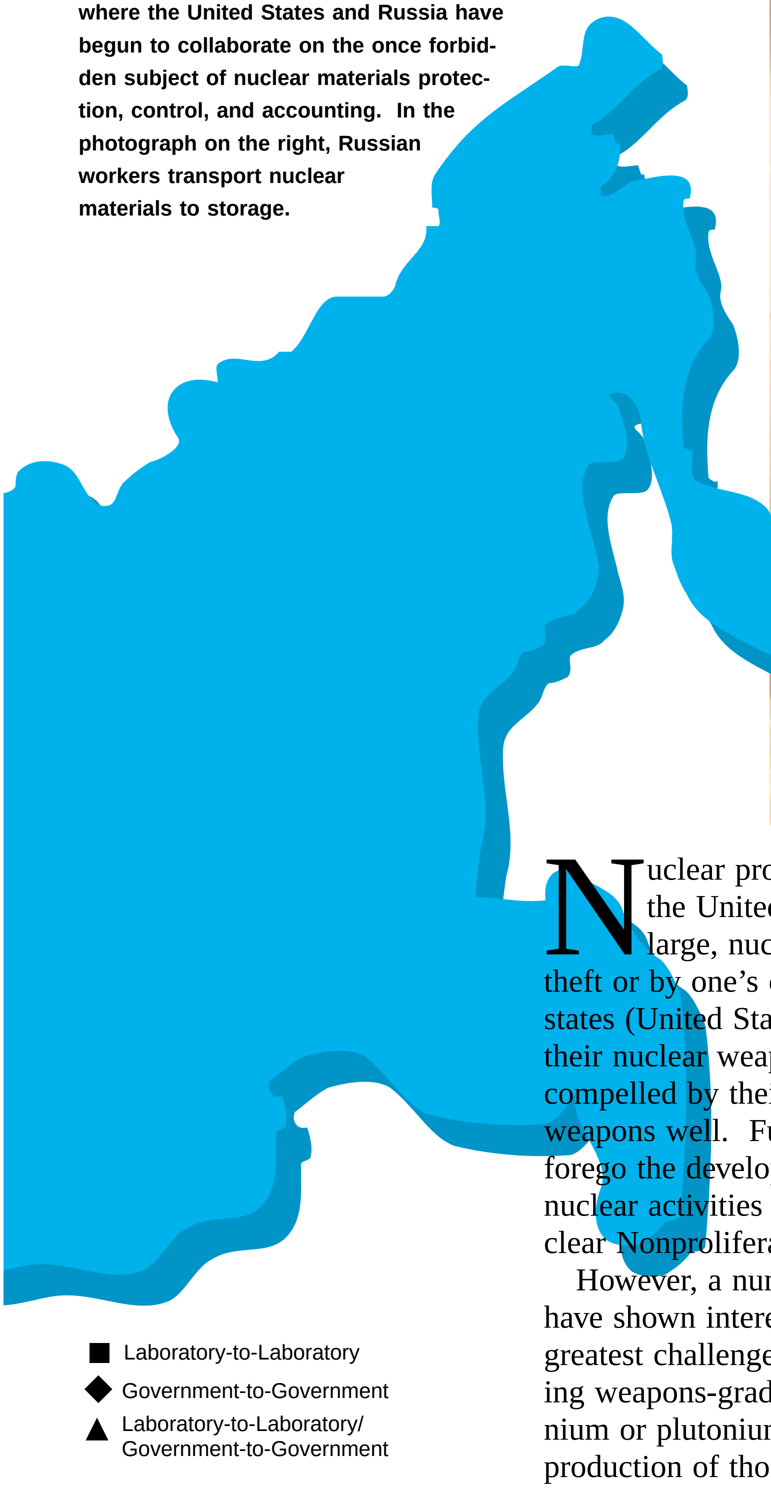
Russian-American MPC&A

Nuclear Materials Protection, Control, and Accounting in the Russian Federation

Ronald H. Augustson and John R. Phillips
as told to Debra A. Daugherty

Figure 1. The map of the Russian Federation below shows the nuclear facilities where the United States and Russia have begun to collaborate on the once forbidden subject of nuclear materials protection, control, and accounting. In the photograph on the right, Russian workers transport nuclear materials to storage.



Nuclear proliferation and terrorism pose serious threats to the United States. Fortunately for us and the world at large, nuclear weapons are difficult to obtain whether by theft or by one's own labor. The five recognized nuclear weapons states (United States, Russia, Britain, France, and China) guard their nuclear weapons very tightly, and undeclared nuclear states, compelled by their own secrecy, probably also protect their weapons well. Furthermore, most nations have formally agreed to forego the development of nuclear weapons and to submit all their nuclear activities to international inspection by signing the Nuclear Nonproliferation Treaty (NPT).

However, a number of states, as well as certain terrorist groups, have shown interest in constructing their own weapons. Their greatest challenge is not designing the weapon but rather obtaining weapons-grade "fissile materials," either highly enriched uranium or plutonium, neither of which exist in nature. Because the production of those nuclear explosives requires a significant expenditure of time and money, potential nuclear weapons states may prefer the alternative—obtaining the materials by theft.

Since the dissolution of the Soviet Union in December 1991, that prospect has become even more worrisome. Economic decline and political unrest within the former Soviet Union have raised concern about the security of nuclear materials there, and reports of small amounts of weapons-grade material found in Germany and other places during the past five years have fed that concern. As a result the United States has taken an active role in helping the Russians maintain the security of their nuclear materials.

Los Alamos scientists became involved in that effort in 1992 as part of the Nunn-Lugar-sponsored "government-to-government" programs initiated immediately following the collapse of the Soviet Union. But, through an outgrowth of the "lab-to-lab" scientific conversion program between Los Alamos and Arzamas-16, its sister city in Russia, the program in nuclear materials protection, control, and accounting—or MPC&A—has been able to make substantial progress. This article traces the development and accomplishments of lab-to-lab MPC&A and discusses the impact of that program on the larger government-to-government program.

From left to right, Vladimir Belugin, Sigfried Hecker, Radi Il'kaev, and Steven Younger form the group that initiated the lab-to-lab MPC&A program.

The History Behind MPC&A

During the Cold War, both the United States and the Soviet Union accumulated enough weapons-grade fissile material to build tens of thousands of nuclear weapons. Both countries have also been acutely aware of the various threats of theft, which range from armed attack by commandos to the more insidious threat from insiders, and both have implemented safeguards to defend their fissile materials. Yet, their approaches have been very different.

In the United States, an external threat—for example, an overt armed attack on a nuclear facility or the hijacking of a nuclear shipment in transit—is countered by physical protection, such as armed guards and high fences. The more subtle internal threat—covert diversion or theft of nuclear materials—is countered by internal control systems, for example, computerized materials control and accounting systems. Those consist of sophisticated radiation sensors integrated with a network of computers that monitor nuclear materials from the moment they enter a facility to the time they leave again. Together, the United States refers to those safeguards against external and internal threats as MPC&A.

In the Soviet Union, however, both external and internal threats have historically been handled by physical protection combined with strong "people control." Whereas most Soviet nuclear facilities were surrounded by physical security to deter and defend against external attackers, it was the "people control" that prevented theft by insiders. The omnipresence of the KGB and the threat of harsh penalties made clandestine behavior among insiders unlikely. That system, under the Soviets, was considered virtually impenetrable.

In recent years, however, fundamental economic, political, and social changes in Russia have put that system into question. When the Soviet Union collapsed in 1991, weapons funding plummeted drastically as the economy, rather than the military, came to the forefront of Russia's concerns. Likewise, the welfare of the formerly honored Soviet defense workers was suddenly in serious jeopardy. Their salaries were frozen by the government and eroded by inflation such that, today, a typical weapons scientist is paid about 30 to 50 dollars per month. Financial need and possible disillusionment among Russian nuclear workers might make the surreptitious diversion of even a small amount of weapons-grade fissile material all too tempting.

Yet, thankfully, there have not been any violations of Russian nuclear safeguards that resulted in the loss of enough nuclear material for a weapon. Although confident that their system remains relatively secure, the Russians want to add controls and accounting to their existing physical protection to bring their nuclear safeguards into line with their new socio-political order. Russian weapons scientists and government officials alike have expressed interest in adopting controls and accounting techniques like those used in the United States.

In November 1991, the Nunn-Lugar bill redirected four hundred million dollars of Department of Defense (DOD) funds to assist with the "transportation, storage, safeguarding, and destruction of nuclear and other weapons [and] the prevention of weapons proliferation." Two Nunn-Lugar programs specifically funded MPC&A. Under one program, a storage facility for fissile materials from nuclear weapons dismantled under the Strategic Arms Reduction Treaties (START I and II) would be constructed and equipped with MPC&A systems. Under the other, MPC&A improvements would be implemented at civilian Russian nuclear institutes. Unfortunately, both of those programs initially moved relatively slowly.

Fortunately, at the same time, some of us from Los Alamos had the chance to informally discuss many aspects of MPC&A theory and design with the Russian scientists from Arzamas-16. Although the Russians were not familiar with computerized controls and accounting, they learned quickly, and our conversations with the Arzamas-16 scientists, especially Sergei Zykov and Vladimir Yuferev, later formed the basis of our joint work with Arzamas-16 under the auspices of the lab-to-lab MC&A program.

While our relationship with those scientists was forming, numerous reports of nuclear materials theft in 1992 and 1993 prompted the Senate Armed Services Committee to address nuclear materials safeguards in the former Soviet Union and the potential for nuclear proliferation. Under Secretary of Energy Charles Curtis attended those hearings and was urged to accelerate efforts being made through government-to-government channels. Two days later Sigfried Hecker, the Director of Los Alamos National Laboratory, had an introductory meeting with the newly appointed Curtis, and Curtis asked him if anything could be done to help the Russians safeguard their nuclear materials. Hecker had a ready answer. He suggested that the lab-to-lab scientific collaborations with Arzamas-16 (see "Lab-to-Lab Scientific Collaborations Between Los Alamos and Arzamas-16 Using Explosive-Driven Flux-Compression Generators") be extended to include MPC&A. Curtis made sure that two million dollars from the Department of Energy (DOE) 1994 budget were allocated to get the program started, and Mark Mullen, Gene Kutyreff, and I (Ron Augustson) began to develop a plan.

