Building an effective nonproliferation program: U.S. support of IAEA safeguards

by Warren Stern and Susan Pepper

The IAEA's safeguards system is intended to encourage peaceful uses of nuclear energy and at the same time inhibit nuclear proliferation.

> To achieve our mutual goals of moving toward a world without nuclear weapons and expanding the peaceful use of nuclear energy globally, we must all give our financial, political, and technical support to a robust international safeguards regime. A growing international safeguards regime, capable of detecting diversion at known facilities and providing assurances regarding the absence of undeclared activities, is a condition for achieving disarmament and making the world safe for nuclear energy.
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> The United States is committed to providing the support that the IAEA needs through our Member State Support Program and the Department of Energy's Next Generation Safeguards Initiative. These programs provide over $25 million per year in extrabudgetary and in-kind support to the Department of Safeguards.
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> *Secretary of Energy Steven Chu, at the 2012 International Atomic Energy Agency General Conference*

A central pillar of international efforts to stem the spread of nuclear weapons is the International Atomic Energy Agency safeguards system. From the inception of the IAEA, the United States has supported the development and evolution of both the safeguards system itself and the devices and systems approaches used by inspectors. The IAEA safeguards system comprises an extensive set of technical measures by which the IAEA Secretariat independently verifies the correctness and completeness of the declarations made by states to the IAEA about their nuclear programs. From Iran to Syria to the more than 187 other countries that accept IAEA safeguards, the IAEA safeguards system enhances international security, seeking to ensure compliance with international nuclear agreements. The cornerstone of the global nonproliferation regime is the Treaty on the Non-Proliferation of Nuclear Weapons (the Non-Proliferation Treaty, or NPT). IAEA safeguards largely have evolved to ensure nonnuclear–weapon state compliance with the NPT.

Because of the importance of IAEA safeguards to international security and the facilitation of the peaceful uses of nuclear energy, the United States provides substantial assistance to the IAEA through its United States Support Program (USSP) to improve the safeguards system. Much of this assistance is provided by U.S. national laboratories and is coordinated by the International Safeguards Project Office at Brookhaven National Laboratory (BNL). This article discusses the behind-the-scenes work of a network of U.S. Department of Energy national laboratories that support the IAEA and international safeguards.

The safeguards system is a complex verification system built on the reporting by states of their nuclear material inventories and on-site inspections conducted by the IAEA. The goal of the system is to enable the IAEA to verify that these accounts are "correct" (everything has been reported correctly) and "complete" (everything that should be reported has been), and thus the accounts represent the facts on the ground: "All present and accounted for." The IAEA's ability to do this with high confidence and to detect discrepancies in a timely manner is intended to deter states from diverting nuclear material and to sound the alarm promptly if states are not deterred.

An intrinsic tension exists between the pursuit of nuclear energy and the effort to prevent the illicit development of nuclear weapons, because elements of the nuclear fuel cycle and nuclear material used to produce energy can also be used to produce nuclear weapons. For example, the enriched uranium that fuels most power reactors is not in itself usable for nuclear weapons, but it is produced in facilities that have the capability to produce uranium at the enrichment levels needed for nuclear weapons. The reprocessing of used reactor fuel assemblies takes place in reprocessing plants whose output consists of separated plutonium in chemical and physical forms that are somewhat easily converted into the forms needed for nuclear weapons. Consequently, uranium enrichment plants and reprocessing plants are regarded as sensitive nuclear facilities.

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This nuclear conundrum—the ability to use energy released from the atom as a weapon of war or as a tool for obtaining seemingly unbounded energy for powering homes, industry, and development—was recognized at the dawn of the nuclear age. IAEA safeguards endeavor to make this conundrum manageable. On the one hand, IAEA safeguards can deter the diversion of nuclear material from peaceful programs to nuclear weapon programs. On the other hand, the IAEA's positive conclusion of nondiversion can provide assurances to all countries in order to reduce regional and international tensions. The IAEA's assurances allow states to engage in nuclear cooperation in medicine, agriculture, and power with confidence that the materials and technology they supply will be used only for peaceful purposes. Thus, the IAEA safeguards system is intended to encourage peaceful uses of nuclear energy and at the same time inhibit nuclear proliferation.[1]

Photo: IAEA

The USSP has provided support in recent years to the IAEA to replace its old safeguards laboratory at Seibersdorf, near Vienna. The new Nuclear Material Laboratory (above) was completed in June 2013 and will help increase the safety, security, and quality of the IAEA's destructive analysis activities.

