VOLUME 7, NUMBER 1 JUNE 2007

Sandia National Laboratories

International Security News

Global Security Programs
Dori Ellis, Director

Advancing International Safeguards with Strong Partnerships and New Technologies

From the Director

In the December 2005 issue of the International Security News, we focused on Nonproliferation and the Civilian Nuclear Fuel Cycle. That newsletter highlighted existing projects and new initiatives at Sandia National Laboratories that were addressing the nonproliferation issues surrounding the expansion of global nuclear energy.

These projects and programs at Sandia and elsewhere received enhanced attention in February 2006 when President Bush announced the Global Nuclear Energy Partnership (GNEP) initiative. About the same time, Russian President Putin announced his country's Nuclear Energy Initiative and invited global participation in Russia's efforts. These two initiatives gathered further momentum at the G-8 summit in St. Petersburg, Russia, in July 2006, where Presidents Bush and Putin articulated a common vision to advance the peaceful use of nuclear energy and to pay particular attention to nonproliferation. The US GNEP program has reached out to other countries in addition to Russia, and collaborations are being developed worldwide.

Much has been written in recent months about these global initiatives, and it is not our intent to repeat those discussions in this issue of the International Security News. Rather, we will be discussing some of the key technology advancements we are developing here at Sandia through our Safeguards Technology Development Group. We hope these advances will contribute to the realization of expanded global energy and to the advancement of safeguards against nonproliferation. As is often stated, the devil is in the details, and the expansion of global nuclear energy must be matched, stride-for-stride, with advancements in safeguards technology.

This newsletter also highlights some of the key domestic and international partnerships we have developed over the years. Our partners include domestic and international laboratories, US industry, and even closer involvement in product development by end-users such as the IAEA. Without the active participation of these partners, our efforts to advance international safeguards would fall far short of our desired goals.

Our guest editorial is from Richard Goorevich, who is the Director of the Office of International Regimes and Agreements, National Nuclear Security Agency (NNSA). We asked Mr. Goorevich to provide a view from the NNSA that would illuminate some of the technical hurdles that the global community faces to ensure nonproliferation goals are being met as nuclear energy expands into the future.

Finally, we would be remiss if we did not acknowledge the importance of our technical and programmatic sponsors, particularly in the NNSA. Safeguards technology development takes time, sometimes several years, to fully qualify a technology for use in the commercial sector. Without a dedicated, long-term commitment to technology development, Sandia and the other national laboratories would not be in a position to quickly contribute to the nonproliferation vision articulated by our President and other world leaders.

Dori

Advancing International Safeguards with Strong Partnerships and New Technologies

From the Director: Advancing International Safeguards with Strong Partnerships and New Technologies 1
Guest Editorial: Introductory Remarks on Integrating International Safeguards and Nuclear Export Controls 3
A Brief Review of International Safeguards 6
The History of Sandia's Role in Supporting the International Atomic Energy Agency and its Safeguards Mission 8
Tags and Seals/Secure Sensor Platform/Reflective Particle Tag 11
Reactor Safeguards using Antineutrino Detection 12
Bilateral Agreements 14
Process Monitoring at Large Bulk Facilities 16
Long-Term Nuclear Material Cooperation with Japan 18
Regional Collaboration Initiative 20
IAEA Vulnerability Assessments 20
K-Area Material Storage at Savannah River Site and International Safeguards with the IAEA 21
Partnering with Industry 22
Equipment Security and Authentication 23
Enhanced Safeguards based on Expanded Information Availability in New Nuclear Facilities 24
US-Russian Strategic Partnership for Enhancing Responses to Future Nuclear Nonproliferation Challenges (3x3) 26
Calendar 27

Integrating International Safeguards and Nuclear Export Controls

Richard Goorevich
Director, Office of International Regimes and Agreements
National Nuclear Security Administration

Richard Goorevich delivered the presentation from which this editorial is derived to the Institute of Nuclear Materials Management (INMM) 47th Annual Meeting. The meeting was held July 16 through 20, 2006, in Nashville, Tennessee.

A Quiet Revolution:

There is a quiet revolution taking place in the international nuclear nonproliferation regime. It is not a revolution that is explosive or sudden. If it were, perhaps more people would be aware and more responsive to it. Rather, the revolution I speak of is one that has been more gradual and subtle.

I recall my earliest introduction to the nuclear nonproliferation regime. It was described as a three-legged stool. One leg was the NPT, another IAEA safeguards, and the third leg was nuclear export controls. Notwithstanding the criticality of each leg, each nonetheless operated independently of the other.

The independence of each "leg" was evident in both the national and international organizational structures for accomplishing the mission of each. All three came together, especially in the United States, at a very senior management level. Staff persons actually working the issues had few ongoing interactions and even less direct contact.

While some might quibble with my choices of the most significant events in this revolution, these are the ones that I believe to be the most critical.

For the NPT, it was first the abrupt halt in the path to universal adherence by North Korea's withdrawal from the Treaty. Then it was the discovery that all states do not live up to their Treaty obligations, such as Iraq, Libya and Iran. Or, said another way, it was the disquieting acknowledgement that the NPT faces serious risks to its very viability.

The IAEA Safeguards Department, from its creation until the discoveries that Iraq had violated its safeguards agreement, operated off center stage with little international attention. From a collegial environment in which IAEA safeguards were welcomed by the recipient as a way of instilling confidence in its neighbors, the IAEA now found itself in the post-Gulf War era in a new adversarial relationship with those accepting safeguards. The mechanism created by the IAEA to strengthen world confidence in its safeguards system was the Additional Protocol. With the Additional Protocol came the most profound changes in how the Agency assesses the conduct of a State towards its commitments. It no longer is focused on material accountancy, but is charged with looking more broadly at a State's conduct.

The Historical Connection:

There has always been a strong connection between safeguards and export controls in the Nuclear Suppliers Group. The first sentence in the NSG Guidelines, as originally written in the mid-1970s and as it has survived to this day, says, "The following fundamental principles for safeguards and export controls should apply to nuclear transfers for peaceful purposes…." Another surviving sentence of the original NSG

Guidelines says, "Suppliers will jointly reconsider their common safeguards requirements, whenever appropriate." Few realize that this simple sentence was the consolation prize for those participants in the London Club who wanted the Guidelines to require fullscope safeguards as a condition of supply. The paragraph as first drafted called for a reconsideration of the safeguards requirements by the end of 1976. This did not happen, and while the paragraph survived, references to any particular time for reconsideration were deleted.

Little did the founders of the NSG know that fullscope safeguards as a condition of supply would finally be realized over a decade and a half later. In 1992, the NSG made a flurry of revolutionary changes to international nuclear trade. It adopted a requirement for fullscope safeguards as a condition of supply, guidelines and control lists for equipment and materials with both nuclear and non-nuclear use, and controls on technology comparable to the equipment itself. Perhaps of even greater significance, especially with respect to the revolution, was the adoption of the so-called nonproliferation principle in 1995. This change to the guidelines said that any NSG state should not cooperate with a country if it were not satisfied that the country was living up to its nonproliferation commitments. For the first time in multilateral nuclear export controls, a subjective basis for export controls was added. It recognized the importance of a country's behavior and intent.

Interestingly, the common denominator in these comments about the revolutionary changes in three pillars of the nuclear nonproliferation regime is the recognition of the importance of a country's behavior. In the case of the NPT, we have realized that ratification of the Treaty provides no guarantees about a country's behavior. In IAEA safeguards, we have had to go beyond material accountancy to assess the entire nuclear program in order to assure the absence of undeclared nuclear activities. And, as the NSG has learned from the Iran lesson, the behavior of a country is more important than its ratification of a treaty or the presence of a fullscope safeguards agreement with the Agency.

It could be said that the true picture of a country's intentions with respect to nuclear weapons can only be derived by an integration of all components of the international nuclear nonproliferation regime and, in particular, export controls and safeguards. This thinking or methodology is reflected in the IAEA's effort to strengthen the safeguards regime under Program 93+2, which as we know is enshrined in the model Additional Protocol.

Today's Challenge:

It is ironic that in the day-to-day business of the nonproliferation regime, as a whole, we have a situation in which the NSG is grappling with the issue of including in its Guidelines as a condition of supply a recipient's commitment to the Additional Protocol. At the same time, the IAEA's Committee on Safeguards Verification has been looking at ways in which the Secretariat should be tracking and factoring in clandestine and black-market activities. While there is a bit of reversal in terms of focus, it shows that the refinement of the fundamental principles of export controls and safeguards is not limited to the individual disciplines and that cross-fertilization is not only encouraged, but also required.

It is imperative for us to consider how we can more effectively integrate export control activities and safeguards initiatives into single-policy strands that are mutually supporting and result in smarter, more efficient non-proliferation results. As a preliminary step, I believe that States that have traditionally partnered in the development and implementation of export controls and the IAEA Secretariat should come together in an attempt to amalgamate several critical areas that cut across the two disciplines.

This includes the updating of Annex II of the Additional Protocol as well as the consideration of when is the correct timing to update the supplier guidelines to explicitly incorporate safeguards elements, such as the revised Small Quantities Protocol, as a condition of supply. Much thought will have to be given to how to integrate the events, attitudes, trends, and other matters of interest of a country with respect to the NPT; the IAEA safeguards agreement; the Additional Protocol; the State's System of Accounting and Control, its national Export

Controls, and its involvement in the IAEA Technical Cooperation Program; activities in or with the NSG; other multilateral arrangements, such as the Australia Group, MTCR, and Wassenaar; implementation of United Nations Security Council Resolution 1540; and any other information about its activities and behavior internationally.

Domestically, we will all need to review the activities that are taking place in exports and imports of nuclear material and equipment with the country under review—NRC licensing, Part 810 authorizations; Agreement for Cooperation issues; physical protection consultations; spent fuel take-back; proliferation security initiative, and generally its role played in the war on terrorism—a cooperating partner in the war versus being a state supporter of terrorism.

As you can see there are many directions this desire to integrate export controls and safeguards can take. You can also see that it involves much more than just export controls and safeguards.

My hope is that the Zangger Committee, also known as the NPT Exporter's Committee, which was formed in the 1970s to be the faithful interpreter of Article III.2 of the NPT, could be a starting point for this discussion. Why the Zangger Committee, and not the NSG? Simply put, it is an existing mechanism that has enjoyed the political support of supplier states, the IAEA Secretariat, and the NPT RevCon process. As an organization created to be the faithful interpreter of one element of Article III of the NPT, I do not believe that it is too far of a stretch for us to consider that the Committee could look at issues that are supportive of both elements of Article III, safeguards and export controls.