We designed the lab-to-lab MPC&A program to be a joint effort like the scientific program. Money would be divided into three roughly equal parts: Russian salaries, American salaries, and equipment. Our initial effort would focus on creating a demonstration of MPC&A for the officials at nuclear institutions that would show them what could be done. In June 1994, a small delegation from Los Alamos went to Russia to negotiate and sign contracts, and our first stop was Arzamas-16. In two days, we signed six contracts with Arzamas. Under the first five, we would produce specific products for computerized controls and accounting. Under the sixth, we would combine the products of the first five contracts into a demonstration that could be used to raise interest in materials control and accounting among the leaders of the Russian nuclear institutes.

That summer we also signed contracts with scientists from the Kurchatov Institute, Chelyabinsk-70, and in November, the Institute of Physics and Power Engineering at Obninsk. We teamed up with five other U.S. national laboratories—Brookhaven, Lawrence Livermore, Oak Ridge, Pacific Northwest, and Sandia—and since then, progress has been rapid at Arzamas-16, IPPE, and the Kurchatov Institute. In the following sections, we describe the work done at those three nuclear institutes, and using the demonstration at Arzamas-16 as a guide, we elaborate on the various features and procedures of MPC&A.

Arzamas-16

Arzamas-16, a city located about 250 miles east of Moscow, existed in complete secrecy throughout the cold war, unheard of to all Soviet citizens outside the Soviet defense complex. Although its name and location are now public knowledge, Arzamas-16 remains a closed city to this day. Forty miles of double fence surround the city and armed guards from the Interior Ministry patrol the perimeter. Visitors to the city are scrutinized and subjected to severe restrictions.[1] Physical protection against outside threats is formidable.

To protect against insiders, however, the scientists at Arzamas-16 wanted to develop a materials controls and accounting (MC&A) system like the one we discussed during work on the Nunn-Lugar storage facility. For a start, we decided to develop a realistic demonstration that would not only arouse the interest of officials at other facilities, but would also serve as a starting point within Arzamas-16 from which the MC&A could spread. The demonstration was a very ambitious prototype with many different components (see Figure 2) that provides a test bed for instruments and systems elements. Although it was designed as if it were to be applied at a storage facility, the demonstration was equipped with instruments that are useful for all sorts of nuclear facilities. (The demonstration does not duplicate any system that will actually be installed.) In all, thirty-nine integrated systems were installed, about half of which were Russian. We Americans contributed financial support, advice, and equipment, but the demonstration was designed and constructed entirely by the Russians.

Nuclear facilities in general are run by four different groups of people who perform four different tasks: protection, management, security, and materials

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[1] Not only are visitors required to apply for permission from MinAtom a month and a half in advance of their visit, but all cameras, computers, and listening devices are taken away from them as they enter the city.

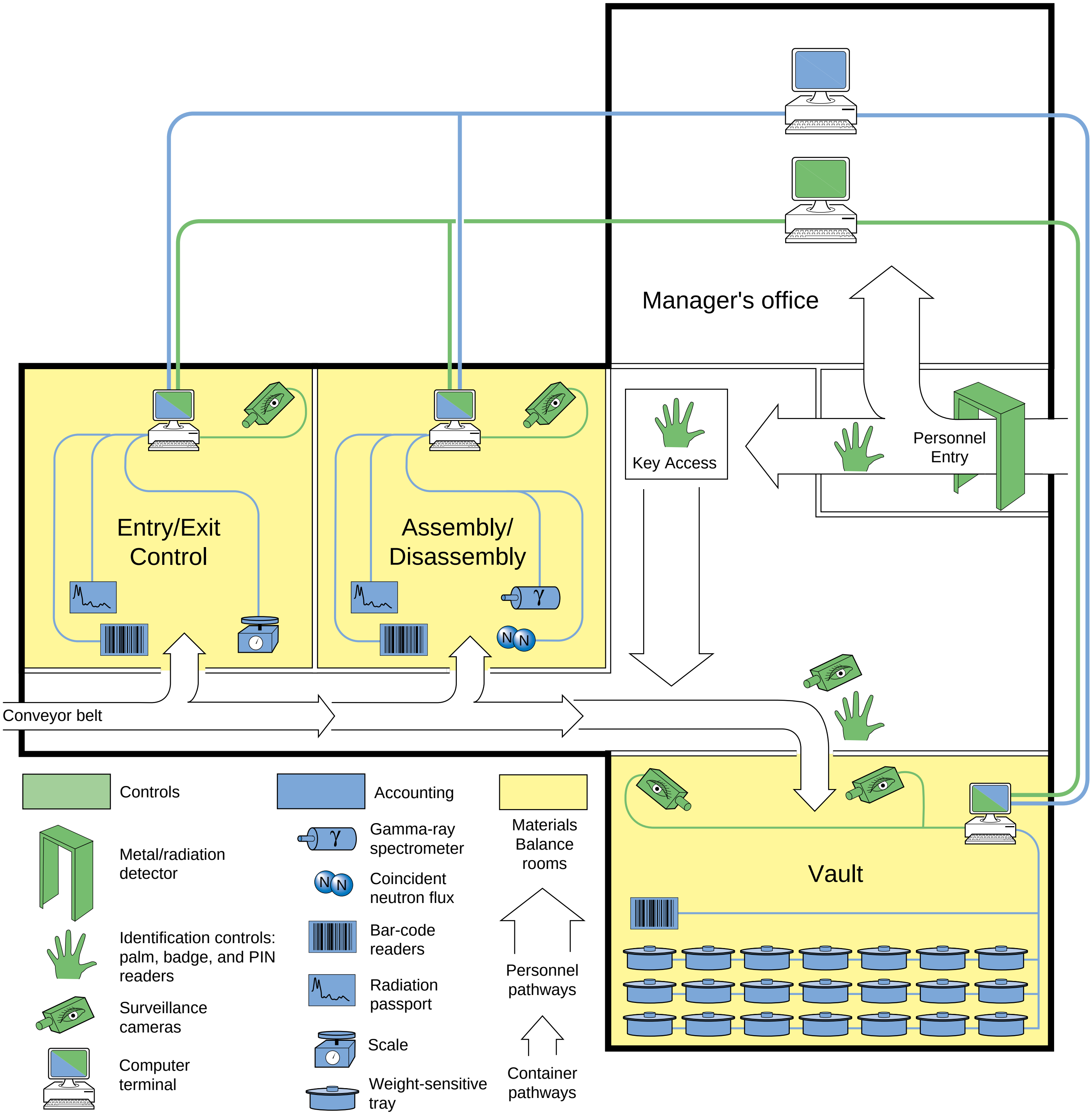

Figure 2. The Arzamas-16 Demonstration

This is a conceptual diagram of the Arzamas-16 demonstration MC&A system. Controls, which limit and monitor access to materials, are shown in green, instruments for accounting in blue, and the three Materials Balance rooms in yellow. All controls and accounting equipment are connected to a computer terminal in each Materials Balance room, and the terminal is connected to the central controls and accounting computers in the Manager's office. Bar code readers play a dual-role between controls and accounting. Not only are they used to identify containers, they also track the movement of materials through the facility.

handling. To promote control, the workers are typically separated on the basis of the task they perform. The protection forces work outside the facility. Inside, managers are limited to the Manager's Office, while security officers and materials handlers work in the Materials Balance rooms (shown in yellow in Figure 2). That separation of functions helps prevent theft.

The demonstration was designed such that managers, security officers, and materials handlers all enter the facility through a single entrance, called Personnel Entry, that is separate from the entrance for materials. As they enter, workers pass through radiation and metal detectors, and their identity is determined by a palm reader, badge reader, and personal identification number (see Figure 3). The computerized MC&A system then unlocks the appropriate door at the end of the Personnel Entry to let managers into the Manager's Office and security officers and materials handlers to the Key Access area. After passing through the Entry, managers no longer interact with security officers and materials handlers directly.

Instead, managers "oversee" the operation of the facility via two central computers. The central computers are connected to computer terminals in each of the Materials Balance rooms, which, in turn, are connected to the controls and accounting instruments in those rooms. One of the central computers, the "accounting" computer, keeps an inventory of the material in every room that is updated in real time as containers of nuclear material enter, exit, and move through the facility. The other computer, the "controls" computer, supervises the movement of materials within the facility and restricts access to materials.

Under the watchful eye of the managers, materials handlers and security officers obtain keys to the Materials Balance rooms from the Key Access area. They are required to operate in teams of three that consist of two materials handlers and a security officer. All three must be identified by their palm, badge, and personal identification number. Then, if the team has permission from the Manager's Office, a key to the appropriate room will be released from the keyboard.

Figure 3. Access Controls
The palm reader on the left determines a worker's identity on the basis of the size and shape of their hand. The size and shape are calculated from the capacitance between the hand and a grid of plates inside the palm reader. The palm, badge, and personal identification number readers (below) are used to identify workers throughout a nuclear facility. On the basis of a worker's identity, access to nuclear materials may be allowed or denied.

To illustrate the operation of the facility, let us assume that a team has obtained a key to the Entry/Exit Control room (on the left in Figure 2), where workers check the contents of incoming and outgoing containers of nuclear material. Newly-arrived containers are brought to the door of the Entry/Exit Control room by a conveyor belt, each with paperwork that lists the container's identification number and contents. Each container also has a bar code, which encodes the same information as the paperwork. At the door to the Entry/Exit Control room, a worker uses a hand-held scanner to read each container's bar code and checks the results with the paperwork. Because the scanner is connected to the accounting computer in the Manager's Office, the new container is automatically registered into the inventory of the facility.

Even if the paperwork and bar code agree, the team weighs the container to make sure its mass is consistent with the alleged contents, and they visually inspect the container's seal to make sure it hasn't been opened. They also verify the identity of the container by measuring its "radiation passport" (see Figure 4). In that way, the team checks and rechecks the validity of the container by independent methods.

When the team has finished inspect-

Figure 4. The Radiation Passport

The "radiation passport," which is a low-resolution measurement of the gamma-ray spectrum and neutron flux emitted by a container of nuclear material, provides a unique and highly reliable method of identifying individual containers. The graph on the right shows two low resolution gamma-ray spectra. Each peak in a given spectrum corresponds to gamma rays of a given energy, and the relative heights of those peaks are unique to a given container.