IAEA safeguards measures are diverse. For example, seals allow the IAEA to monitor access to states' material or their own inspectors' supplies while inspectors are absent from a facility. Seals are applied to material stores, reactor hatches, and office cabinets where inspection equipment is stored. Seals are tamper-indicating devices that if broken indicate that an area has been accessed; they do not prevent access. Surveillance cameras are used in conjunction with seals to provide additional assurance of the lack of movement of materials within a facility or to verify that movements are related to scheduled operations. The foundation of nuclear material accountancy is a variety of destructive and nondestructive analysis techniques that provide qualitative and quantitative information regarding the composition of nuclear materials at a facility.

The IAEA safeguards system has evolved over the past decades in response to new challenges. Traditionally, international safeguards were focused on inspections, nuclear material accountancy, and nuclear material measurements. After the first Gulf War in 1991, the IAEA member states recognized the importance of enabling the IAEA to detect undeclared activities, as well as to confirm nondiversion of declared nuclear material. In 1993, the member states began a program called 93+2 to enhance the IAEA's safeguards capabilities and authority. The results of this effort were a broad new set of inspection rights and techniques for the IAEA codified in a new legally binding document, the Additional Protocol to the member state/IAEA safeguards agreement, as well as a host of new safeguards techniques.

The verification activities of the IAEA safeguards system would not be possible without international political and technical support over the decades to enhance the system, its technology, and the training of its personnel, and to accept the application of safeguards. Because of the intrusive nature of international safeguards, international political support for their use has been vital. Article III of the NPT lays out the obligation for states to accept the visits of international inspectors to their nuclear facilities. These inspections may take place on a periodic or even an unannounced basis to deploy cameras, seals, and measurement equipment to verify states' declarations. This political support has been facilitated by a careful balance that is struck between the intrusiveness of the safeguards and their technical necessity to ensure that verification is effective.

The IAEA's budget, including the budget provided for international safeguards, is approved by its member states. While all member states value the IAEA's nonproliferation role, some have economic concerns and programmatic interests that result in constraints on the IAEA's safeguards budget to a level that is widely considered lower than what is necessary to fully carry out its mission. The technical accuracy and quality of IAEA safeguards has required significant member state support to supplement the IAEA's regular budget. Some member states make extrabudgetary contributions to ensure that the IAEA has the tools and skills it needs.

For example, the IAEA's 2014–2015 budget includes "unfunded activities" that the IAEA is required to undertake but are not funded, as there are higher priorities. Because of its budgetary situation, the IAEA requires assistance from member state support programs; this extrabudgetary support is in excess of $30 million per year. The United States has contributed substantial extrabudgetary technical assistance to demonstrate its commitment to effective international safeguards.

The USSP was established in January 1977 to respond to urgent needs of the IAEA Department of Safeguards more quickly than they could be met through the IAEA's administrative procedures. Although the USSP was originally intended as a short-term program, it has continued because of its success in the transfer of technology from U.S. national laboratories and commercial equipment suppliers.[2] The USSP provides support to the IAEA through a network of national laboratories and private companies that perform the work requested by the IAEA and approved by the U.S. government. The requests have included nondestructive and destructive analysis instrumentation and techniques, procedures and training, system studies, information technology, containment and surveillance, and management support. In addition, the USSP sponsors a small number of administrative tasks, involving subjects such as technical writing and quality assurance. Typi-

[1] This paragraph is drawn from the textbook *Deterring Nuclear Proliferation: The Importance of IAEA Safeguards*. The book was prepared by Michael D. Rosenthal and Leslie Fishbone, of Brookhaven National Laboratory, together with consultants. It is available for classroom or individual use and can be downloaded at <www.bnl.gov/gars/NNS/IAEAtextbook.php>. Please contact Dr. Fishbone (<fishbone@bnl.gov>) for information about the book.

[2] Equipment to be used for IAEA safeguards is approved for use by the IAEA through a rigorous process that tests the safety, vulnerability, reliability, and operational performance of the equipment. Member states also must approve the use of the equipment in their facilities.

[3] As a comparison, the IAEA's Safeguards expenditures in 2012, the most recent year for which figures are available, amounted to €121.2 million (about $165.7 million) in regular budget funds and €25.5 (about $34.9 million) in extrabudgetary contributions from member states. See <www.iaea.org/Publications/Reports/index.html>, Safeguards Statement 2012.