The Zangger Committee and the IAEA, perhaps an element of SAGSI [the Standing Advisory Group on Safeguards Implementation], or, eventually, an expert group of the Committee on Safeguards and Verification, should work together to address this issue on a more global basis and establish a joint working group to examine the intersection of all nonproliferation functions, which of course will focus on export control and international safeguards systems. The idea is to bring together the wealth of experience and knowledge of a select group of persons who have been working in the nuclear nonproliferation field for many years. The planned outcome of the study should be to identify aspects of export control and international safeguards systems that lend themselves to greater cooperation, and over time, to wholly integrated activities. Last but not least, the study should provide a set of recommendations of how to best integrate these functions into a tangible product for implementation by export control and safeguards experts.

As both safeguards and export controls continue to evolve, they can do so in coordination or in isolation. The Additional Protocol, UNSC/1540, and policies under consideration within the NSG all point to the convergence of these disciplines in coming to conclusions about nuclear security. At some level we all realize that within various governments a cadre of nonproliferation experts and officials exists that will identify synergies and overlaps. Frankly, however, the level and nature of activities in both areas has become so intense and complex, that designed or engineered coordination of the process and products will be required in the future. We have an opportunity and an obligation to strengthen the nonproliferation regime in a substantive way through integration and mutual support within these disciplines.

National Nuclear Security Administration

Opinions expressed by Guest Editors are not necessarily the opinions of Sandia National Laboratories.

A Brief Review of International Safeguards

This issue of the International Security News focuses on the rich history of and the currently active cooperation between Sandia and international technical organizations to develop and implement effective methods and equipment for controlling, measuring, and protecting nuclear materials and facilities. A few words to introduce the processes and goals of international nuclear safeguards may help set the stage for the following articles.

Since the start of the nuclear era, politicians and scientists have struggled with the dilemma of sharing the benefits of peaceful nuclear technologies while constraining the spread of nuclear weapons. Although there are many legal and formalistic aspects to the control of nuclear material, Sandia's role is mostly concerned with the technical aspects of detecting, quantifying, and protecting nuclear material. These are the areas in which we have many cooperative international activities and technological advances.

Developing international control of nuclear materials has a long history. In his 1953 "Atoms for Peace" speech before the United Nations, President Eisenhower proposed that the nuclear-capable countries assist the rest of the world with nuclear development under terms of international management. A United Nations-affiliated agency, the International Atomic Energy Agency (IAEA), was created in 1957 to provide third-party oversight for the control of nuclear materials and technology. The US was then allowed to cooperate with other countries under the terms of an IAEA inspection agreement for each specific facility. Later, the Treaty for the Nonproliferation of Nuclear Weapons (NPT) would be negotiated and placed into effect in 1970. The IAEA became the verifying agency for the NPT-mandated control of nuclear materials. Under NPT terms, each non-nuclear weapon state's agreement with the IAEA became much broader, with a country-wide purview instead of only facility-by-facility. This became known as full-scope safeguards, codified under the IAEA's INFCIRC/153 document.

An international precedent did not exist for the scope and timeliness requirements that the IAEA nuclear safeguards encountered to stop theft or diversion of material sufficient to construct a nuclear weapon. First of all, designers of the safeguards system had to define the minimum quantities that had to be accounted along with estimated time durations during which such quantities must be identified as missing. Then they needed to envision a comprehensive system of weighing and assaying materials, identifying and registering assemblies or casks, calculating transformation of nuclear materials in the reactor process, and establishing accounting zones within facilities. Safeguards focused on accounting for enriched uranium and plutonium on an item-by-item basis for discrete elements, like fuel assemblies, and on a mass measurement basis for bulk materials, like UF6 powder in drums. All of this required an accounting system with obligations by the nation to report to the IAEA, as well as authority for IAEA inspectors to independently verify any aspect of the reporting. No nation had ever voluntarily submitted to such intrusive international control before.

Over the ensuing years, until 1991, the international safeguards system became more systematic and efficient. An international cadre of inspectors, almost 200 IAEA personnel, and corresponding numbers of national experts in the inspected countries developed a community of shared goals and commitment. Technical challenges were overcome, and the international safeguards system approached maturity, even while identifying needs for more technical research.

The discovery of Iraq's covert nuclear program after the First Gulf War upset any complacency regarding safeguards. Iraq showed that a covert program could co-exist with a properly inspected nuclear energy program. In fact, technical skills developed in the peaceful program could nurture the hidden program, even if materials were not diverted from one to the other. Under the traditional full-scope safeguards agreement, the IAEA did not have the capability to aggressively look for undeclared programs, and was

not exercising all of its powers to acquire data within declared programs.

This led to an international effort to define a new approach to safeguards that would be able to detect undeclared, covert programs. This effort, named the "93+2 Program," started in 1993 and was completed and accepted in 1997. The 93+2 Program mandated a "Strengthened Safeguards" in two parts. Under Part I, the IAEA resolved to more fully exercise existing powers. For example, the IAEA already had the power under INFCIRC/153 agreements to perform unannounced inspections at declared facilities and take "swipe samples" during routine inspections. The IAEA would also perform more analysis of design information and open-source data on imports/exports.

Part II methods built on the mid-1990's international acceptance of more intrusive inspection methods, many of which verged on "go anywhere, sample anything" techniques. US labs contributed research in wide-area environmental sampling, trace detecting, and methods for managing access while protecting sensitive information. The IAEA decided that a nondiscriminatory, worldwide implementation of wide-area environmental monitoring would be expensive and politically unattractive. Consequently, Part II provisions allow for conducting short-notice and unannounced inspections of facilities and immediately related areas and taking swipe samples to capture local environmental information beyond the bounds of routine inspection points at any facility within a declared nuclear site. National acceptance of intrusive Part II measures requires a new legal power for the IAEA, which is the "Additional Protocol" known as the IAEA's INFCIRC/540. The accepting state gains compensating benefits for agreeing to a more intrusive system. To avoid making overlapping and wasteful inspections, the IAEA and the country can rationalize the traditional and additional methods in a new approach known as "Integrated Safeguards." Under this system, conducting random or unannounced inspections greatly reduces the need for routine visits.

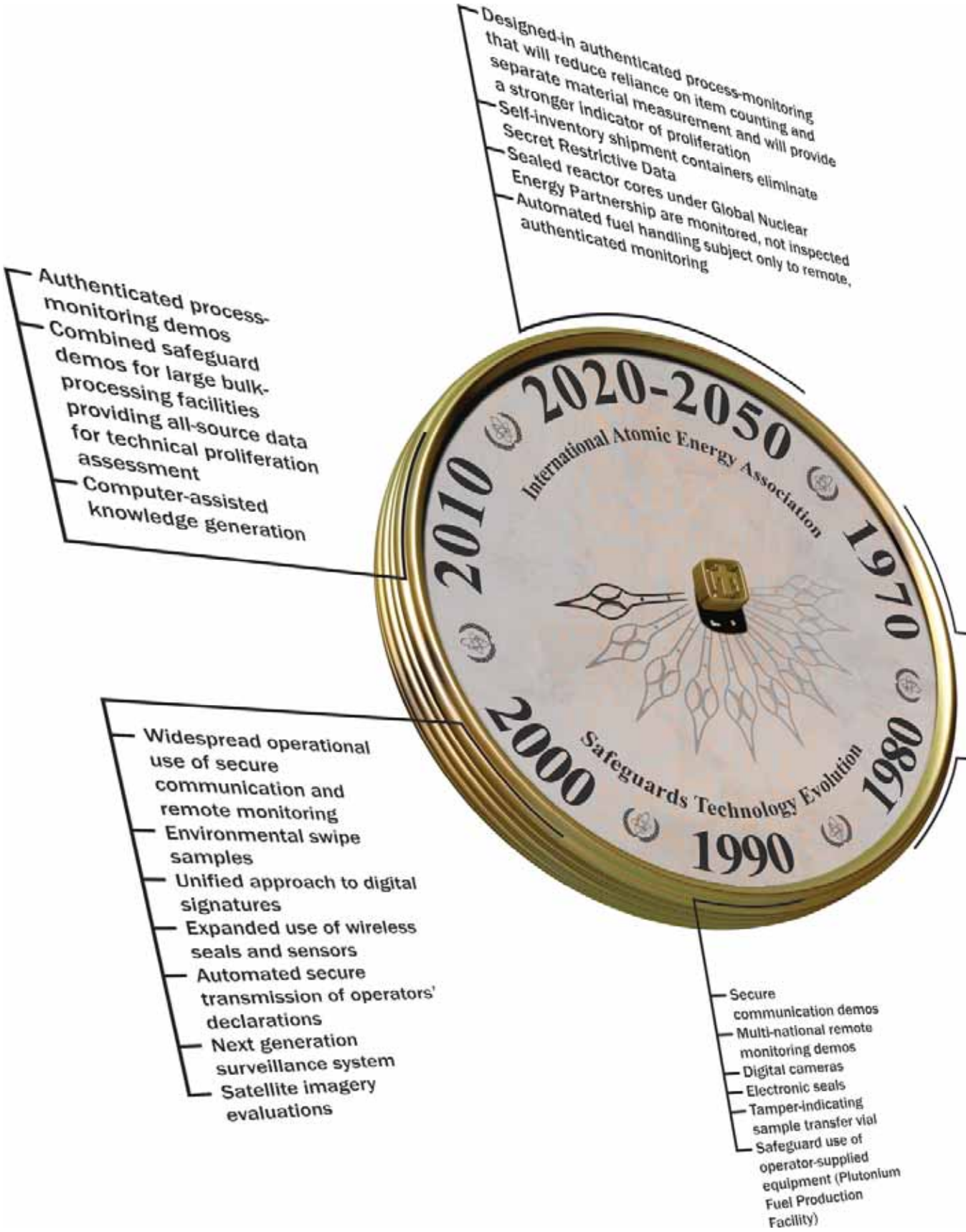
A prime goal in technical research is extending rationalized, more technically efficient safeguards methods to more sensitive areas of the fuel cycle, specifically facilities where proliferation-attractive, bulk quantities require an extraordinary amount of inspector time. Some of the bilateral cooperation noted in the following articles may support this development.