A record of the radiation passport for each container is stored in the central accounting computer. When a new container arrives at a facility, its identity is checked by measuring its radiation passport and comparing it with the passport on record for that container. If, for example, the two spectra in the figure were the measured and recorded passports, the central accounting computer would reject the alleged identity of the container.

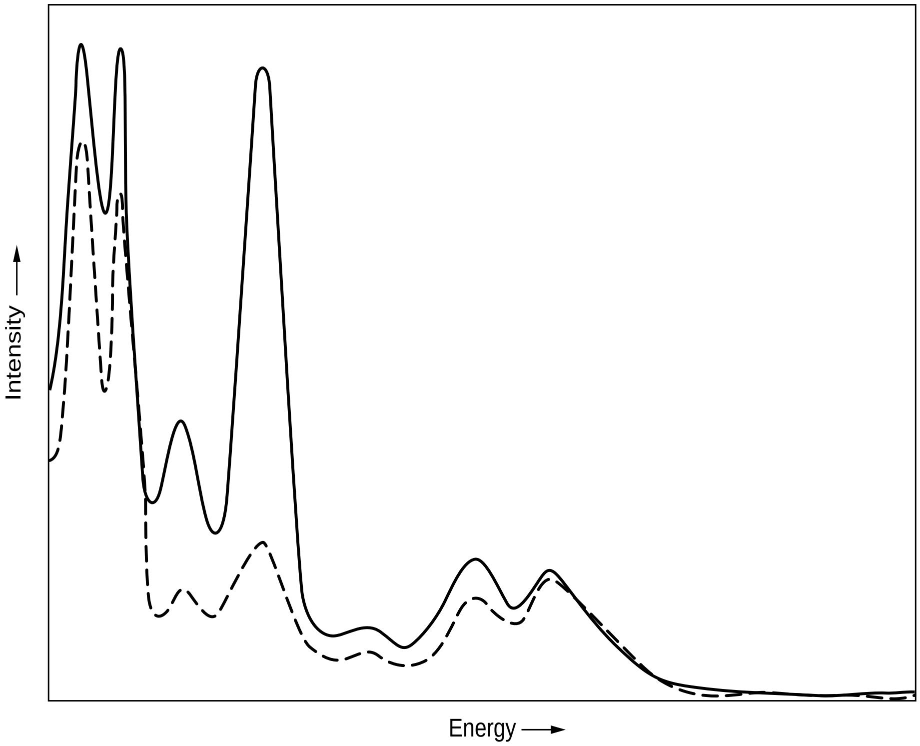

Figure 5. Gamma-ray Detector

In the photograph on the right, Sergei Razinkov and Valeri Belov from Arzamas-16 examines an American-made gamma-ray detector. The high-resolution spectrum produced by that detector can be used to determine the relative masses of the different isotopes of nuclear material inside the container. With a precise count of the fission neutrons emitted by the material, and knowing the decay rates of the isotopes of plutonium and uranium, the total mass of each isotope inside the container can be calculated.

ing the container in the Entry/Exit Control room, it can be taken to the Assembly/Disassembly room or straight to the Vault. Let us assume that, because the material arrived in shipping containers, the team must take the material to the Assembly/Disassembly room to put it in storage containers. Before they leave Entry/Exit Control, one worker must enter the destination of the container into the computer terminal. Another worker reads the container's bar code, which makes the central controls computer start a timer. If the container is not detected in the Assembly/Disassembly room in a certain amount of time, the controls computer will sound an alarm.

When the container's bar code is read at the door to the Assembly/Disassembly room, the timer is stopped.

The shipping container is then opened and the materials are redistributed among storage containers. New bar codes and radiation passports have to be established for each new storage container.

One worker allocates identification numbers for the new storage containers on the computer terminal while another worker measures their radiation passports. The accounting computer records the radiation passport along with the identification number of each container for future identification purposes (see Figure 4). The precise isotopic composition of the contents of each container is then determined from a high-resolution measurement of the container's gamma-ray spectrum and fission neutron flux (see Figure 5). A new bar code listing the container's identification number and the isotopic composition of its contents is printed out for each new storage container.

Now that the material is prepared for storage, one of the workers enters the next destination—the Vault—into the computer terminal. Another reads the bar code on the storage container to start the timer. Like the vault in a bank, the storage vault is barricaded by an extremely heavy door. All three members of the team must be identified by their palm, badge, and personal identification number, and if that team has permission from the Manager's Office, the controls computer unlocks the door. The computer terminal inside the Vault lists the "station" where each container is to be placed. The team then reads the bar code of each container and its station to register them into the inventory stored on the accounting computer (Figure 6).

Figure 6. The Vault

As many as 20,000 containers can be kept in the vault of a typical storage facility on shelves like the ones above. The bar code reader shown in the bottom center of the photograph is used to register both the container and its station into the accounting computer's inventory. The containers are placed on weight-sensitive trays, which are monitored by the controls computer to make sure that the containers are not moved without permission. Surveillance in the vault is strict. Several cameras are dedicated to watching the Vault door, while a number of others oversee the containers themselves. The video images produced by those cameras are digitally processed by the controls computer to search for unauthorized movement within the vault.

The Vault, like the hallways of the demonstration, is continuously watched by video cameras, which are monitored by the controls computer. The images from the camera are digitally processed, and unauthorized changes in the images automatically set off an alarm.

In January 1995, only six months after the contracts with Arzamas-16 had been signed, the demonstration facility was up and running. The successful demonstration spurred interest in the design and possible installation of systems that would meet the specific needs of relevant facilities. Interest was intense in both Russia and the United States. Representatives of the U.S. national laboratories were the first to visit the demonstration, followed by Russian government officials, Russian nuclear facility operators, and American congressmen. In May 1995, the Minister of Atomic Energy Viktor Mikhailov asked Arzamas-16 to transport the demonstration to Moscow and set it up in a conference room next to his office so that it would be accessible to everyone. In a single day, well over one hundred representatives from both Russian and American nuclear facilities and government agencies went through the Arzamas-16 demonstration, including the U.S. Secretary of Energy Hazel O'Leary.

The Institute of Physics and Power Engineering

The Institute of Physics and Power Engineering (IPPE) is located about 100 kilometers southwest of Moscow in the city of Obninsk, Russia. Although IPPE is administered by MINATOM, it is not a defense facility but rather a civilian center for research and development of nuclear technologies. At IPPE's Bystrye Fisicheskie Stendy (BFS) facility, scientists perform research on fast breeder reactors using the two critical assemblies BFS-1 and BFS-2.

In August 1994, not long after we had signed contracts with Arzamas-16, IPPE was brought into the public eye by a front-page article of the *New York Times* called "Russian Nuclear Materials Controls Are Leaky." As described in the article, the eight metric tons of highly enriched uranium and plutonium at BFS are in the form of thousands of small, hockey-puck-sized disks (Figure 7). The disks, which are used in reactor fuel rods, are "clad" in aluminum or stainless steel that absorbs the alpha and beta radiation of the uranium or plutonium in the disks. Therefore, a thief could simply place a few disks in his pockets without fear of being exposed to radiation. The *Times* article highlighted the proliferation risks associated with those disks.

Following up on several preliminary contacts in September and October of 1994, John Phillips from Los Alamos and representatives from five other U.S. national laboratories visited IPPE in November to initiate a lab-to-lab MPC&A program there. With the Russian scientists, we decided to concentrate our efforts on the so-called "Stone Sack," an isolated section within the BFS facility that contains the BFS-1 and BFS-2 reactor rooms, a storage vault, a manager's office, and a large portion of the most attractive nuclear materials at IPPE.

We began by installing a four-tiered system of controls. At the outermost fence surrounding the BFS facility, we installed a vehicle monitor to detect nuclear material in vehicles leaving the site (Figure 8). Inside the fence, at the entrance to the BFS facility, we put a radiation detector that can detect a single disk of highly-enriched uranium or plutonium. A "people trap" developed by the Russian company Technocom,[2] was placed at the entrance to the Stone Sack within BFS. The people trap is a sophisticated system of controls that includes palm, badge, and personal identification number readers, a scale to check the worker's weight, and metal and radiation detectors. Any violation will trigger the people trap to ensnare the offender. Finally, surveillance cameras were installed to monitor any slight changes in the storage areas and the reactor rooms.

Figure 7. Researchers at IPPE
In reactor research, fuel rods of various configurations are built out of large numbers of disks such as the one above. Bar coding the disks that contain nuclear material was the first step in the implementation of computerized accounting at IPPE.

Figure 8. The Vehicle Monitor
The large white posts on either side of the truck contain sensitive gamma-ray and neutron detectors that measure the amount of nuclear material inside the truck. If the measured amount is greater than expected, the vehicle must stop for inspection.

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[2] Tehnocom is a private enterprise formed by former Arzamas-16 weapons scientists that provides a number of technologies to the Russian defense complex.

As a precursor to a total computerized accounting system, we installed "stand-alone" accounting equipment in the Stone Sack. The two reactor rooms and the storage vault were equipped with low-resolution gamma-ray spectrometers to measure the radiation passports of the disks. High-resolution gamma-ray spectrometers and fission neutron counters were installed near both of the reactor rooms to measure the isotopic composition of the disks.

The tens of thousands of disks of nuclear material are in the process of being labeled with bar codes that list the identification number and contents of the disk—that process alone is expected to take three years to complete. A network of computers and bar code readers was installed in the two reactor rooms, the storage vault, and the manager's office, and in the near future, we plan to connect the stand-alone accounting equipment into the network.

The work done at IPPE marked one of the first times the lab-to-lab MPC&A program had implemented a safeguards program that protected real nuclear materials. IPPE also houses the MINATOM training center where workers from other Russian facilities can come to learn about MPC&A.

The Kurchatov Institute

The Kurchatov Institute in Moscow is a leading research center in the design of nuclear reactors for space and naval propulsion. Kurchatov has been independent of MINATOM since 1992. Its accessible location and its advocacy of the importance of improved safeguards made Kurchatov a priority for the lab-to-lab MPC&A program.