Photo: Josh Tackentien, BNL

IAEA inspectors receive training at SCK-CEN, in Mol, Belgium, in a Design Information Verification for Research Reactors course that was jointly sponsored by the United States and Belgian Support Programs in 2011.

cally, about 100 USSP tasks are active at any given time. Since 1977, the USSP has contributed in excess of $300 million to fund over 1200 tasks.[3]

The USSP also assists the IAEA with three types of human resources support:

- Cost-free experts (CFE) to work for the IAEA Department of Safeguards on specific projects for two or more years. The CFEs are extrabudgetary positions for which salary and benefits are reimbursed by the United States.
- Junior professional officers (JPO), who are given entry-level positions to perform basic, yet essential, work. In turn, they gain valuable professional and technical experience.
- Shorter-term consultants.

The USSP has provided significant human resources support through 188 CFEs and 25 JPOs, representing an accumulated 688 person-years of effort.

The USSP largely draws its funding from the Program on Technical Assistance to IAEA Safeguards, which is funded through an act of Congress under the State Department's Nonproliferation, Anti-terrorism, Demining, and Related Programs account. This account includes the United States' extrabudgetary funding—called the U.S. Voluntary Contribution (USVC)—to the IAEA. The USVC includes funding for safeguards, technical cooperation, nuclear safety, and nuclear security, and provides funds for the analysis of environmental samples, commercially available safeguards equipment, infrastructure improvement projects, CFEs and JPOs in the nonsafeguards departments of the IAEA, and other activities.

The USSP activities are sometimes complemented by funding through other U.S. programs, such as the State Department's Nonproliferation and Disarmament Fund for special projects and the National Nuclear Security Administration's Next Generation Safeguards Initiative. Over the years, the DOE, the Nuclear Regulatory Commission, and the Department of Defense have also contributed in-kind support. All U.S. technical support to the IAEA's Department of Safeguards is coordinated through the USSP, regardless of the source of funding.

Brookhaven's role

The day-to-day management of the USSP occurs through the International Safeguards Project Office (ISPO), which is based at BNL and includes a liaison office in Vienna, Austria, in the IAEA section of the U.S. Mission to International Organizations in Vienna. BNL offers a unique open national laboratory campus outside of New York City with a 60-year history of science-based work related to U.S. arms control and nonproliferation goals. BNL's distinguished reputation in international safeguards precedes the establishment of the USSP. In the 1960s, the Atomic Energy Commission selected BNL to develop international safeguards principles. BNL's Technical Support Organization (TSO) became the home for many technical experts who developed their own reputations in the field through domestic safeguards activities with the Atomic Energy Commission, the NRC, or the DOE, tours of duty with the IAEA, and work on international safeguards projects funded by U.S. government agencies. It was Herbert Kouts, then the head of TSO, who originally proposed the concept of the USSP to U.S. government contacts in the mid-1970s.

In the early years of the USSP, BNL scientists and engineers designed a handheld device called the Portable Multichannel Analyzer that was eventually deployed by the IAEA for simple nuclear material measurements. This instrument was the workhorse for IAEA safeguards for many years until it was replaced by more modern, advanced instruments. More recently, BNL experts have become involved in the NNSA's Next Generation Safeguards Initiative and assist the IAEA with technology development, concepts and approaches, policy, human capital development projects, and outreach to other member states. According to Doon Gibbs, BNL's laboratory director, "Support for the IAEA safeguards system is one of the most important activities the lab pursues. We are a science laboratory with a long tra-

The central campus of Brookhaven National Laboratory. The National Synchrotron Light Source II, under construction at the time of this photo, is at bottom right, and the 3.8-km-circumference ring of the Relativistic Heavy Ion Collider can be seen in the distance at the top of the frame.

dition of supporting national security efforts, and we are very proud of the work we have done in this area for decades."

Over the past 15 years, BNL has become a safeguards training center, presenting courses for IAEA inspectors and member states. BNL made use of its expertise in reactor design to develop a course on Design Information Verification of Research Reactors. This course teaches inspectors the safeguards-significant attributes of research reactors and provides field exercises to help them practice associated skills. From about 1995 to 2001, the course was held at BNL and used the lab's research reactors for facility tours. After a hiatus, the course was resurrected as a joint project with the Belgian Support Program, making use of expertise from BNL and facilities in Mol, Belgium. BNL won the honor of conducting a course on Additional Protocol/Complementary Access[4] for IAEA inspectors and has delivered the training at BNL since 2006. More recently, this training has been redesigned for delivery to IAEA member states to teach them their responsibilities under the Additional Protocol. BNL's open campus makes it an excellent venue for hosting IAEA staff members and officials from other countries for training activities.