Source: John Olsen, 6721, MS 1373, 505-284-5052, fax 505-284-5550, jnolsen@sandia.gov

Example Technical Element

An example of a technical element of the Integrated Safeguards approach is the increased use of remote, digital video camera systems to deliver more timely surveillance data with decreased travel requirements for IAEA inspectors. Establishing the necessary skills in remote monitoring and secure communications is a technical goal. Development skills in such technologies has long been a part of Sandia's cooperation with the European Commission and with several countries, notably Japan, the Republic of Korea, Argentina, Brazil, and Australia. Continuing efforts to perfect these technologies, train more national authorities in their use, and demonstrate them for nonproliferation and transparency purposes are the subject of current or prospective agreements for Sandia National Laboratories and partners in Europe, South America, and Asia.

The History of Sandia's Technology Solution for the International Atomic Energy Agency and its Safeguards Mission



The safeguards mission of the International Atomic Energy Agency (IAEA), to assure the peaceful use of nuclear materials and facilities, has been historically supported by two technologies—Material Accountancy (MA) and Containment and Surveillance (C/S). MA is fundamental because the IAEA inspectors have to independently confirm declarations made by facility operators about the status of nuclear materials and plant operations. Likewise, C/S technologies provide the inspector with a form of continuity of knowledge during his absence. MA can be accomplished through either destructive or non-destructive analyses of nuclear material, and involves the use of radiation detectors and spectrometers. C/S, on the other hand, uses tags, seals, video surveillance, tamper-indicating enclosures and systems, and process-monitoring systems. The application of IAEA safeguards today requires inspector presence, which can be intrusive and time-consuming. In recent years, the concept of remote monitoring has become acceptable, particularly for C/S devices, and advances in this area have been made.

Sandia National Laboratories became involved in supporting IAEA safeguards in the 1970s. Although Sandia did have some MA activities under sponsorship of the Arms Control and Disarmament Agency, the bulk of the lab's work involved C/S. Los Alamos National Laboratory (LANL) was one of the pioneers in providing technology to the IAEA, with the focus on MA. Toward the end of the 1970s, the two New Mexico labs became leaders in developing technologies for the IAEA—LANL in the area of MA, and SNL in the area of C/S. Over the years, the Department of Energy (DOE) provided the funding for research and development in MA and C/S. Through its Program of Technical Assistance to IAEA Safeguards, the Department of State (DOS) was responsible for technology implementation, including the commercialization of technologies. In the 1980s and the 1990s, LANL and SNL were recognized within the DOE community as the leaders in MA and C/S, respectively. The DOE would rely on the technology expertise of these two labs on many occasions. For example, the labs provided technical support to the DOE delegation, which negotiated the agreement between DOE and the Power Reactor and Nuclear Fuel Development Corporation (PNC) of Japan, allowing the labs to develop technologies (some of it jointly) for use in the PNC facilities. Likewise, the two labs would provide technical support to various interagency delegations on foreign visits. Under the DOE/EURATOM agreement, the two labs provided technical support to EURATOM safeguards, and in several instances developed joint technology for use in European nuclear facilities.

Film cameras
Cup seals
Destructive analysis of material samples

Videotape cameras
In-situ readable seals
Remote monitoring demos
Process-monitoring demos
Non-destructive analysis of material samples

During Sandia's involvement in developing technologies for the IAEA, many systems were developed, and most were implemented by the IAEA. These systems include the STAR, the Modular Integrated Video System (MIVS), the Fuel

Assembly Identification Device, the E-cup Seal, the Cobra Seal, the Tamper-indicating Sample Transfer Vial, wireless fiber optic loop seals, the Material Monitoring System, process-monitoring systems, and remote monitoring systems.

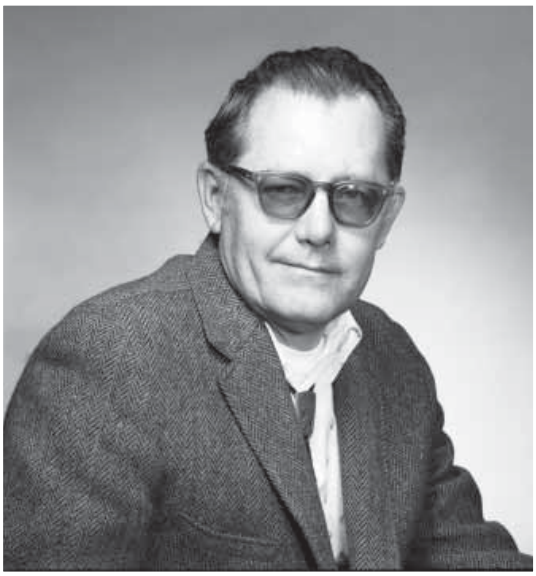
Sandia was very instrumental in developing and furthering the remote monitoring concept. In September 2006, the IAEA conducted its first-ever inspection of a facility (the K-Area Material Storage Facility) from Vienna using Sandia's remote monitoring technology.

In 1996, the Director General of the IAEA, the Minister of Atomic Energy of the Russian Federation, and the US Secretary of Energy met to consider practical measures to fulfill the statements made by the President of the US and the President of the Russian Federation, and agreed to conduct trilateral consultations to address the various technical, legal, and financial issues associated with implementing IAEA verification of weapon-origin fissile material, even if the material had classified features. In forming the US delegation to support this Trilateral Initiative, DOE requested that SNL and LANL each provide a senior technical advisor to the delegation. Other laboratories (Lawrence Livermore National Laboratory, Oak Ridge National Laboratory, and the Pacific Northwest National Laboratory) were also involved in supporting various technical aspects of this initiative, which was successfully concluded in Fall 2002.

Sandia continues to play a role in the efforts of the DOE and DOS to support the IAEA and its evolving safeguards mission. An example of a new technology for the future is the secure sensor platform, which is part of SNL's miniaturized Secure Sensor Development Program. This technology is geared to enhance the capabilities of fiber optic loop seals with an eye towards the development of an international security seal for global nuclear nonproliferation, and the development of a tiny gamma spectrometer system for radiation-monitoring applications.

Source: Dennis Mangan, 6720, MS 1363, 505-845-8710, fax 505-284-5974, dlmanga@sandia.gov

Cecil Sonnier

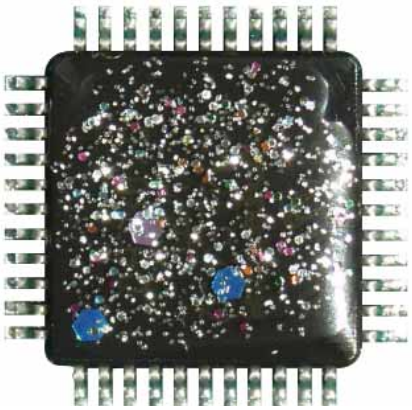


Cecil Sonnier was a key player in Sandia's involvement in IAEA safeguards. Sonnier was a cornerstone throughout his tenure with Sandia's International Safeguards group. In 1979 and 1980, he spent time as a cost-free expert at the IAEA in Vienna. When he returned, he was instrumental in having the Institute of Nuclear Materials Management (INMM) form an International Safeguards Committee of which he was appointed chair. When the INMM reorganized into Technical Divisions, Cecil became the Chair of the International Safeguards Technical Division. He became well-known in the international safeguards community, and perhaps "Mr. C/S" might be an appropriate moniker.

Tags and Seals/Secure Sensor Platform/Reflective Particle Tag

Tags and seals have important roles in the security and tracking of materials in international safeguards and global nuclear nonproliferation. The concept of tags and seals is not a new idea, however. In ancient Mesopotamia, unique patterns were engraved on cylinders, which could be rolled to create an impression on clay, creating a seal. Seals have been used to detect tampering since 1639, when pine resin seals on vellum tags were applied to English deeds. Modern definitions for tags and seals identify specific individual roles for these concepts. Tags are used to identify an item to which it is attached; seals are used to verify that an enclosure has not been opened.

Sandia has participated in the development of many tags and seals over the years. The Cobra Seal developed at Sandia is still in widespread use by both the US government and the IAEA. Recent Sandia developments in this area include the Reflective Particle Tag (RPT) and the Secure Sensor Platform (SSP).



Reflective particles applied to a microprocessor in a T-1a seal.

RPT

The RPT technology was originally developed for tagging mobile intercontinental ballistic missiles and other assets categorized under bilateral arms control treaties. The concept of the technology is quite simple. Reflective particles are mixed into an adhesive that is applied to the article being tagged. When the tag is illuminated with a point light source, the reflections from the particles form a pattern unique to that tag and that incident light angle. The tag reader employs a camera to record these patterns in individual pictures, each taken with a different incident light angle. These images form a set of "fingerprints" unique to that tag, which can be verified when additional tag readings are taken during subsequent inspections. If the adhesive was chosen properly, the tag cannot be removed from the article and transferred to another item without destroying the pattern, so the item can be uniquely identified by reading the tag.

There have been several applications considered for RPT, such as identifying credit cards, the welds on nuclear material containers, and electronics components. This latter application may be of considerable interest in verifying that security-critical integrated circuits, such as microprocessors, have not been replaced in monitoring equipment, compromising the equipment security.

SSP

The SSP is a highly sophisticated active device designed to provide secure and authenticated collection and radio frequency transmission of different types of sensor data. The sensor module requires software and hardware support from the SSP to collect the sensor's data. This capability makes the SSP quite suitable for supporting fiber optic loop sensors, radiation dose rate sensors, and balanced magnetic switches. A fundamental characteristic of the SSP is that each one can be uniquely identified. Because of this, when the SSP is configured as a fiber optic seal, it is also considered to be a tag, since it is attached to the item being monitored by the seal. The SSP system, which consists of the sensor platforms, a translator, and a host computer, is part of an overall monitoring system that may support many sensor platforms. Each platform is typically battery-operated. Although a single battery is intended to last for multiple years, the actual battery life depends on the type of sensor and communication requirements.

The SSP concept is currently being developed through a cooperative research and development agreement with a local technology company, Canberra Albuquerque. An intention of this collaboration is to reduce the amount of time normally required to commercialize a new technology concept. This benefit is being realized by working directly with Canberra Albuquerque during the design phase of the project. The first commercial prototype SSP devices will be configured as fiber optic loop seals and are planned to be produced in late Winter 2007.