We focused our efforts on Building 116 where two critical assemblies, the Nartzis and the Astra, are used for nuclear reactor studies. Like the disks at IPPE, the nuclear material used in Building 116 is in relatively small, and therefore vulnerable, units—tiny "pellets" for the Nartzis and baseball-sized "pebbles" for the Astra. Thousands of such pellets and pebbles, each of which contains a few grams of nuclear material, are kept within the two storage rooms and two reactor rooms in Building 116.

Figure 9. Building 116
Building 116 at the Kurchatov Institute houses two experimental critical assemblies, the Nartzis and the Astra, and a large amount of nuclear materials.

Most of our work at the Kurchatov Institute has addressed the most pressing issue of physical protection. The grounds around Building 116 were cleared of bushes and trees to improve surveillance of the area, and we erected tall, sturdy fences and gates as shown in Figure 10.

We also installed surveillance and certain controls. Video cameras and infrared sensors, which detect the presence of people by the heat they give off, were installed along the perimeter of the facility, and additional cameras were installed inside the building. All windows and all but one entrance to Building 116 were sealed off, and the entrance was equipped with a people trap similar to the one at IPPE.

Lastly, we supported Kurchatov in taking total inventory of the nuclear materials of the two critical assemblies. Computer terminals were placed in each of the critical assembly rooms, and a third was installed in a separate building at the Kurchatov Institute, and the inventory is updated on the computer as it changes.

In December 1994, the Kurchatov Institute was the very first Russian nuclear institute to demonstrate its new safeguards. In February 1996, the Russian Navy[3] visited Building 116. Since then, the Navy has signed contracts through Kurchatov to begin lab-to-lab MPC&A work.

Conclusion

In less than two years, the lab-to-lab MPC&A program has made remarkable progress, and we expect progress to continue. New contracts have been signed to install complete computerized MC&A systems at the Arzamas-16 crit-

[3] The Kurchatov Institute maintains a close relationship with the Russian Navy because the nuclear reactors for the Navy's submarines and surface ships were originally designed at Kurchatov.

Figure 10. Before and After

The top photograph shows the gate outside Building 116 of the Kurchatov Institute before the lab-to-lab MPC&A program, and the bottom photograph shows the same gate after. Physical protection such as strong fences and secure gates is the focus of our work at the Kurchatov Institute.

ical assembly and processing facility, IPPE's central storage and processing facilities, and the Kurchatov Institute's central storage facility. And progress at Chelyabinsk-70 has been steady. Personnel and vehicle monitors have been installed at the Chelyabinsk critical assembly area, and the vehicle monitor has survived its first Siberian winter. Soon we will install a computerized MC&A system there.

Three other Russian nuclear institutes have recently joined our program. Two of them, the Institutes of Automatics and Non-Organics, will be developing and constructing instruments and developing methods for MPC&A. At the third, Tomsk-7, we will be installing computerized MC&A systems at the spent-fuel reprocessing and uranium processing plants. In January 1996, the Russian Minister of Atomic Energy Viktor Mikhailov and the U.S. Secretary of Energy Hazel O'Leary signed a joint statement to open up Sverdlovsk-44 and Krasnoyarsk-26 to the lab-to-lab MPC&A program.

The trust and confidence that has been built up between the Russians and the Americans under the lab-to-lab MPC&A program has helped the government-to-government MPC&A program make progress. Our work has also inspired collaborations with two new Russian agencies. DOE has been allocated 10 million dollars for a new collaboration with Gosatomnadzor (GAN), the Russian equivalent of the U.S. Nuclear Regulatory Commission, and the U.S. national laboratories have been allocated 5 million dollars for a collaboration with the Russian Navy which involves the Kurchatov Institute as a partner.

Funding for the lab-to-lab program has increased from the two-million-dollar "start-up" fund of 1994 to 15 million dollars in 1995. Forty-five million dollars are budgeted for 1996, and plans are for funding to expand next year and continue until 2002, at which time Russia and its nuclear institutes should have sufficient infrastructure and resources, both human and technological, to carry on the work of MPC&A independently.

Above all, we would like to mention that the commitment of our Russian colleagues has been critical to the success of the lab-to-lab MPC&A program. Without their understanding and vision, we could not have met with such success. On the American side, we would like to acknowledge the contributions of the staff from all six participating DOE laboratories who worked very well together to solve technical, administrative, and cultural problems. The chemistry of the Joint Russian/American team has been tremendous. ■

Acknowledgements

We would especially like to thank all those at Los Alamos who have made exceptional contributions to the lab-to-lab MPC&A program, including Mark Mullen, Gene Kutyreff, Edward Kern, Cheryl Rodriguez, Tom Sampson, Gregory Sheppard, Susan Voss, Rob York, Boris Rosev, and Richard Wallace. Finally, the program could not have happened without the support and personal involvement of DOE management.

Further Reading

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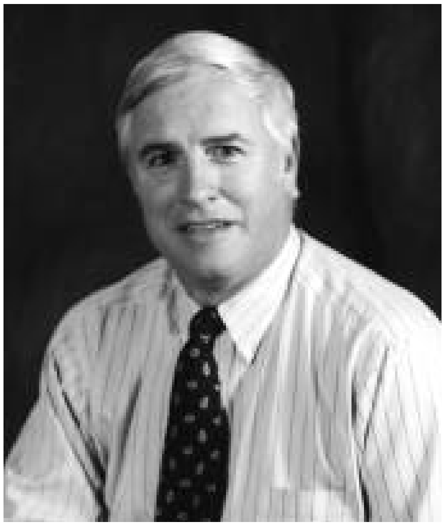
Ronald H. Augustson is the project leader for the Russian/American Lab-to-Lab Nuclear Material Protection, Control, and Accounting program at Los Alamos, and he is a member of that program's steering group.

Ron received his doctorate in physics from Rensselaer Polytechnic Institute in 1967. During the same year, Ron joined the Nuclear Materials Safeguards Program at Los Alamos to work on the development and implementation of neutron and gamma-ray based nondestructive assay techniques. In 1977, he was appointed technical project manager and group leader for the development of a dynamic nuclear-materials control system for the Los Alamos plutonium fabrication facility. In the summer of 1979, Ron took a position with the International Atomic Energy Agency in Vienna for 3 years, work that brought him to Tokai-Mura, Japan. After he returned to Los Alamos in 1982, Ron became the Los Alamos liaison for the U.S. Technical Support Program to the IAEA Safeguards Department. In 1992, he became involved with Russian nuclear safeguards by helping to design the Nunn-Lugar Russian Fissile Material Storage Facility. In the spring of 1994, Ron contributed to the formation of the Russian/American lab-to-lab MPC&A program that led to his present position.

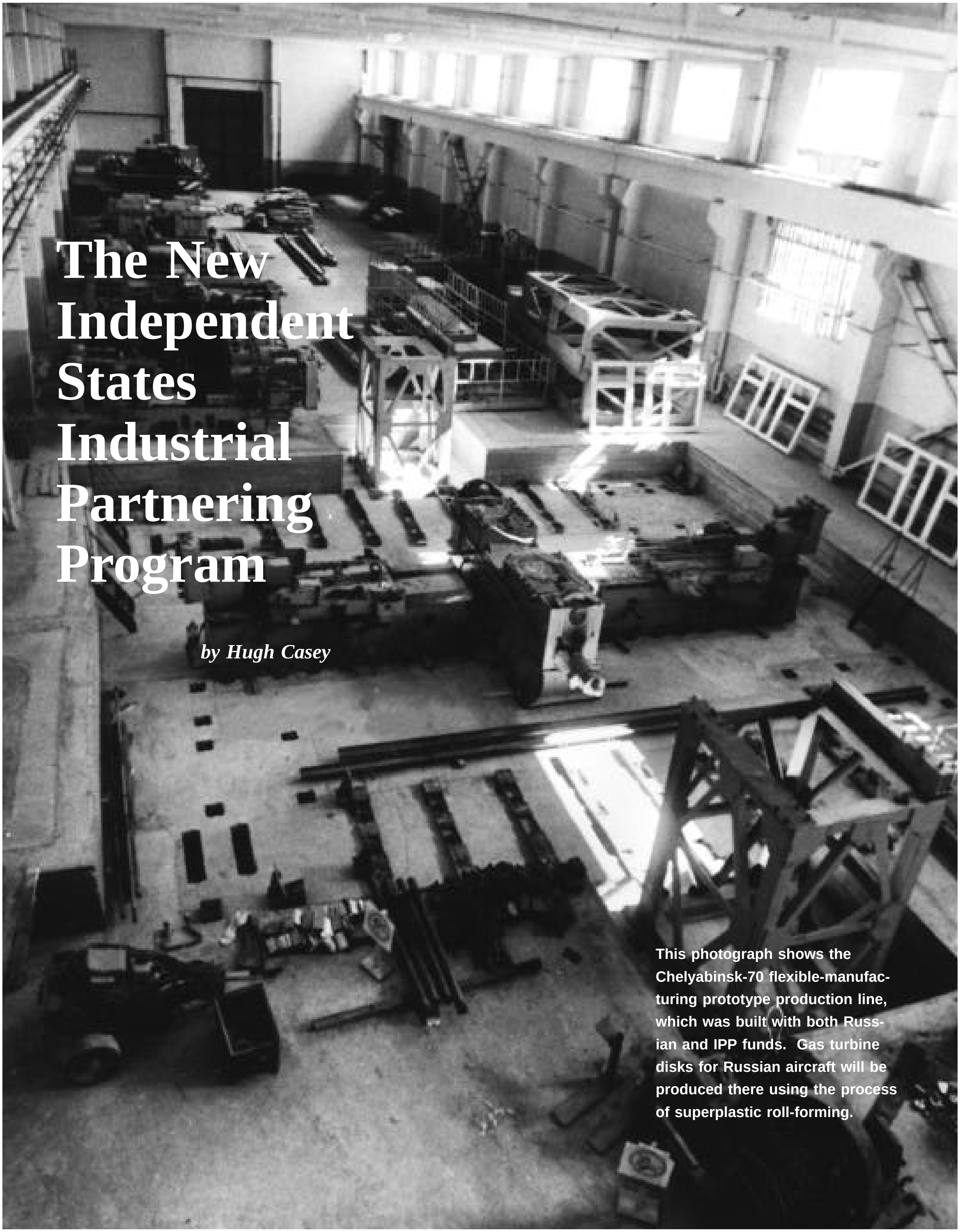


John R. Phillips has served as the team leader for the U.S. multi-laboratory support for the Russian/American MPC&A program at the Institute of Physics and Power Engineering (IPPE) in Obninsk, Russia. He is also a member of a multi-laboratory team developing a program for DOE on Countering Nuclear Smuggling.