In addition, under the Next Generation Safeguards Initiative, BNL has offered a course for the past five years that is intended to encourage qualified Americans to enter the fields of safeguards and nonproliferation. Called "Nuclear Nonproliferation, Safeguards and Security in the 21st Century," the three-week course is designed to give students a sound understanding of the foundations of the nuclear nonproliferation regime, the IAEA safeguards system, and U.S. efforts to meet emerging nuclear proliferation threats. In addition to lectures, the course includes exercises and demonstrations that take advantage of BNL's unique facilities. Above all, the course aims to give participants the knowledge, analytic tools, and motivation to contribute to the improvement of the nonproliferation regime.

In recent years, the USSP sponsored many tasks designed to assist the IAEA in implementing the Additional Protocol, including programs in environmental monitoring, remote monitoring, and information technology. For the IAEA's remote monitoring program, the USSP funded field trials for testing communication technologies such as telephone, Internet, and satellite. In addition, three engineers were sponsored as CFEs to help the IAEA develop its remote monitoring program, which is now operating effectively. Similar human resources were provided to help the IAEA establish the open source information collection and analysis program. Field trials and training were conducted for environmental sampling, and as a result, the IAEA was able to quickly implement its environmental sampling program. The USSP has traditionally provided significant support in enhancing the nondestructive assay[5] and containment/surveillance capabilities[6] of the IAEA.

ISPO works with a network of 16 national laboratories and numerous companies to meet the challenges facing the IAEA Department of Safeguards. For example, Los Alamos National Laboratory develops equipment and provides training in nondestructive analysis principles and implementation. Argonne National Laboratory provides training in export controls. Sandia National Laboratories has expertise in containment/surveillance, remote monitoring, and vulnerability assessments. Lawrence Livermore National Laboratory provides support in open source information and environmental sampling. Oak Ridge National Laboratory assists the IAEA with safeguards of enrichment technology. Idaho National Laboratory provides training in pyroprocessing to address an emerging technology with which the IAEA must contend. Savannah River National Laboratory assists the IAEA with destructive analysis and related techniques and technologies. Pacific Northwest National Laboratory has developed tools for visualizing open source information to assist analysts in drawing conclusions from widespread sources of information. Companies working with ISPO include Aquila Technologies Group, Canberra Industries, and URS. The list of suppliers is long; the USSP is a national team effort.

"The United States Support Program has played a key role through its R&D and implementation support activities in ensuring the IAEA safeguards system is able to continue to provide credible assurances that states are honoring their safeguards obligations, at a time of increasing verification challenges and resource limitations," according to Jill Cooley, the IAEA's director for concepts and planning.

The IAEA outlines its objectives in short-term, medium-term, and long-term strategic and research and development plans. Its technical needs are documented in its biennial Development and Implementation Support Program.[7] When the USSP was established, the U.S. government expected its $2.6-million investment to solve all the needs of the Department of Safeguards. In reality, the Department of Safeguards' workload and need for support have increased as national interests in nuclear technology increase. In addition, as technology advances, so does the IAEA's and member states' desire for better

One of 10 national laboratories overseen and primarily funded by the U.S. Department of Energy's Office of Science, Brookhaven National Laboratory conducts research in the physical, biomedical, and environmental sciences, as well as in energy technologies and national security. BNL also builds and operates major scientific facilities available to university, industry, and government researchers. BNL is operated and managed for the DOE's Office of Science by Brookhaven Science Associates, a limited-liability company founded by the Research Foundation of the State University of New York on behalf of Stony Brook University, the largest academic user of the lab's facilities, and Battelle, a nonprofit, applied science and technology organization.

[4] "Complementary Access" is a new form of inspection provided under the Additional Protocol that allows the IAEA greater flexibility in its inspection mission. The IAEA Safeguards Glossary 2001 Edition (IAEA/NVS/3/CD) defines complementary access as "access provided by the state to IAEA inspectors in accordance with the provisions of an additional protocol for three purposes: 1) to assure the absence of undeclared nuclear material and activities at sites, mines, concentration plants, and other locations where nuclear material has been declared to be present; 2) to resolve a question relating to the correctness and completeness of the information provided by the state pursuant to Article 2, or to resolve an inconsistency relating to that information; and 3) to confirm, for safeguards purposes, the declaration of the decommissioned status of a facility or a location outside facilities where nuclear material was customarily used."