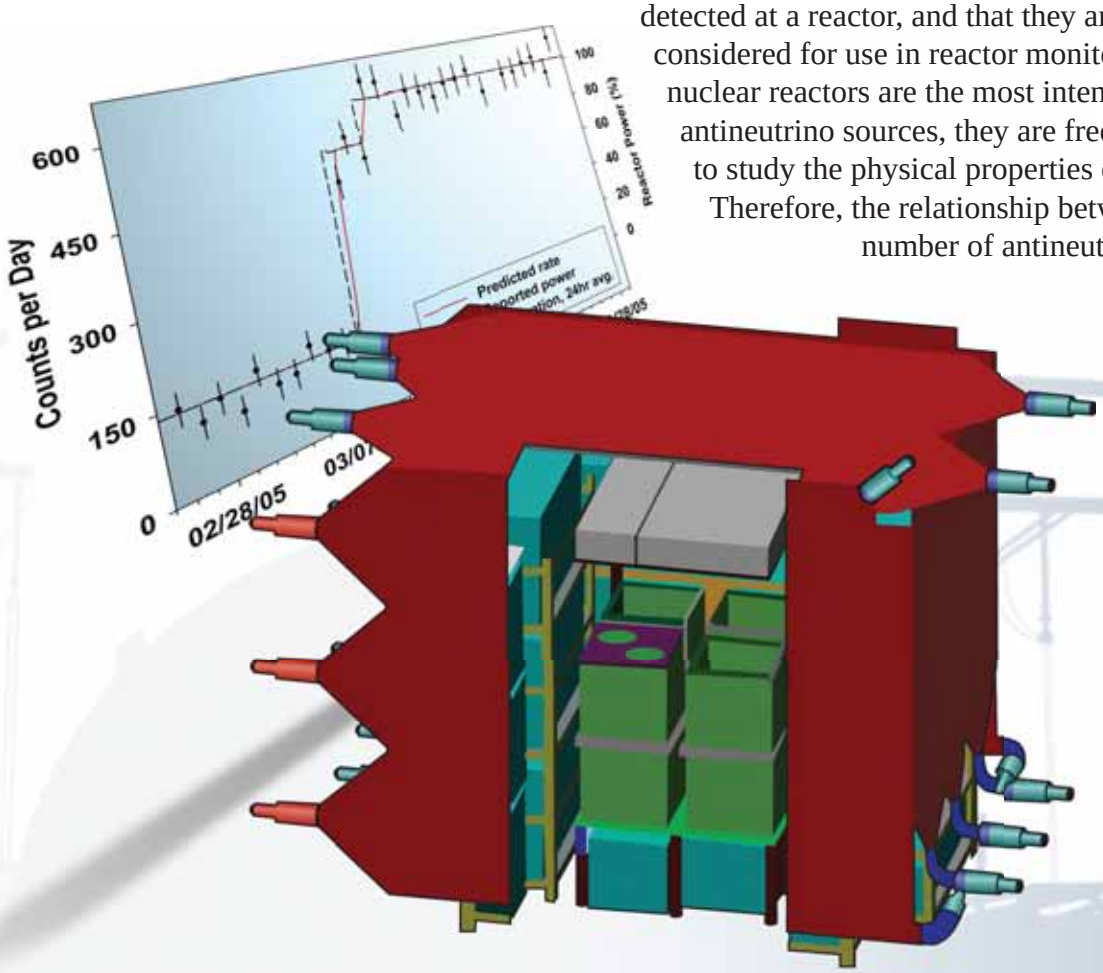
Sources: Barry Schoeneman, 6722, MS 1371, 505-844-0554, fax 505-284-8870, bdschoe@sandia.gov and Keith Tolk, 6722, MS 1371, 505-845-2306, fax 505-284-5437, kmtolk@sandia.gov

Reactors Safeguards using Antineutrino Detection

The large-scale expansion of nuclear power foreseen as a response to increased global economic development and concerns about carbon emissions could strain the resources of International Safeguards Agencies to fulfill their missions. New technologies that provide automated, real-time, unattended measurements at reactors could reduce the burden of inspections upon both Safeguards Agencies and Reactor Operators, provide independent confirmation of reactor parameters with a device controlled by the Safeguards Agency, and strengthen safeguards regimes through the addition of direct quantitative measurement of reactor power and fissile content. Under sponsorship of the National Nuclear Security Administration (NNSA), a team of physicists, engineers, and safeguards analysts at Sandia National Laboratories (SNL) and Lawrence Livermore National Laboratory (LLNL) has been investigating a novel new technology based upon the detection of antineutrinos emitted by reactors that could provide measurements of this kind.

Antineutrinos may ring of science fiction, but decades of study and experiment by physicists have firmly established the existence of these subatomic particles. First postulated by quantum physics pioneer Wolfgang Pauli in 1930 to explain the dynamics of radioactive beta decay, it was not until 26 years later that their existence was confirmed by experiments at nuclear reactors in the United States. This long gap highlights one of the principle properties of these particles—matter is almost invisible to them, and therefore they are very difficult to detect. Nonetheless, through the development of many technologies specifically tailored to antineutrino detection, physicists have made great strides in the study of these elusive particles.

It is no coincidence that antineutrinos were first detected at a reactor, and that they are now being considered for use in reactor monitoring. Because nuclear reactors are the most intense manmade antineutrino sources, they are frequently used to study the physical properties of neutrinos. Therefore, the relationship between the number of antineutrinos leaving



a reactor and the reactor power and fuel isotopic composition is well known. The SNL/LLNL team seeks to apply this knowledge and the antineutrino detection technology physicists have developed to the problem of reactor safeguards.

To demonstrate that measurements appropriate for reactor safeguards can be made using antineutrino detection, the SNL/LLNL team has deployed a prototype antineutrino detector at the San Onofre Nuclear Generating Station (SONGS) in the United States. The key features of this device, when compared to a typical neutrino physics detector, are its simplicity, compact size, robust construction, and ability to operate in a completely automated fashion for months at a time. Deployment in the infrequently accessed 'tendon gallery' of a reactor containment building means that the presence of the device does not interfere with plant operations.

The prototype detector can clearly observe both changes in thermal power and the evolution of the reactor fuel over a fuel cycle using only the antineutrino signal. Short-term changes in reactor power are readily observed within 24 hours. Longer integration times yield better precision, while a reactor scram from 100% power can be detected in about four hours. Measurements over the course of a reactor fuel cycle have observed a change in the antineutrino rate due to the ingrowth of plutonium in the core. The SNL/LLNL team is currently preparing its results for publication.

With this first prototype having succeeded in demonstrating the essential principles of the monitoring technique, future detector development will focus on shrinking the footprint and increasing the efficiency of the device. This effort will be greatly aided by contacts with the academic community, many of whom have expressed strong interest in this application of their work. Indeed, some have expressed surprise that this most esoteric of subatomic particles may find a practical application so quickly at the location of its discovery.

Source: Nathaniel Bowden, 8132, MS 9956, 925-294-2566, fax 925-284-6842, nbowden@sandia.gov, and
Adam Bernstein, Lawrence Livermore National Laboratory

Bilateral Agreements

Our Global Security Engagement and International Safeguards Department focuses on preventing the proliferation of weapons of mass destruction by developing technical solutions to regional security problems, enhancing the effectiveness of international safeguards, and promoting the peaceful uses of nuclear technology. The department participates in bilateral safeguards cooperation agreements between foreign partners and the National Nuclear Security Administration's International Nuclear Safeguards Engagement and Cooperation Program. The purpose is to enhance the effectiveness and efficiency of safeguarding non-weapons nuclear materials. The following paragraphs briefly describe current technical collaborations.

Argentina

Sandia supports the Argentina Nuclear Regulatory Authority's (ARN) secure national communications network. This network transmits sensitive safeguards and physical protection information from remote nuclear facilities to ARN Headquarters in Buenos Aires. Phase I of the project was completed when a secure communications link was established between Bariloche and Ezeiza. Phase II began when Sandians met with the Secretary General of ARN to design a network extension to include nuclear facilities at Atucha and Embalse.

Brazil

Sandia is working with the National Nuclear Energy Commission of Brazil (CNEN) to improve its capabilities to safeguard nuclear materials. This improvement will be fostered through a safeguards laboratory at a CNEN facility near Rio de Janeiro. Once CNEN procures the necessary equipment, a Sandia team will return to Rio de Janeiro to install the equipment and train the personnel. Sandia will also provide a secure communications link between the laboratory and Sandia to facilitate keeping CNEN current with developing technology.

ABACC

ABACC, the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials, is a bilateral inspection agency staffed by experts from Argentina and Brazil. ABACC works with the IAEA to ensure the safeguards of nuclear materials within the two countries. Sandia supports ABACC through a series of training courses to improve the technical capabilities of inspectors and technicians. SNL also provided training on virtual private networks, facilitating secure communications between the Resende site and ABACC Headquarters to transmit safeguards data.

Australia

Sandia cooperated with the Australian Safeguards and Nonproliferation Office (ASNO) to evaluate Multispectral Remote Sensing of uranium mines to detect undeclared activities. Images captured from the Multispectral Thermal Imagery satellite of the Ranger mine near Darwin, Australia, will be compared to spectral samples of various materials from the mine. The aim of the project is to serve as an "honest broker" in advising the IAEA of the feasibility of employing satellite imaging technology.

EURATOM

EURATOM is the treaty that established the European Atomic Energy Community, as represented by the Commission of European Communities. Sandia has an ongoing collaboration with the Joint Research Centre (JRC) in Ispra, Italy, to evaluate the application of wireless data collection and secure transmission. This evaluation was initiated at the request of the IAEA to improve the effectiveness and efficiency of international safeguards systems.

A current FY07 project investigates the utility of 3D sensor technology for improved IAEA safeguards. This collaboration is intended to advance the technology to provide an effective inspection tool. Another project is the continued development of the Secure Sensor Platform (SSP) and its application to EURATOM safeguards. The SSP will be adapted to collect and authenticate data from sensors currently employed by EURATOM. In a follow-on phase, the SSP will be integrated into wireless networks to further improve safeguards efficiency and effectiveness. For more information about the SSP, see the article on page 11.

Indonesia

Sandia is one of five laboratories working closely with the Nuclear Regulatory Agency (BAPETEN) of Indonesia to provide enhanced nuclear safeguards capabilities. The team established a Needs Assessment Methodology to evaluate Indonesia's safeguards capabilities, with emphasis on regulatory, operational, and training programs. The next step is to generate a Safeguards Roadmap to serve as NNSA's technical collaboration plan with BAPETEN.