John has a Ph.D. in analytical chemistry and an MBA from the University of New Mexico. He has served as a technical expert to the IAEA for the development and implementation of nondestructive assay instrumentation. He has served on a number of advisory groups including the DOE Laboratory Advisory Group on Effluent Research (LAGER). He has served as a member of the UNSCOM inspection team that discovered the calutron and centrifuge enrichment systems in Iraq following the Gulf War. His technical interests include spent-fuel examination, analytical chemistry of actinides, assessment of nuclear capabilities of potential proliferants, and effluent monitoring and analysis.

The New Independent States Industrial Partnering Program

by Hugh Casey



This photograph shows the Chelyabinsk-70 flexible-manufacturing prototype production line, which was built with both Russian and IPP funds. Gas turbine disks for Russian aircraft will be produced there using the process of superplastic roll-forming.

During the Cold War, the Soviet Union developed a vast infrastructure of science and technology to support its defense needs. In contrast with the United States, however, the Soviet Union had no civilian research and development supporting a private sector. Consequently, thousands of scientists skilled in the various aspects of weapons development, including weapons of mass destruction, have found themselves ill-equipped to deal with the economic crisis that accompanied the Soviet Union's collapse. There are few alternative employment opportunities for those highly skilled specialists, and the possibility exists for defection of personnel or sales of sensitive information to rogue nations.

Figure 1. The New Independent States

On December 25, 1991, the Soviet Union broke up into the 15 New Independent States (NIS) shown above. All members of the NIS are eligible to participate in the Industrial Partnering Program; however, as a nonproliferation program, IPP focuses on the four "nuclear successor states"—Russia, Belarus, Kazakhstan, and Ukraine.

The Industrial Partnering Program (IPP) addresses the threat of "brain drain" by engaging weapons scientists from the New Independent States (NIS) (Figure 1) in cooperative research and development projects. The projects are specifically directed toward the development of non-military applications for the scientists' skills and technologies. The Department of Energy (DOE) laboratories identify and evaluate the technologies and facilitate the involvement of U.S. industry, which, in turn, shares the cost of the research and development effort and supports the commercialization phase of successful ventures.

The foundations of IPP date back to the late 1980s and President Gorbachev's policy of *glasnost*, or "openness," when the Soviet Union began overt attempts to market defense-based technology in eastern and western Europe. In 1988, the Soviets sponsored their first MATec conference in Helsinki, Finland, featuring advanced materials and manufacturing technologies from the Soviet defense institutes. Tony Rollett, 'Krik' Krikorian, and I, all from Los Alamos, were among the few Americans who attended.

I was specifically interested in the high-powered Soviet gyrotrons, which produce ultrahigh-frequency collimated microwave beams because at Los Alamos we had been experimenting with microwave sintering of ceramics. Our low-power industrial equipment was inadequate, and we were unable to obtain funding to build a more appropriate microwave source. During my conversations with Soviet scientists at MATec, I became convinced of the value of the Soviet gyrotron technology, not only for defense but for industry at large.

Our research on microwave technology continued, but it was not until several years later, following the collapse of the Soviet Union, that we had the opportunity to acquire the Soviet gyrotron technology. John Hnatio, who is the program manager for technology transfer at DOE, and I arranged a partnership between Los Alamos and the National Center for Manufacturing Sciences (NCMS), the United States largest consortium of manufacturing industries. With Hnatio's help, Los Alamos secured DOE funds from the Advanced Manufacturing Initiative (later called the Technology Transfer Initiative) to evaluate the equipment for NCMS applications. We acquired three gyrotron tubes and associated equipment from the Paton Institute in Kiev, Ukraine. With the help of Ukrainian and Russian engineers, we established a "user facility" at Los Alamos where the experimental work could be performed. Hnatio had also been instrumental in setting up an industrial consortium at Sandia Laboratory, and some of the member companies were interested in acquiring Russian technology.

When Senator Domenici expressed interest in involving U.S. industry in laboratory partnerships with the Russians, the labs held a series of three meetings to assess the level of interest and commitment on the part of U.S. industry to that concept. With positive response from industry, the Senator moved forward with legislation to provide funding for a program of technology transfer from NIS defense institutes to U.S. industry.

As a result, 35 million dollars were included in the fiscal year 1994 Foreign Operations Act to establish a "program of cooperation between scientific and engineering institutes in the New Independent States of the former Soviet Union and national laboratories and other qualified academic institutes in the United States" that was "designed to stabilize the technology base in the cooperating states" and to "prevent and reduce proliferation of weapons of mass destruction." More specifically, the U.S. national laboratories were to help NIS scientists convert their defense technologies into commercially viable products and to facilitate the transfer of those technologies to U.S. industry.

The Interlaboratory Board was formed between six U.S. national laboratories who prepared the original program plan for IPP. Since then, the board has grown to include all ten DOE multi-program laboratories. Following a long series of interagency negotiations, funds were received at the laboratories in July 1994. Shortly after receipt of funds, we helped establish the U.S. Industrial Coalition, a consortium of private companies with interests in investing in NIS technology.

In April 1994, confident that the funds would come through, I made my first trip to Russia accompanied by John Shaner. We visited Arzamas-16 and Chelyabinsk-70 as well as a number of institutes in the Moscow region, including the Institute for High Pressure Physics, the Bochvar Institute, and the Institute of Solid State Physics in Chernolgolovka. We collected a number of proposals, which we circulated to the technical divisions at Los Alamos. John Shaner and I headed up a committee of technical experts to select proposals for Los Alamos projects. Los Alamos received approximately 4.5 million of the 20 million dollars that were allocated for lab-to-institute projects. Our target was an average of 100,000 dollars per project, at least half of which had to be spent abroad at the Russian institutes. In August 1994, Los Alamos signed its first IPP contract with Arzamas-16, to be followed shortly thereafter by multiple contracts for twenty-four projects with twenty NIS institutes.

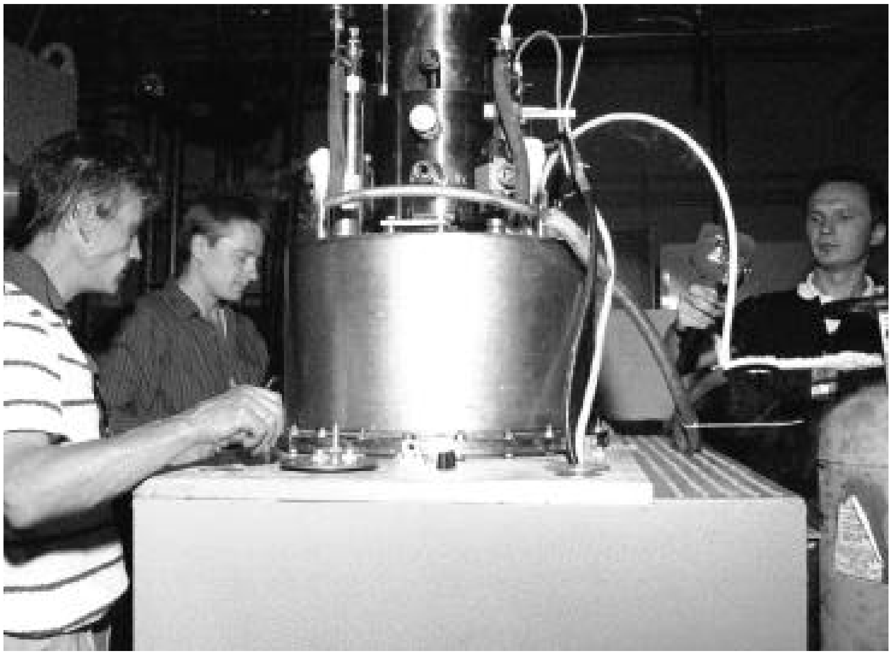


Figure 2. The Gyrotron

Peter Alekseevich Syrovets and Andrey Ivanovich Bunenko from the Paton Institute in Kiev, Ukraine, and Vladimir Ivanovich Irkhin from Gycom in Nizhny-Novogorod, Russia, are shown working on the gyrotron in the Los Alamos "user facility."

IPP projects cover a broad range of technologies that reflect the core competencies of the NIS institutes. The similarity of the NIS institutes' technical base with our own labs is not coincidental. Materials, manufacturing sciences, theory and modeling, lasers and particle beams, and sensors and diagnostics are all represented in the IPP project portfolio. We have a few fairly basic scientific projects, but most of our activities are in the areas of applied science and engineering. There are no military projects, and we have avoided technologies covered by other government programs. The following brief descriptions will illustrate the nature of the project work.

The Gyrotron

Since the days of the Advanced Manufacturing Initiative, the gyrotron project has matured and grown to capture the interest of the automotive, oil, electronics, communications, manufacturing, and aerospace industries. Individual companies participating include Ford Motor Company, AT&T, General Atomics, Tycom, Continental Electronics, Baxter Health Care, and Ferro, a list that indicates the diversity of applications as well as the level of industrial interest. The gyrotron (Figure 2) is being investigated for use in numerous operations, including heat treating auto windshields, sintering ceramic and plastic appliance hardware, coating tool bits, separating and recycling plastics, vitrifying radioactive sludge, and other fascinating applications. At Los Alamos and the Paton Institute, we investigate the interaction of the millimeter-wave radiation produced by the gyrotron with different materials. We then optimize the gyrotron to specific applications.

The first gyrotron-based "production machine" will be installed at Ford Motor Company this year, and we are assisting the scientists at the Paton Institute to set up user facilities in Kiev.