[5] Nondestructive assay (NDA) refers to a measurement of the nuclear material that does not produce significant physical or chemical changes in the item being measured. This is in contrast to analysis methods that destroy the sample in the course of measurement, e.g., by dissolution. NDA is generally carried out by observing the radiometric emission or response from the item and by comparing that emission or response with a calibration based on essentially similar items whose contents have been determined through destructive analysis.

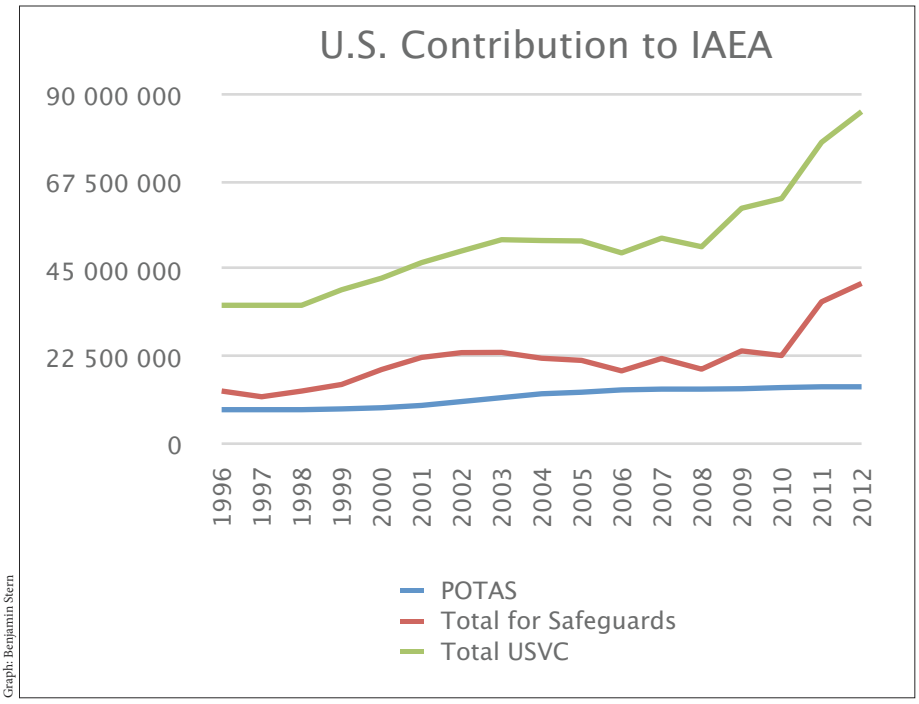
[6] Containment/surveillance refers to the IAEA's use of tamper-indicating seals and digital, integrated cameras to monitor the movement of material and equipment in a facility while inspectors are absent. The data from these devices is either stored within the instrument for collection by inspectors or transmitted to IAEA headquarters via remote monitoring technologies.

[7] See <www.bnl.gov/ispo/docs/pdf/RD%20Programme/RD-Programme.asp>.

measurements and analysis. The Development and Implementation Support Program lists 24 projects for which the IAEA needs extrabudgetary assistance. Despite having access to the extrabudgetary resources of 21 member state support programs, the IAEA's technical needs outpace its resources.

Because of the strong U.S. support for IAEA safeguards, the USVC has increased substantially over the years. See, for example, Fig. 1, which shows a 60 percent increase in total funding for the program over the past decade. At the same time, increasing security and economic concerns draw resources away from the IAEA and member state support programs. It is not clear in the current environment of decreasing budgets whether and how the right balance will be achieved. The USSP has been able to maintain its high level of support to the IAEA Department of Safeguards through increased efficiency, prioritization of needs, and increases in other areas of the IAEA budget, such as direct support to large infrastructure projects.

The IAEA provides an important service to the world community in deterring the spread of nuclear weapons and enabling access for its member states to the benefits of nuclear technology. The USSP and other member state support programs sponsored by countries around the globe provide the IAEA with financial and technical resources that help it in its mission. Without these resources, the IAEA would not have obtained the advanced tools and developed the capabilities it needs to verify member states' compliance with the NPT. Brookhaven National Laboratory is proud of its role in managing ISPO. There is still much work to be done and new challenges ahead. BNL looks forward to assisting the U.S. government in future efforts to strengthen the effectiveness and improve the efficiency of safeguards. NN



Graph: Benjamin Stern

Fig. 1. U.S. Voluntary Contribution to the International Atomic Energy Agency