China

Sandia was part of an NNSA/NA-24/NA-25 and multi-laboratory team that conducted a US–China Integrated Nuclear Materials Management Technology Demonstration at a China Institute of Atomic Energy facility near Beijing. A Sandia International Safeguards team trained 80 nuclear specialists on integrated nuclear material management systems. This demonstration, attended by Ambassador Linton Brooks, was a milestone in the bilateral relationship and has resulted in plans for increased cooperation.

Japan

Sandia has a long history of supporting international safeguards in Japan through a safeguards cooperation agreement with the Japan Atomic Energy Agency (JAEA) and its predecessors. (See article on page 18.) This includes ten years of full-time presence in Japan through its International Fellowship program and the implementation of remote monitoring systems at JAEA nuclear facilities.

Republic of Korea

The relationship between Sandia and the Korean Institute of Nuclear Nonproliferation and Control (KINAC) and its predecessor organizations has resulted in advancements in the effectiveness and efficiency of international safeguards globally. As a direct result of Sandia's secure communications workshop for the Korean Atomic Energy Research Institute and the IAEA, the Republic of Korea is now the world leader in secure data transmission for international safeguards, with safeguards confidential data being reported directly to the IAEA from 16 light water reactors. This has resulted in a tremendous cost savings to the IAEA and improved safeguards effectiveness.

France

Historically, Sandia has participated in safeguards technical collaborations with atomic energy institutions in France. There has been a hiatus over the past two years due to a reorganization within France and the need to establish new Safeguards Cooperation Agreements between DOE and the current French organizations: the Atomic Energy Commission (CEA) and the Institute of Radioprotection and Nuclear Surety (IRSN). The safeguards agreement with CEA has recently been signed, and DOE and CEA are exploring collaborations. One promising area for Sandia involvement is the continued development of secure communications for safeguards applications.

Source: Don Glidewell, 6721, MS 1373, 505-844-9261,
fax 505-284-5055, ddglide@sandia.gov

Process Monitoring at Large Bulk Facilities

For many years, countries such as France, Russia, and Britain have recycled spent fuel from commercial nuclear reactors to recover reusable fissile material and reduce the volume of waste. In February 2006, the United States announced its intention to pursue recycling as well. Opponents of spent fuel recycling or reprocessing argue that it increases proliferation risks. In particular they point to the accounting difficulties associated with tracking substantial quantities of fissile material in large, bulk facilities.

The standard technique for fuel reprocessing, which has been used for more than 50 years, is an aqueous extraction process known as PUREX (Plutonium-Uranium Extraction). In this process, spent fuel is dissolved in hot nitric acid, and then the various constituents are preferentially separated via organic solvent extraction. The resultant product streams are uranium, plutonium, and virtually everything else constituting waste. Modifications of this process are being considered for future plants in which the partitioning scheme is altered to support evolving nonproliferation and waste management goals.

Modern plants process on the order of one to two thousand tonnes (metric tons) of spent fuel per year separating from ten to thirty tonnes of plutonium annually. A difficulty of these large throughput facilities is that the precision of the measurement techniques must be very high in order to achieve accountancy goals.

If US interest in reprocessing is to be sustained, it will be critical to demonstrate that large bulk facilities do not increase proliferation risks. The Safeguards Technology Development Group at Sandia is involved in several research and development (R&D) efforts, which will contribute to the deployment of advanced facilities consistent with global nonproliferation goals.

This work seeks to develop advanced methods for materials monitoring in large reprocessing plants for the purposes of assessing vulnerabilities and increasing the accuracy of material accounting.

The goal of tapping into process-monitoring data that is generated to support plant operation has long interested researchers, but the technical and political barriers to supplementing or replacing independent safeguards measurements with operator-generated data are significant. It is difficult to meet the operator's performance requirements while also meeting the IAEA stringent requirements for joint use of equipment.

Process data, no matter how copious and precise, may not include those parameters necessary for material accounting or assessing proliferation risk. Sophisticated processing algorithms are necessary to collect, synthesize, and analyze the data in order to extract the parameters necessary for safeguards. Finally, data should be authenticated and protected to assure the safeguard officials that it has not been compromised.

Sandia is developing a material mass and measurement uncertainty tracking model to examine fault detection, optimize sampling strategies for monitoring equipment, and test the impact of new instrumentation to reach higher levels of measurement precision. The primary objective is to identify where instrumentation is most helpful to monitor the process and detect diversions with minimal false alarms. The process for meeting this objective involves conducting a set of statistically designed simulation experiments that explore a range of operating conditions and instrument deployments. The efficacy of an accountancy strategy is measured by how quickly the diversion is detected (in cases of a diversion) and the false alarm rate. The results are analyzed across the range of operating conditions to assess the value of the measurement instruments (alone and in combination).

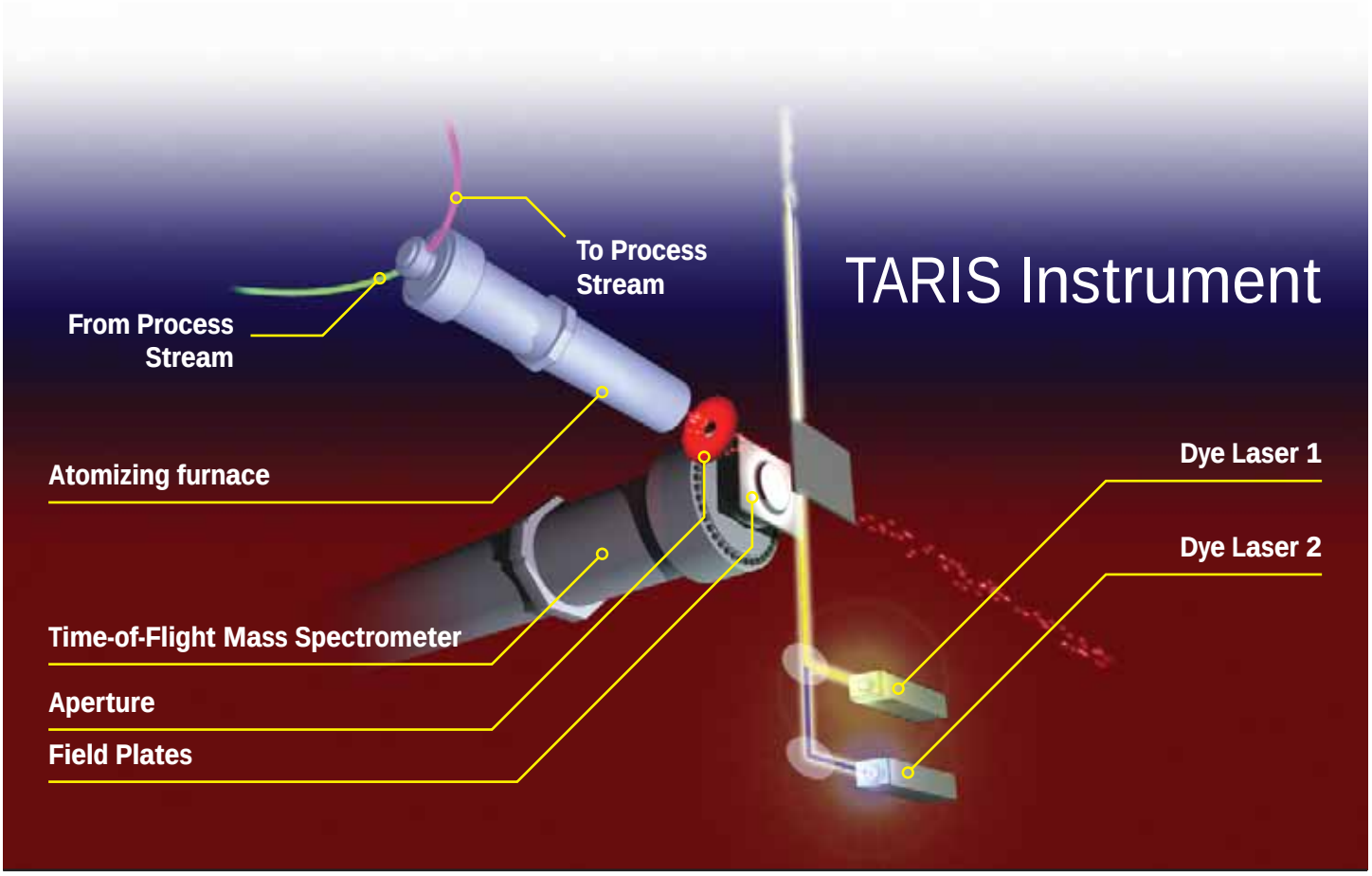
The model is useful for designing future reprocessing plant instrumentation, defining the goals of new instrumentation that may be developed in an R&D program, and assessing facility or process vulnerabilities which may increase proliferation risk. The model simulates the standard error of the inventory difference (SEID) for a particular instrumentation package to determine locations in the

plant that require better measurements. Preliminary work has shown how better measurements of the amount of plutonium in process could decrease the SEID substantially—new instrumentation is currently being examined for this use. The model can also determine how well an instrumentation package can detect a simulated diversion of material. It is being used as part of the Global Nuclear Energy Partnership to help develop instrumentation mappings for the next reprocessing plant built in the US.

Mass spectrometry techniques have been found to be the only way to achieve the high precisions needed for plutonium accountability in a mixed stream. The Process Monitoring Model has helped show that increased sampling and mass spectrometry measurements may be the only way to achieve better accountancy than what is currently achieved. However, sampling is limited by the amount of time it takes to chemically separate the samples. Sandia is working with Atom Sciences, Inc., in Oak Ridge, TN, to investigate techniques such as TARIS (Thermal Atomization Resonance Ionization Spectroscopy) and IC-MS (Ion Chromatograph-Mass Spectrometry), which have the potential to speed up measurement times considerably.

A final challenge to the acceptance of process monitoring tools is assuring stakeholders that the data being used is authentic. (See article on page 23.) That is, it must be known that the data originated from the intended source, the data was not changed in transit, and it is not a repeat or delayed copy of previous data. Also, the IAEA must be assured that the integrity of the monitoring equipment has not been compromised. While the necessary tools exist to provide these assurances, monitoring systems must be designed with authentication in mind if they are to be accepted by the IAEA and the operator without adding excessive cost.