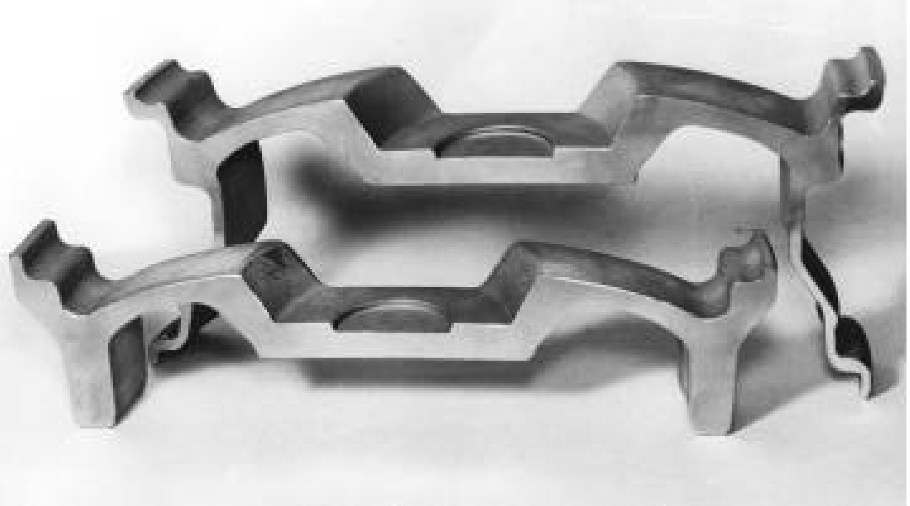


Figure 3. Superplastic Forming
The photograph above shows two cross sections of automobile wheel rims that were produced at the Russian Federal Nuclear Center at Chelyabinsk-70. They were made of ultrafine aluminum which, like most ultrafine and nano materials, exhibits "superplastic" behavior at certain temperatures and certain rates of strain. Under those conditions, superplastic materials are as pliable as paste and can be formed into complicated shapes, such as automobile wheel rims, simply by pushing on them.

Ultrafine and Nano Materials

The size of the grains, or "crystallites," in metals and alloys has a pronounced effect on their physical and mechanical properties. The grain size in engineered materials, such as steels or aluminum alloys, is determined by the manner in which the materials are prepared. Historically, manufacturers of metals and alloys have obtained specific properties by controlling alloy composition or the thermomechanical processing steps used in the production of the material. For most conventional processing methods, grain sizes are typically in the range of tens to hundreds of micrometers.

Recent research in the United States, Russia, and Ukraine has shown that many materials exhibit remarkable properties when their grain-size is refined. Ultrafine materials have grains a few tenths of a micrometer in diameter and exhibit strengths as much as a factor of five times that of their unrefined counterparts while retaining excellent ductility and resistance to fracture. They also show improved corrosion resistance and, in many instances, "superplastic" properties—that is, they can be deformed without any "localized yielding" in a manner similar to heated plastics and glass (Figure 3).

Nano materials have grains as small as hundredths of a micrometer and have the same advantages as ultrafine materials but to an even greater extent. In addition, nano materials have a multitude of unique characteristics, such as their magnetic properties, that are not yet fully understood.

Early efforts to produce ultrafine and nano materials employed conventional methods of powder compaction in which solid shapes were formed by compressing finely ground powders, usually at high temperature. However, that process produced materials with relatively high levels of impurities and numerous defects. Under the IPP project headed by Terry Lowe of Los Alamos, we use the Russian-developed technique called "severe plastic deformation" in which a material is put under severe stresses that breakdown, or "refine," the material's grains. Although there remains considerable work to optimize that process, the Russian technique is the first to produce solid shapes of high enough quality to be considered useful in load-bearing engineered structures.

The Ufa State Aviation Technical University in Ufa, Russia produces all of the ultrafine and nano materials used in this IPP project. Three other Russian institutes in Ekaterinberg and Tomsk study and test those materials for practical applications, and Los Alamos and Northwestern University use them to test theoretical models of material behavior.

Recently, the researchers in Ufa began to produce superplastically formed ultrafine titanium plates for endoprosthetic applications (Figure 4). We expect to establish a U.S. Industrial Coalition partnership before the end of the year that will expand this application to other areas of traumatic medicine and biomedical engineering. Another partnership would apply nano materials to the construction of permanent magnets with "structural integrity"—that is, magnets that can be formed into complex shapes and still retain their strength and resistance to fracture.

IPP also funds two projects related to

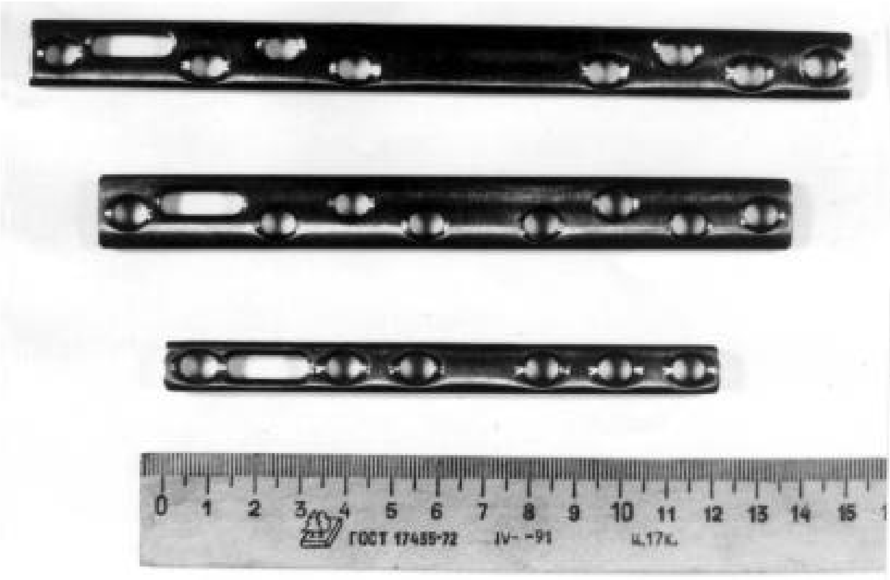


Figure 4. An Application of Ultrafine Materials

The photograph above (taken at the Ufa State Aviation Technical University) shows endoprosthetic appliances produced from ultrafine-grain titanium. The "plates" in the picture are between 1.5 and 2 times stronger than conventional titanium alloys engineered for traumatic medicine applications. Even more importantly, these pure titanium devices will not react with the body's chemistry. They will be undergoing medical certification at the Research Center of the Republic Clinical Hospital in Ufa, Russia.

nano and ultrafine materials. One is geared toward the production of nanocrystalline powders that are commonly used in cosmetics and paints as ultraviolet absorbers. In the other, Los Alamos is helping Russian scientists to convert a weapons facility at Chelyabinsk-70 into a manufacturing facility for superplastic roll-forming of turbine discs (see opening photograph). Industrial partners in that venture include Rockwell International Science Center, United Technologies Research Center, and several members of the U.S. Industrial Coalition.

The Optical Microresonator

About twenty-five years ago, physicists conducting high-precision experiments approached the so-called "standard quantum limit," a theoretical bound on the accuracy of measurements on single objects (for example, a macroscopic oscillator or an electromagnetic wave) imposed by the fundamental principles of quantum mechanics.

Going back to thought experiments due originally to Bohr and Einstein, Vladimir Braginsky developed a theory of measurement called quantum non-demolition (QND) that outlined ways to overcome the standard quantum limit in different kinds of elementary measurements. Not only did QND eliminate any a priori limit on the accuracy of certain measurements, it also provided experimental recipes on how to make measurements without perturbing the quantity to be measured. For example, it indicated how the energy of a photon might be measured without destroying the photon. QND provided the capability to make repeated and predictable measurements on a single quantum system.

During the past decade, the principles of QND, as applied to electromagnetic waves in the optical band, have been demonstrated by researchers at NTT Basic Research Lab (Japan), Institute of Optics (France), and Cal Tech (U.S.). Despite those fine efforts, QND measurements have yet to reach the level of a practical technology because of the expense and labor associated with those experimental techniques.

Vladimir Braginsky and Vladimir Ilchenko of Moscow State University and Salman Habib and Wojciech Zurek of Los Alamos believe that simpler, inexpensive, and higher-resolution QND measurements are not only feasible but can also be the basis for useful applications. They are directing an IPP project to do just that.

A scheme has been proposed to measure the energy of a small number of photons in a resonator. The first and hardest step is to find a way to store photons in isolation for relatively long periods of time. One of the experimental schemes being explored under the IPP program is a new technology invented by the Moscow group called an "optical microsphere resonator." That device is a tiny sphere (30 to 300 micrometers in diameter) made out of very high-purity fused silica, or glass. The microsphere operates as a "photon trap," allowing only photons of very precise energy to enter. Due to total internal reflection, the photons glide continuously along the walls. They circulate inside the microsphere for a few microseconds—

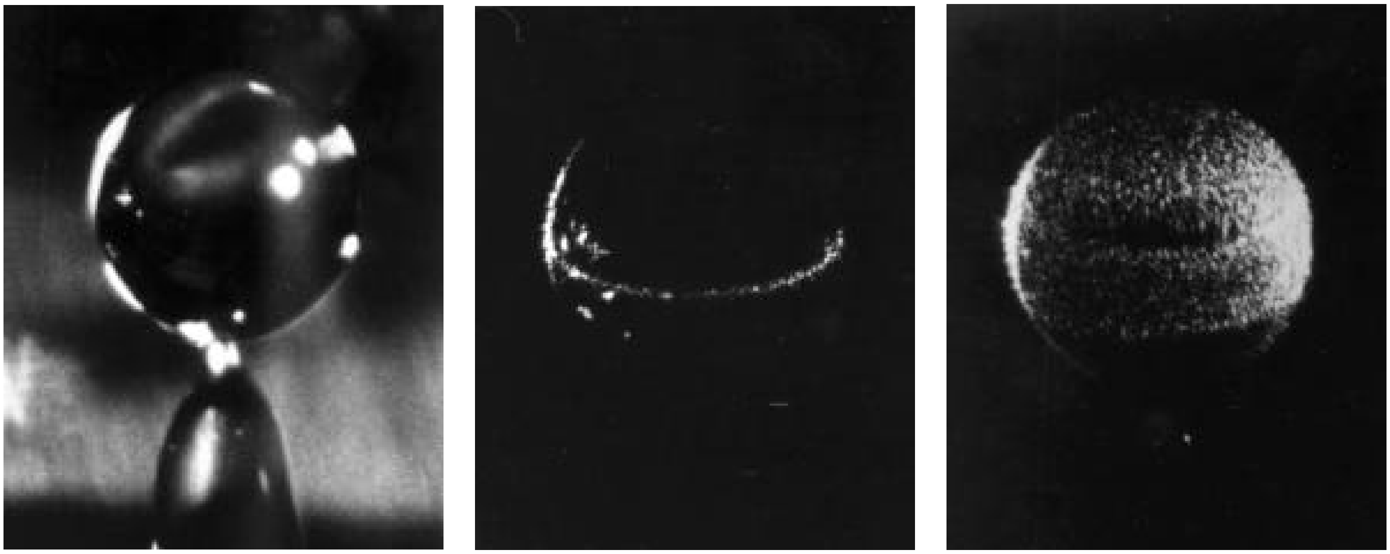


Figure 5. The Optical Microresonator

The black and white photograph on the left shows the optical microresonator under external illumination. The photographs in the middle and on the right show photons trapped in two different modes of the microresonator. (The photons are from a helium-neon laser and are at a wavelength of 633 nanometers (red visible light.) The resonant modes are defined by the difference between two of the photons' quantum numbers, l and m. The middle photograph shows the mode satisfying the relationship $l - m = 0$, and the photograph on the right shows the mode $l - m \approx 70$.

long enough to perform successive measurements on the photons.

