are the consequences of losing the material? What possible types of threat does it face? What is the maximum level of acceptable risk for it? The objectives of the protection system must be identified and understood before an evaluation can be made of its effectiveness.

In addition to the workshops, subsequent vulnerability analyses, performed solely by Russians or jointly with U.S. scientists, are used to evaluate and prioritize physical and procedural security upgrades. The approach of these analyses differs from the present Russian approaches, so the rationale of the analysis tools must be communicated. The work also has to do with inculcating an MPC&A culture throughout the Russian institutes, so that both physical protection to fight off outsider threats and resistance to insider threats will be improved.

Additional Benefits

Lawrence Livermore's work in the area of nonproliferation and arms control

is one of critical importance to national and global security. This work draws on the expertise of personnel from directorates throughout Lawrence Livermore: Nonproliferation, Arms Control, and International Security as well as Engineering, Physics and Space Technology, Environmental Programs, Energy Programs, Chemistry and Materials Science, Computation, and Plant Operations. These staff are involved in the nonproliferation effort because their technical expertise allows them to work directly with scientists from Russia and other newly independent states in ways that diplomats and politicians could not. Their face-to-face interactions are yielding benefits beyond the goals of their various collaborative efforts. As Bill Dunlop, Program Leader, Proliferation Prevention and Arms Control, notes, "The access that U.S. and Russian scientists now have to each other's secure facilities is remarkable. It would have been unimaginable not too long ago. This level of trust results from common technical expertise, our similar background in national security issues, and our mutual respect."

—Gloria Wilt

Key Words: arms reduction; Chelyabinsk-70; gamma-ray spectrometer; highly enriched uranium (HEU); Initiatives for Proliferation Prevention (IPP); International Science and Technology Center (ISTC); laboratory-to-laboratory program; low-enriched uranium (LEU); Materials Protection, Control, and Accounting (MPC&A) program; newly independent states (NIS); nuclear nonproliferation; Nunn–Lugar Cooperative Threat Reduction bill; safeguards, transparency, and irreversibility; transparency measures; verification; vulnerability analysis; Russia.

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Figure 6. This prototype gamma-ray spectrometer can quickly, easily, and nondestructively determine the isotopic signatures of plutonium and enriched uranium using computer codes developed at Livermore.

About the Team

Lawrence Livermore personnel who contributed to this article are: (back row, left to right) PAUL HERMAN, JIM MORGAN, and SCOTT MCALLISTER; (front row) BILL DUNLOP, EILEEN VERGINO, and DOUG LEICH. (Not pictured are T. R. KONCHER, DEBBIE BALL, and JANET HAUBER.) All, except Leich, are members of the Proliferation Prevention and Arms Control Program, which is part of the Nonproliferation, Arms Control, and International Security Directorate. Leich is part of the Fusion Energy and Systems Safety Program in the Energy Directorate.

The work of these scientists and engineers is performed under the auspices of the U.S. Departments of Energy and State and focuses on reducing the risks of nuclear proliferation through collaboration and partnership with scientists and engineers in the newly independent states of the former Soviet Union. Projects range from negotiating mutually acceptable ways to monitor arms reduction and the disposition of excess nuclear materials to developing technologies to safeguard nuclear materials from theft or diversion to promoting commercial, non-weapons applications of nuclear weapons know-how and technology.