Sources: Benjamin Cipiti, 6763, MS 0748, 505-284-8757, fax 505-844-2829, bbcipit@sandia.gov; Paul Rexroth, 6722, MS 1371, 505-844-7470, fax 505-285-8870, perexro@sandia.gov; David Saltiel, 6721, MS 1373, 505-844-0231, fax 505-285-5055, dhsalti@sandia.gov; and Keith Tolk, 6722, MS 1371, 505-845-2306, fax 505-284-5437, kmtolk@sandia.gov



Long-Term Cooperation with Japan

Safeguards cooperation with Japan is one of the most important nonproliferation activities of the Department of Energy (DOE)/National Nuclear Security Administration (NNSA), as well as one of the longest running. With 53 operating nuclear power reactors, Japan is the only non-nuclear weapon state to deploy full-scale enrichment and reprocessing facilities. This advanced capability requires that safeguards and physical protection performance must be exceptionally high. Fortunately, commitment to nonproliferation goals is strongly embedded in Japanese industry, government, and research organizations. The US DOE/NNSA has executed a long series of safeguards agreements with counterparts at the Japan Atomic Energy Agency (JAEA) to develop safeguards technologies and to adapt these to many unique facilities. In addition, Japanese possession of the full fuel cycle has brought about close cooperation between the DOE labs and the JAEA on various subjects in physical protection.

Remote Monitoring Technology Development

Since the early 1990s, the world safeguards community has hoped to take advantage of global communications to make containment and surveillance (C/S) activities more timely and cost-effective. As data acquisition system memory capabilities expanded exponentially a decade ago, it became feasible to replace magnetic tape storage with computer memory. Initially, the systems used dial-up modems to report surveillance information. Since then, the rapid development of internet data transmission capabilities has revolutionized many C/S activities.

The collaboration between Sandia National Laboratories (SNL) and the JAEA has made them leaders in this development since 1996. Technical capabilities demonstrated at the JAEA under this collaboration have directly affected implementation of remote monitoring around the world. One reason this has been so productive is the decision by the JAEA to accept an SNL expert for long-term assignment, the sixth assignee having started in May 2006.

Technically the work has progressed from one-of-a-kind systems with proprietary software and dial-up modems, to International Atomic Energy Agency (IAEA)-approved technologies and commercially supported data transmission software. The long-term SNL-JAEA demonstration and fielding of new systems has consistently nurtured this approach to C/S. Worldwide, the IAEA now fields more than 300 cameras with remote monitoring in 15 states and Taiwan.

The latest emphasis in this collaboration is to establish remote monitoring cooperation between the JAEA and the Republic of Korea's safeguards institute, the Korea Institute of Nuclear Nonproliferation and Control (KINAC), with the goals of technically developing and strengthening the regional nonproliferation culture. SNL is facilitating discussions of an appropriate agreement and is also getting Australia interested in potential accession, as a step towards true regional nuclear transparency.

Cooperation in Physical Protection

SNL-JAEA cooperation has been responsive to the changing security environment in the face of worldwide terrorism. In response to Japan's Diet having passed a major new law on protection of nuclear material and sensitive information in 2005, the competent authorities in the Ministry of Education, Sports, Culture, Science and Technology (MEXT) have promulgated comprehensive new regulations to implement these legal requirements in 2006.

SNL has supported timely and effective response to the regulations by conducting training and planning workshops with the JAEA. Reflecting that Japan must find a national solution to a problem that the US has previously addressed, SNL's approach has been to deliver information about how to address the security issues, rather than simply transferring the US solution. Working from the logical starting point,

SNL delivered a workshop on design basis threat (DBT) before workshops on evaluating protective systems and considering transportation security. Ongoing work in transportation security is moving forward rapidly and is currently focusing on a vulnerability assessment that is combined with specific consequence analysis for several potential circumstances.

JAEA colleagues face somewhat different challenges than other countries. To their advantage, they have a stronger sense of cultural unity that may mitigate insider threats. Like all countries, the Japanese DBT will likely be different from that of the US, but the basic methodology will likely be similar. SNL perceives that this cooperation is just now hitting full stride and will continue for some time.

Editor's Note: John Olsen recently returned from a two-year NNSA assignment at the JAEA. Source: John Olsen, 6721, MS 1373, 505-284-5052, fax 505-284-5550, jnolsen@sandia.gov

The JOYO Reactor

The test bed for SNL-JAEA cooperation in remote monitoring is JAEA's JOYO Experimental Fast Reactor. As a fast reactor with fresh fuel that has more than 20% plutonium, JOYO is of high safeguards interest. Since 1995, the JAEA has offered testing of remote monitoring technologies at the Fresh Fuel Storage and at one of the spent fuel ponds as a venue for cooperation with SNL. The most recent configuration of the system has achieved conformance with IAEA standards.

This image shows a typical display for observing events that trigger the system into action. For example, if workers open a vault door, the system's cameras begin shooting a sequence of images. These images are authenticated, stored, backed up, encrypted, and sent by file transfer protocol in a routine nightly transmission.

Regional Collaboration Initiative

The Regional Collaboration Initiative (RCI) began as a bilateral collaboration between the Republic of Korea (ROK) and the US, under the auspices of the Department of Energy (DOE)-Ministry of Science and Technology (MOST) Safeguards Cooperation Arrangement. RCI has expanded to formally include the Japan Atomic Energy Agency (JAEA) and is in the process of expanding again to include the Australia Safeguards and Nonproliferation Office (ASNO). The overall objective of the RCI is to strengthen cooperation and transparency between regional nuclear material control entities, enhance the effectiveness and efficiency of international safeguards, and establish a sustainable nonproliferation culture.

Regional cooperation and transparency have been effected through a series of technical collaborations. The JAEA's Nuclear Nonproliferation Science and Technology Center conducted a workshop on "Regional Cooperation in Remote Monitoring for Transparency and Non-Proliferation" in February 2006, with participation from the US, the ROK, and the IAEA. The IAEA is a very interested observer in the RCI and sees the potential of employing this mechanism as a test bed for potential international safeguards technologies.

In addition to providing the opportunity to advance international safeguards technology, the RCI provides the type of international nuclear partnership that could be instrumental to the multinational efforts that will be required to successfully advance the benefits of the Global Nuclear Energy Partnership.

Source: Don Glidewell, 6721, MS 1373, 505-844-9261, fax 505-284-5055, ddglide@sandia.gov

IAEA Vulnerability Assessments

The Program of Technical Assistance to IAEA Safeguards (POTAS) is the primary source of funding for the US Support Program to IAEA Safeguards (USSP), which provides extra budgetary assistance to the IAEA for research and development projects to address technical safeguards issues. The tasks funded by POTAS include vulnerability assessments (VA), equipment development, training, and software development. Congress passed the bill that originated POTAS in 1977, and Sandia received its first USSP task that same year. There have been many more tasks throughout the years, including the following current and recently completed VAs.

Vulnerability Assessment of the Electro-Optical Sealing System

A team of Sandians recently completed a VA of the firmware and software for the Electro-Optical Sealing System (EOSS). This is an electronic fiber optic loop seal that has been developed by a German firm and is likely to be adopted as one of the main seals for use in IAEA safeguards.

Vulnerability Assessment of Sign and Forward

The Sign and Forward system was developed by the IAEA to apply cryptographic signatures to data collected by its monitoring systems and to forward the data to a data storage device on another computer. The Sandia team that evaluated the EOSS software and firmware will begin assessing the hardware and software as soon as this equipment is received from the IAEA.

Vulnerability Assessment of the Tamper-Indicating Foil

The EOSS uses a special tamper-indicating foil to actively detect any attempt by an adversary to gain access to the security-critical components inside the seal. The same foil is proposed for protecting many other pieces of equipment used by the IAEA. A team of Sandians has begun an assessment on the foil.

Source: Keith Tolk, 6722, MS 1371, 505-845-2306, fax 505-284-5437, kmtolk@sandia.gov

K-Area Material Storage at Savannah River Site and International Safeguards with the IAEA

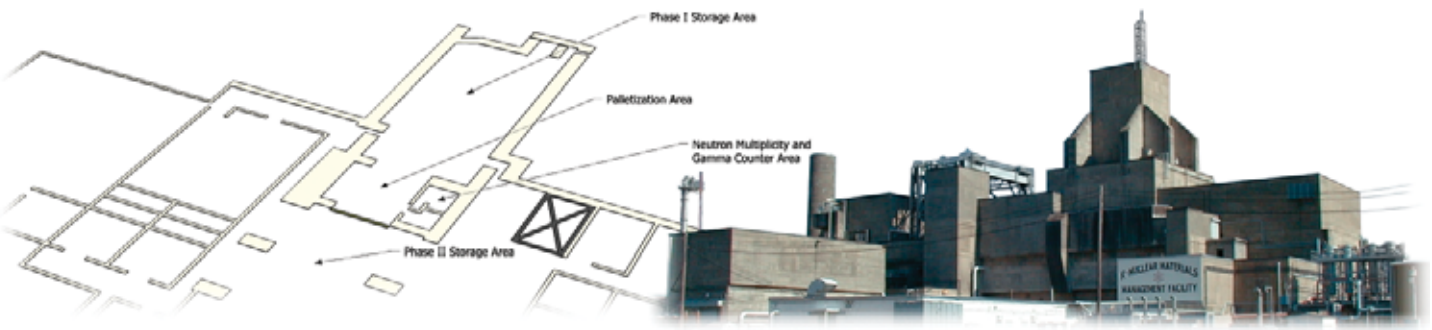
After many years of planning, the K-Area Material Storage (KAMS) at Savannah River Site (SRS) came on line in 1999. The original purpose of KAMS was to serve as an interim storage facility for excess weapons grade fissile materials from the Rocky Flats facility in Colorado. During the time the material was stored at Rocky Flats, the IAEA performed monthly international safeguards inspections on the material. The purpose of these inspections was to ensure that the US was not diverting any of this material for use in any type of weapons production.

At the conceptual phase for KAMS, the management at Savannah River decided to use Sandia's active radio frequency tamper indicating device (RFTID) fiber optic seals to monitor the material. A very extensive system of antennas, receivers, and data collection equipment was installed in the storage area, and user displays were installed in the control room for quick response to any alarm issues. The RFTID system came on line in September 1999. Replacing the normal metal seals with RFTID seals for container tamper monitoring lengthened the period for performing inventories of the material. This resulted in a reduction in US and IAEA labor for inventories and a reduction of personnel exposure to the material radiation.