The photons occupy a "field mode" (such as the thin annular belt in the equatorial region of the microresonator shown in the middle photograph in Figure 5) of hardly any volume (down to 10^{-10} cubic centimeters). This allows very large electric fields to be established, even with only a small number of photons occupying the mode. For a single photon circulating in the microsphere, the field is larger than 100 volts per centimeter.

The index of refraction of the glass microsphere has a nonlinear component. Large fields produced by a relatively small number of photons in the "signal" mode change the refraction index in the mode area. That change can be monitored by the resulting shift of the resonance frequency of another "probe" mode that overlaps the signal mode. Absolute energy resolution in such a scheme can be made several orders of magnitude better than has been achieved in earlier QND experiments.

Successful QND experiments would allow attainment of the highest possible sensitivity permitted by quantum mechanics. On the way to that ultimate goal, the microsphere QND concept promises a host of less fundamental, yet important, technological spin-offs. The most obvious ones follow naturally from the microsphere's ability to choose photons of very precise wavelength. Relevant applications include high-resolution spectroscopy, investigation of fundamental loss mechanisms in transparent solids and liquids, and frequency stabilization of widely used semiconductor lasers (for which proof-of-principle experiments have already been conducted at Moscow State University).

The realization of QND measurements opens up another set of applications, wholly quantum mechanical, that arise from this new and intriguing ability to manipulate and non-destructively control an object's quantum states. The presently embryonic, but very exciting, areas of quantum computing and quantum communications are two areas where QND measurements will eventually find their natural niche.

The IPP Information System

Early in the development of IPP, we realized that we would need an effective means of communication and a method for storing, tracking, and exchanging technical data. To meet those needs, Molly Cernicek of Los Alamos designed the IPP Information System, a secure and convenient computer-based system that provides information in near real-time to all the participants in the program. The Information System was built using "Lotus Notes Groupware"

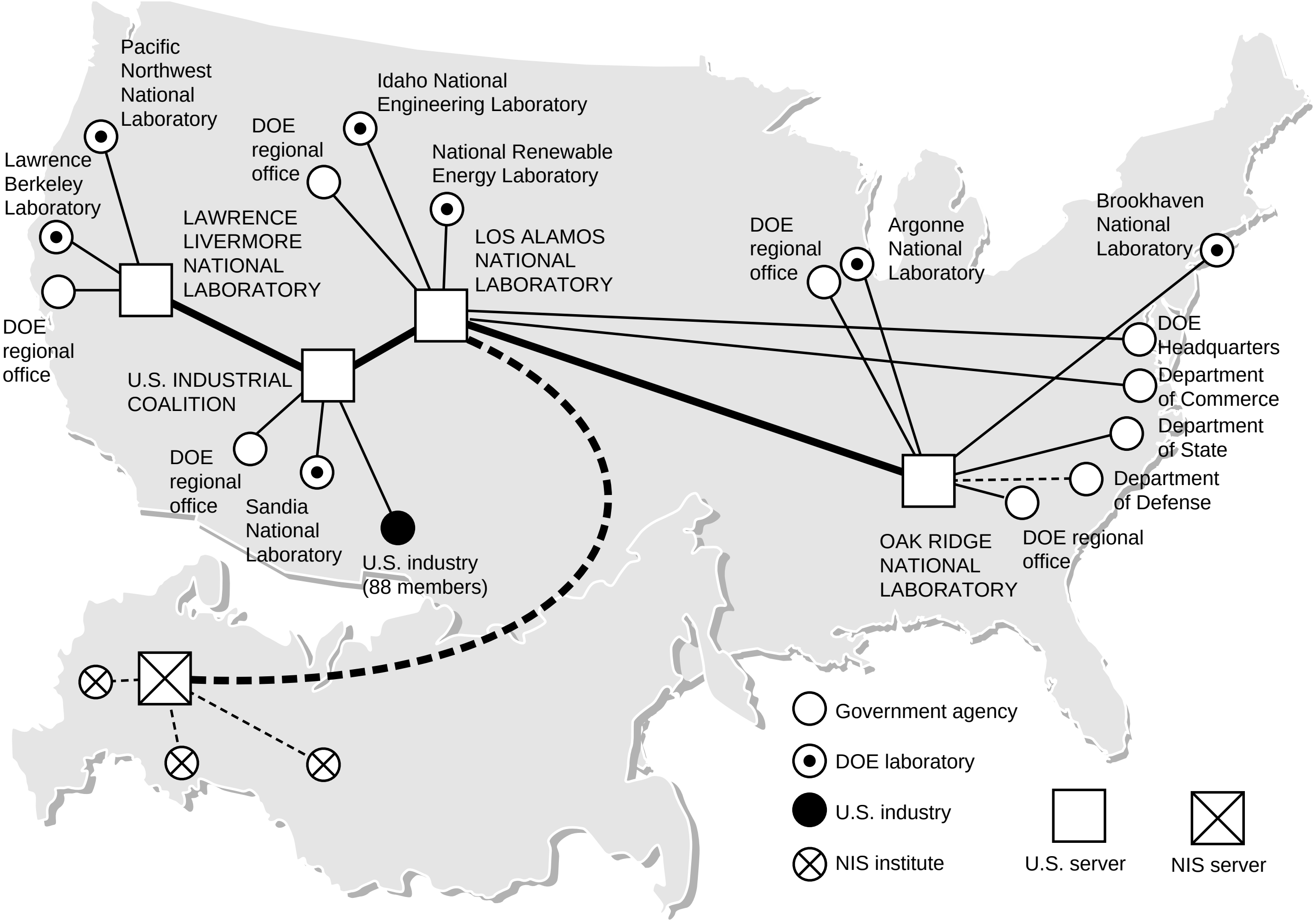


Figure 6. The Net

The IPP Information System is a secure and convenient network of computers that provides effective communication of technical information between the participants in IPP. The current configuration (shown in solid lines) includes the Department of Energy and five of its regional offices, the Department of State, the ten participating DOE laboratories, and over 80 companies from the U.S. Industrial Coalition. Future servers and clients (shown in dashed lines) include the Department of Commerce, the Department of Defense, and most importantly, several nuclear institutes in Russia and other New Independent States.

software. All information exchanged within the network is encrypted to provide security—that is, information can only be decoded by the computer to which it is sent. Furthermore, because the system is based on a single, comprehensive software program, it provides complete compatibility.

By October 1995, the IPP Information System had developed into the nation-wide network shown in solid lines in Figure 6. With few exceptions, the network relies upon existing Internet connections. The five servers in the network (the U.S. Industrial Coalition has two servers) house and share all the databases, which are "replicated," or copied onto one another, every hour. That way, all IPP participants have access to current IPP information in near real-time. In addition, the system holds dozens of clients representing DOE headquarters and regional offices, the ten participating DOE laboratories, the Department of State, and more than 80 members of the U.S. Industrial Coalition. Future clients in the United States include the Department of Commerce and the Department of Defense as well as both the government-to-government and the lab-to-lab MPC&A programs.

During the summer of 1996, we plan to connect several weapons institutes in Russia (see the inset in Figure 6) to the IPP Information System. Then NIS scientists will be able to use the Information System to electronically submit their own proposals for IPP projects and to rapidly establish relevant contacts with U.S. scientists and engineers. Because the IPP Information System facilitates the movement of NIS scientists from defense to paying peacetime work, it helps keep those scientists in their own countries and serves as a tool against nuclear proliferation.

Lastly, the Information System is used to track the progress of each project in terms of both the general goals of IPP and financial expenditures.

The IPP Information System enables IPP participants to collaborate with one another and to share knowledge and expertise unbounded by factors such as time and distance. Molly Cernicek, Mike Wyman, and their team of students, who put together this system, have introduced us all to what appears to be an interstate on the "information superhighway."

Conclusion

The Industrial Partnering Program has funded nearly 200 projects involving over 70 NIS institutes and approximately 2000 NIS scientists and technicians since the program began in July 1994.

U.S. industry has shown great enthusiasm for IPP. For every dollar invested by the federal government in NIS-IPP collaborations, two dollars have been invested by members of the U.S. Industrial Coalition. We have received encouraging reviews from many sources, including the John F. Kennedy School of Government at Harvard.

Lastly, IPP has spontaneously integrated with the International Science and Technology Center (ISTC) in Moscow and its equivalent Center in Kiev (see "The International Science and Technology Centers in the Former Soviet Union"). IPP and ISTC are coordinated to avoid redundancy and to promote synergetic interactions among the participants. Several large projects, such as the superplastic forming facility at Chelyabinsk-70, are being funded by both programs, and because of that larger integrated effort, our projects have a greater chance of success.