Originally, the material from Rocky Flats was to be moved to KAMS and withdrawn from international safeguards. However, in early 2002, the DOE decided to make a voluntary offering to the IAEA to have some part of the materials allowed in international safeguards. Upon the final agreement between the IAEA and the DOE, the materials were placed under international safeguards in Fall 2002. The KAMS management provided a CD to the IAEA every month, starting in November 2002, which contained data from a portion of the material in storage. The IAEA read the data from this CD into their local computer to determine that there had been no tampering with any of the materials. This data analysis could only be conducted on site. In addition to receiving the domestic data, the IAEA installed a video system in order to have dual containment surveillance.

After several years, the IAEA decided to prototype Remote Monitoring (RM) to the process in order to increase efficiency and effectiveness and to allow for viewing RFTID and video surveillance information at any time from dedicated computers at the IAEA in Vienna. The success of these prototype tests would allow the IAEA to reduce the number of onsite inspections from monthly to quarterly. The tests proved to be very successful. In September 2006, almost four years after inspections began, the IAEA performed a monthly inspection at KAMS by remote monitoring. Now, during the IAEA's inspections, the data will still be authenticated in Vienna; the success of that will be transmitted to the onsite inspectors, thus eliminating inspectors having to perform any kind of data analysis at the site. The KAMS facility is the first in the world to implement the remotely monitored dual containment/surveillance international safeguards approach for a plutonium storage facility. The new RM system will benefit both the IAEA and DOE and should result in extensive costs savings on both sides.

Source: Lawrence Desonier, 6754, MS 1361, 505-845-8332, fax 505-284-5437, lmdeson@sandia.gov



Partnering with Industry

Several articles in this issue of the International Security News highlight the critical nature of partnerships in Sandia's safeguards work. Partnerships with other labs and institutes, both domestic and international, are essential to developing leading edge technologies to meet the demands of effectively safeguarding the expanding global growth nuclear energy. When it comes to developing technologies that are truly deployable in realistic international settings, no partnership is more important for a research and development (R&D) organization like Sandia than one with an internationally recognized track record. Such a partnership ensures that the technologies developed by Sandia's R&D efforts result in fieldable systems in realistic settings worldwide.

Sandia's Safeguards Technology Development Group is fortunate to have such a partner for the development of the Secure Sensor Platform, or SSP. (See article on page 11.) Canberra Albuquerque, Inc., is a $20 million, wholly owned subsidiary of Canberra Industries engaged in the development, manufacture, sale, and maintenance of state-of-the-art electronic equipment. Located in New Mexico since 1971, Canberra Albuquerque has been designing and producing specialized equipment for international safeguards since 1989. It supplies nuclear safeguards products to governments and industries worldwide, and its services include the development, manufacture, sale, and maintenance of all equipment.

Canberra Albuquerque also manufactures containment seals and is involved in replacement seal technology development. It is precisely this core competency that the Sandia SSP team engaged in July 2005 to discuss the prospect of entering into a Cooperative Research and Development Agreement (CRADA). The CRADA proposal was met with enthusiasm by Canberra Albuquerque, and the technical teams have been working well together for over twelve months. Additional ideas for collaborative safeguards technology development have already emerged from this relationship.

The fact that Canberra Albuquerque operates on a program and project level with ISO 9001:2000 quality workmanship will ensure that the highest level of quality will be attained at every stage of development and production of the SSP. The first production units of the SSP are expected in late Winter of 2007, and international collaborators are eager to work with the Sandia/Canberra Albuquerque team on future design efforts.

Source: Bob Huelskamp, 6722, MS 1371, 505-844-0496, fax 505-284-8870, rmhuels@sandia.gov

Equipment Security and Authentication

In order to draw valid safeguards or treaty compliance conclusions from a monitoring system's data, it is essential that this data is known to be authentic. This requires trusting that the equipment collecting the data is secure against compromise by all possible adversaries. It is also important to ensure that the data came from the specified equipment during the specified time frame and that the data has not been changed in any way since it was taken.

The term used for establishing both of these assurances is "authentication." Authentication of equipment is the process of ensuring that the data from the equipment accurately represents the conditions at the monitored facility and that no adversary has compromised the integrity of the equipment. Authentication of data is a cryptographic process used to ensure that the data cannot be modified in any way without detection.

Sandia did much of the early development work in data authentication back in the 70's and 80's and continues to be a leader in this area. Sandia also did much of the work in the development of tamper-indicating enclosures and in the area of tags and seals used to secure equipment and materials.

Sandia participated in developing monitoring systems for verifying several arms control treaties, including the various test ban treaties, the Intermediate Nuclear Forces treaty, and all of the Strategic Arms Reduction treaties. We also had a lead role in the Authentication Task Force, a multi-agency team that created approaches for developing equipment that would allow outside parties to make confirmatory measurements on nuclear weapons components inside containers. Sandia has also helped the IAEA establish the equipment security architecture and security policies for IAEA monitoring equipment.

Designing monitoring equipment and systems to be used in monitoring the compliance with international treaties or for international safeguards is a difficult task. One of the first steps in the authentication process is to understand the party being inspected. It should be assumed that the inspected party knows everything about the system except for secret cryptographic keys and passwords. He may even have copies of the measurement systems to practice his attacks. It should also be assumed that the inspected party has the resources of a national entity behind him, with extensive computing and manufacturing resources at his disposal. It has been demonstrated that an inspected party can even compromise the security of equipment in a way such that it gives accurate results during operational testing and false results during actual use.

The equipment is almost always deployed in the inspected party's facility, even though the equipment's purpose includes detecting any diversion of nuclear material by that party. For example, material under safeguards might be nuclear material that could be used in a covert nuclear weapons program; the diversion of such material could reduce the cost of that covert program by several millions of dollars!

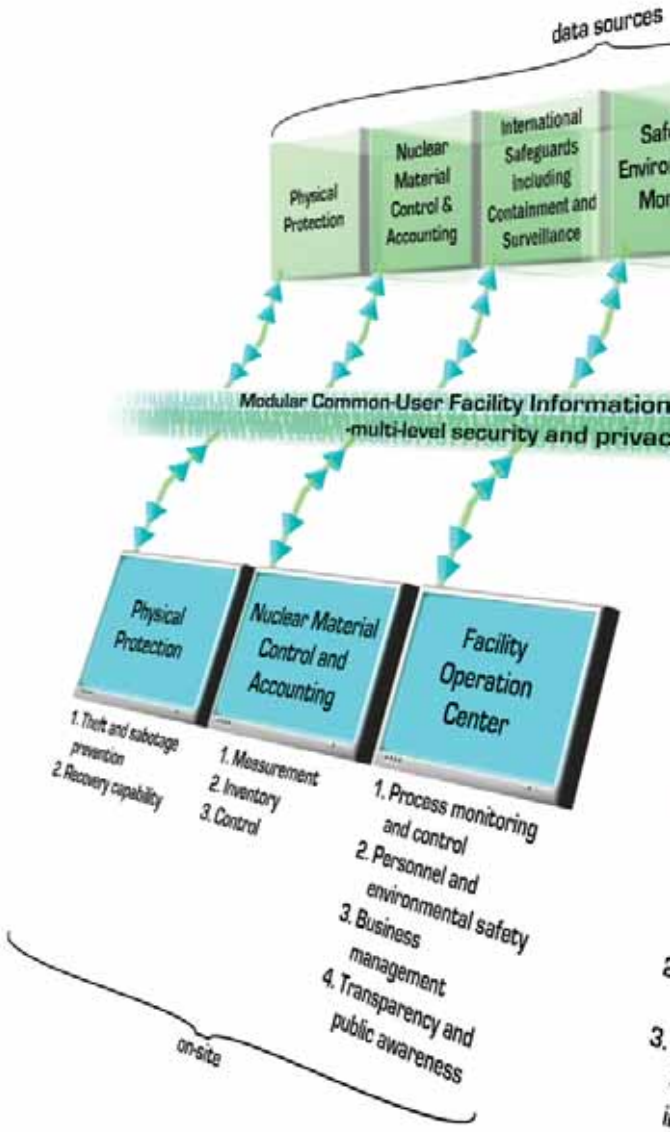
In order to be effective, we have found that the equipment authentication process should start during the design process and continue throughout the lifetime of the system. Failure to provide for authentication in the design of the equipment will almost certainly increase the cost of the authentication process and may make full authentication impossible. First, the system should be as simple as possible. Equipment that is easily understood is much easier to authenticate. Next, the system should be modular with well-defined interfaces between the modules. This allows the system to be analyzed in easily understood pieces, rather than attempting to perform adversarial analysis on the more complex system. The authentication measures should be designed into the system, and the preparation of a plan for verifying the integrity of the equipment should be part of the design documentation.

Failure to integrate authentication measures early in the design may result in systems that are expensive or, perhaps, impossible to deploy securely. It is actually possible to spend more money on adding the necessary authentication measure to a system than designing and installing a new system. Although it is difficult to design systems that are adequately secure to address the requirements for treaty verification and international safeguards, we have found that these goals can certainly be met if the system is properly designed and implemented.

Source: Keith Tolk, 6722, MS 1371, 505-845-2306,
fax 505-284-5437, kmtolk@sandia.gov

Enhanced Safeguards based on Expanded Information Availability in New Nuclear Facilities

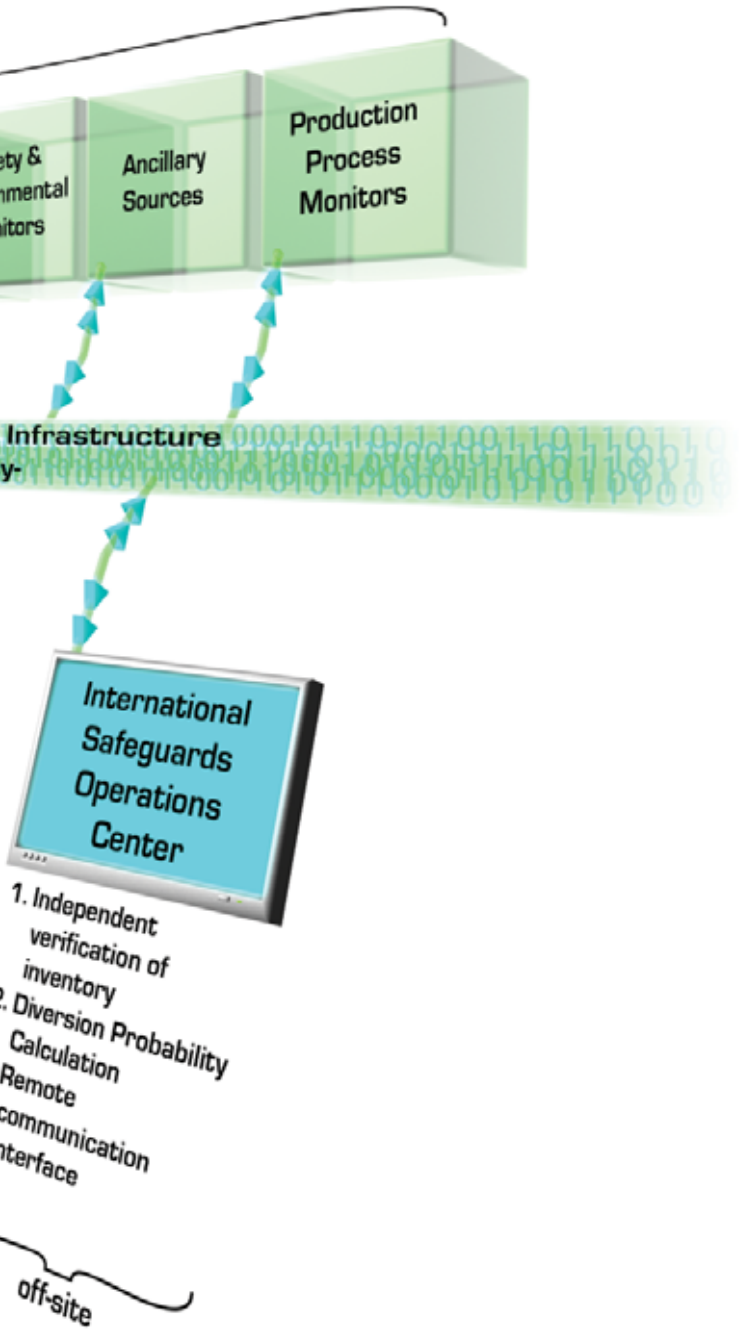
The Global Nuclear Energy Partnership (GNEP) vision includes the concept of "designing-in" both domestic and international safeguards into new facilities to achieve enhanced safeguards performance with minimum cost and operational impact. The International Atomic Energy Agency (IAEA) has highlighted the need to develop new or improved safeguards approaches and techniques, including enhanced information acquisition, analysis, and evaluation, in order to safeguard the future civilian nuclear energy enterprise in an effective and efficient manner. The Nuclear Energy Study Group of the American Physical Society (APS) Panel on Public Affairs report entitled "Nuclear Power and Proliferation Resistance: Securing Benefits, Limiting Risk" noted the need for improving system integration (not to be confused with the IAEA's integrated safeguards), which includes upgrading information management and analysis tools, and integration of data from disparate sensor types and automated anomaly detection. A key factor in achieving these goals will be the development and certification of advanced technologies, which will enable efficient and secure collection of data from various sensors and other information sources and the utilization of this data by multiple users for multiple purposes.



This expanded information availability can be used to enhance the performance of both international and domestic safeguards, including physical protection as well as facility safety and process monitoring and control. These benefits will be realized only with the participation of a wide range of partners including technology specialists, facility designers and operators, domestic and international safeguards experts, national and international policy makers, and sponsors.

Creating a facility all-source information system will be a major element in enabling this expanded information availability in new facilities. This network would allow appropriate access to data from a wide range of sources. A multi-level secure

facility data bus with open architecture, interface standards, and protocols based upon advanced Ethernet and wireless technologies can support the needs of various users while providing them assured full privacy and flexibility to execute their unique operational missions. The modularity of the data bus architecture allows its application to a large number of different types of facilities and provides a "plug and play" capability permitting adaptation to meet new requirements as they change over time, exploitation of lessons learned, and insertion of new technologies. A block diagram showing the conceptual system architecture is shown in the graphic.



Realizing this capability will require the development and integration of a wide variety of technologies including:

1. modeling and simulation techniques to guide the systematic design of systems and the analysis of vulnerabilities
2. microsensors, nanosensors, and machines for measuring and monitoring material properties such as isotopic content, radiation, motion, and physical conditions
3. radiation-resistant components for stressed environments
4. end-to-end information integrity and secure transmission techniques based on exportable encryption and authentication technologies and tamper-resistant enclosures
5. data collection and transmission techniques utilizing advanced Ethernet and wireless technologies
6. extremely low-power system components with robust, small power sources
7. data fusion and data mining to transform vast amounts of data into actionable knowledge

As mentioned above, success will depend on the active participation of a wide range of partners to assure that fundamental requirements are met and that cost and operational impacts are limited.

Source: Tom Sellers, 12101, MS 1363, 505-284-9473, fax 505-284-5974, taselle@sandia.gov

US-Russian Strategic Partnership for Enhancing Responses to Future Nuclear Nonproliferation Challenges (3x3)

In the December 2005 International Security News, we reported on the progress of the 3x3 partnership. Since then, the partnership has explored potential areas and methods of collaboration and engagement with the Russian labs in pertinent topical areas not currently covered by other cooperative agreements. It is important to note that the 3x3 has already expanded to include non-weapons laboratories and institutes in various projects (see table below). To date, Oak Ridge National Laboratory (ORNL), Kurchatov Institute (KI), and the Mining and Chemical Combine (MCC) have expressed interest in proposed projects. This controlled expansion will continue and will be driven by the technical needs of specific projects.

The US and Russia have already demonstrated that successful bilateral cooperative science and technology collaboration can be achieved. The Warhead Safety and Security Exchange and the Science and Technology Agreement are two such examples of existing programs. The 3x3 partnership has matured to the point where a Steering Committee has been established, collaboration projects have been initiated, and future projects are being explored. With its emphasis on nonproliferation versus nuclear energy technology development, the 3x3 partnership is suited to be complementary to any US–Russian cooperation to develop proliferation-resistant nuclear energy technology.

Source: Ruth Duggan, 6726, MS 1375, 505-844-9320, fax 505-284-9043, rduggan@sandia.gov

12 3x3 Projects Under Consideration

Reference	Title	US Lab	RF Institute
2.01	Material Accountancy Verification through Process Monitoring during Enrichment	LANL SNL	VNIIEF
2.02	Plutonium Estimation from Fission Product and Actinide Ratios	SNL ORNL	VNIIEF
2.03	Reactor Monitoring with Antineutrino Detectors	LLNL SNL	VNIIA KI
2.04	Systems Analysis Approach toward Interim Irradiated Nuclear Fuel Storage	SNL	VNIITF MCC
2.05	Development of Liquid Scintillator Multiplicity Counters (LSMC)	LANL	VNIIEF
2.06	Improved Safeguards for High-Volume, High-Throughput Enrichment Facilities	LANL LLNL	VNIIEF
2.07	Detection and Identification by Radiographic Methods	LLNL	VNIIA
2.08	Environmental Testing and Evaluation on Advanced Fiber Optic Loop Seals	SNL	VNIIA
2.09	Hyperspectral Remote Sensing of the Nuclear Fuel Cycle	LLNL SNL	VNIITF
2.10	Carbon Nanoparticles as a Potential Forensic Signature	LLNL	VNIITF
3.01	Quantifying the Attractiveness of Nuclear Materials	LANL LLNL	VNIIEF VNIITF
3.02	Fuel-Power Complex of Russia and CIS	SNL	VNIIEF KI

Calendar: Visits, Workshops, and Conferences

April 2-4 **Muscat, Oman:**
RMCC Workshop.
Amir Mohagheghi 6721, 505-844-6910.

April 4-6 **Albuquerque, NM:**
3D Computer Vision Error Assessment Seminar.
Tim Miller 1534, 505-284-8194.

April 9-13 **Singapore:**
International Security Conference.
Arian Pregenzer 6720, 505-844-4967, and
David Saltiel 6724, 505-844-0231.

April 17-19 **Bangkok, Thailand:**
Biosecurity Conference.
Jennifer Gaudioso 6724, 505-284-9489.

April 23-27 **Albuquerque, NM:**
Advanced Laser Applications.
Mike Valley 1535, 505-844-1201.

April 26-27 **Albuquerque, NM:**
Eagleson Training Workshop.
Paula Austin 6724, 505-844-4272.

May 7-16 **Albuquerque, NM and Sanford, ME:**
Eagleson Bio Seminars.
Jennifer Gaudioso 6724, 505-284-9489.

May 8-11 **Albuquerque, NM:**
Readiness for Duty Workshop.
Elaine Hinman-Sweeney 6723, 505-845-7380.

May 27-28 **Richland, Washington:**
Mining and Chemical Combine (MCC).
Adriane Littlefield 6721, 505-284-5067.

May 31-June 11 **Albuquerque, NM:**
Border and Port Security Exchange.
Amir Mohagheghi 6721, 505-844-6910.

June 4-8 **Albuquerque, NM:**
US Army Tour.
Don Glidewell 6721, 505-844-9261.

June 17-22 and June 25-27 **Albuquerque, NM:**
IEEE Pulsed Power Conference (PPC).
Ken Struve 1671, 505-845-7483.

June 23-29 **Albuquerque, NM:**
IHED Russian Delegation.
John Aidun 1435, 505-855-1209.

June 30-July 4 **Hawaii:**
IHED Russian Delegation.
John Aidun 1435, 505-855-1209.

July 8-13 **Tucson, AZ:**
INMM Conference.
Kevin Seager 6723, 505-845-8730.

July 16-18 **Albuquerque, NM:**
Taipower Meeting.
Mark Soo Hoo 6751, 505-284-4389.

August 6-10 **Albuquerque, NM:**
NRC Meeting.
Mark Soo Hoo 6751, 505-284-4389.

September 22-October 1
Albuquerque, NM and Sanford, ME:
Eagleson Bio Seminars / Certification
Jennifer Gaudioso 6724, 505-284-9489.

October 9-12 **Albuquerque, NM:**
ILABS Meeting.
Gloria Chavez 6721, 505-845-8737.

October 13-20 **Albuquerque, NM:**
SEVERSK Program Review.
Charlie Harmon 6753, 505-845-7028.

October 13-20 **Albuquerque, NM:**
International Training Course (ITC-20)
John Matter 6754, 505-845-8103.

International Security News is on the Web
http://isn.sandia.gov/

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

SAND2007-2950 P

PUBLISHED BY:
Sandia National Laboratories
Global Security Programs
Doris E. Ellis, Director

EDITOR:
Heather McDaniel 6034, MS1376
location: IPB/2163
phone: 505-845-1250
fax: 505-844-5771
e-mail: hmmcdan@sandia.gov