IPP is a nonproliferation initiative with the added benefit that technology flows back to the United States as a result of the program's cooperative research and development activities. Programs like IPP have the opportunity to demonstrate the delicate balance between defense and industrial applications of advanced technology as well as promote and facilitate the transfer of NIS defense scientists to peacetime work. ■

Acknowledgements

From a personal point of view, this has been a tremendously exciting and rewarding experience. I would like to take this opportunity to thank all of my Los Alamos colleagues who have provided support and encouragement for this program. Also, I would like to acknowledge the cooperation and support of my colleagues in the Departments of Energy and State who have become members of the team responsible for implementation of this program.

Further Reading

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Hugh Casey is the project leader for IPP. Hugh earned his masters degrees in science and engineering from the University of Glasgow and the University of Strathclyde, Scotland. Upon moving to the United States, he worked in corporate research in the aerospace industry. While employed by United Aircraft corporation (now United Technologies), Hugh's research and development work with high-energy electron beams and industrial scale lasers included contract research work for Los Alamos and Lawrence Livermore labs. He joined the Chemistry and Materials Division at Los Alamos in 1972.

At Los Alamos, Hugh has worked on translating conceptual designs into engineered systems and developing advanced materials processing and fabrication facilities, particularly electron-beam, plasma, laser, and microwave systems. In his current assignment, Hugh is Chairman of the Interlaboratory Board, which consists of the ten DOE multi-program national laboratories responsible for implementing the cooperative projects with the weapons institutes in the former Soviet Union.

Hugh has numerous personal interests but is best known locally for his association with the Los Alamos Ski School, where he has taught as a certified PSIA instructor since 1978.

The International Science and Technology

Since 1992, the United States has been involved in the establishment and operation of a science and technology center in Russia—the International Science and Technology Center (ISTC)—and a similar center in Ukraine—the Science and Technology Center in Ukraine (STCU). These centers provide funding support—on a government-to-government basis—to scientists and engineers from the defense sector of the former Soviet Union for work in a wide range of civilian science and technology projects.

The concept of an international science and technology center was raised during the Bush-Yeltsin Summit, held in Washington, D.C. in January 1992. The primary role of the center would be to reduce the possibility that personnel with knowledge and expertise in weapons of mass destruction or missile delivery systems would leave the former Soviet Union and offer their services to rogue nations. As stated in the agreement that established the ISTC, weapon scientists would have the opportunity to "…redirect their talents to peaceful activities…and [contribute] to the solutions to national or international technical problems…" This agreement was initialed in May of 1992, with the United States, Russia, the European Union, and Japan as signatories.

Despite the desire of the United States to move quickly on ratification of the agreement, formal operation of the ISTC program proceeded somewhat slowly. Money was not the major stumbling block, because the program, in effect, was an outgrowth of the larger and more encompassing Soviet Nuclear Threat Reduction Act (Nunn-Lugar), and funding initially came from Department of Defense moneys committed under that legislation.

The ISTC agreement was provisionally approved via a decree by President Yeltsin in December 1993. Although the Russian parliament still has not taken formal action on ISTC ratification, Yeltsin's approval allowed the ISTC to became operational in March of 1994.

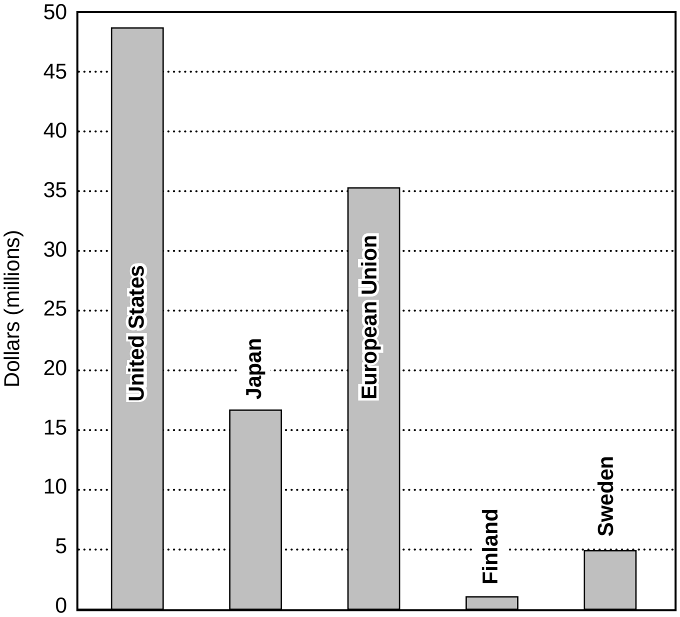


Figure 1. Total Funds Pledged to the International Science and Technology Center by Country (through 1995)

Likewise, there were strong political pressures to create a science center in Ukraine distinct from the one being established in Russia. Ratification for the STCU wasn't finalized by Ukraine's parliament—the Rada—until July 1994.

Regardless of the delays in starting the ISTC and the STCU, both centers are today operating successfully. The ISTC has been funding projects since March 1994, and the STCU since December 1995. To date, nearly 11,500 scientists and engineers with knowledge of weapons of mass destruction have received funding through science-center projects. Approximately 210 projects have been funded at the two centers, amounting to commitments of the funding parties (grown to include Finland and Sweden) of approximately $84 million. United States funding currently falls under the Freedom Support Act, which uses Department of State Foreign Assistance moneys. This source allows project funding in the original nuclear inheritor states (Russia, Kazakhstan, Ukraine and Belarus) as well as additional states of the Former Soviet Union (including Georgia, Armenia, Kyrgyzstan).

The diversity of science and technology areas of the ISTC funded projects is shown in Figure 2. The two largest areas supported by the ISTC—energy and environment—account for over 40 per cent of the 197 funded projects.

Centers in the Former Soviet Union

Steven J. Gitomer

In addition to funding projects, the ISTC has organized a number of symposia to provide opportunities for scientists of the former Soviet Union to present their work to an international audience. The symposia have addressed topics including the environment, conversion in the area of biological weapons, science and technology in Georgia and Kazakhstan, and biotechnology.

Los Alamos was involved with the ISTC from the earliest days and has had a continued influence on the shaping of ISTC throughout its formative period to the present. For example, the author has been involved with the ISTC from 1992 to the present, first serving as a DOE representative, then as a senior scientific advisor to the State Department (1993-1994), and now as a member of the ISTC Scientific Advisory Committee. Boris Rosev served as a senior project manager at the ISTC for over one year (1993-1994), while currently, David Giebink is on a two year assignment at the ISTC.

Los Alamos technical staff members contribute to proposal development and review and monitor various projects. In fact, most of the nearly 500 proposals received from the ISTC and STCU have been reviewed by Los Alamos scientists. Additionally, lab scientists are often committed collaborators in joint research, interacting in quite a wide variety of areas. Many of these research projects were summarized in a series of Los Alamos reports entitled "Los Alamos National Laboratory Interactions with Organizations in the Former Soviet Union" compiled by the author and Jim Kowaczyk.

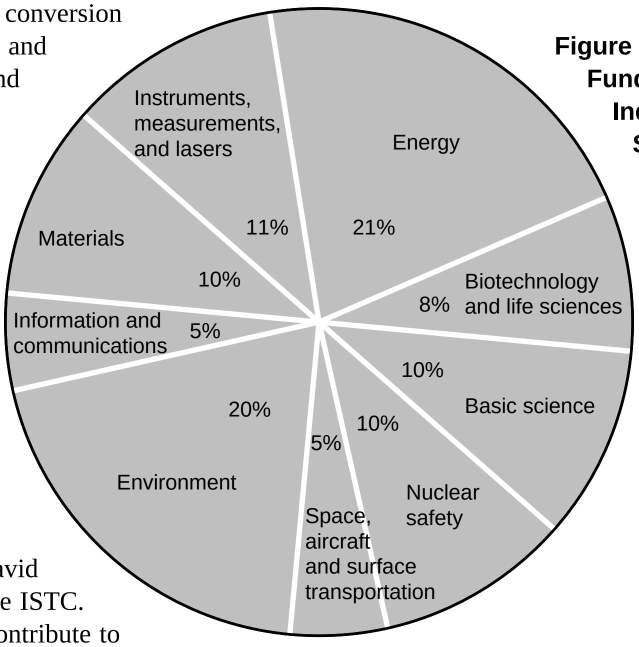
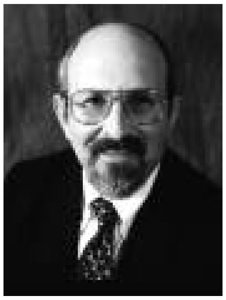


Figure 2. Percentage of ISTC Funds Used to Support the Indicated Areas of Science (through 1995)

As this issue of *Los Alamos Science* goes to press, the ISTC has completed another meeting of its Board of Governors at which more than thirty proposals were approved and funds totalling nearly seventeen million dollars were committed. Nearly a thousand additional scientists and engineers, many of whom have knowledge of weapons of mass destruction, will be engaged in projects of a civilian nature. Los Alamos scientists will be involved as collaborators[†] in these projects, which cover areas including seismic monitoring, upward-propagating lightning, and environmental characterization and remediation.

The Western scientific community is having its impact on science and technology in the former Soviet Union in many ways and, specifically through the ISTC and STCU, is becoming a part of their future. As time goes by, I hope more of my colleagues will take advantage of and benefit from the opportunities connected with these centers, and I hope I can help make this so. ■



Steven J. Gitomer received his Ph.D. in electrical engineering from the University of Wisconsin-Madison. He has been with the Laboratory since 1974. He joined the Center for International Security Affairs in 1995 and has been a member of the Nonproliferation and International Security Division since 1993. His current responsibilities include: U.S. member of the Scientific Advisory Committee of ISTC, Senior Science Advisor to the U. S. Department of State for STCU, and principal Los Alamos point-of-contact for the ISTC, STCU, and lab-to-lab interactions with the Former Soviet Union. From 1991 to 1993, Gitomer served at the U.S. Department of Energy's Office of Arms Control in Washington D.C., where his work focused on implementation of the Threshold Test Ban Treaty and the establishment of the science and technology centers in Russia and Ukraine.

[†] ISTC/STCU monies only cover salaries, equipment, supplies, travel, and overhead of the project participants from the former Soviet Union. There is no provision for funding collaborators who are not from the former Soviet Union.