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The US Support Program to IAEA Safeguards Priority of Containment and Surveillance

Raymond A. Diaz
International Safeguards Project Office
Nonproliferation and National Security Department
Brookhaven National Laboratory
Upton, NY 11973
www.bnl.gov

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Brookhaven National Laboratory
P.O. Box 5000
Upton, NY 11973-5000
www.bnl.gov

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Raymond A. Diaz
Brookhaven National Laboratory
P.O. Box 5000, Upton, NY 11973-5000

ABSTRACT

The United States Support Program (USSP) priority for containment and surveillance (C/S) focuses on maintaining or improving the reliability and cost-effectiveness of C/S systems for IAEA safeguards, expanding the number of systems that are unattended and remotely monitored, and developing verification methods that help streamline the on-site inspection process. Existing IAEA C/S systems have evolved to become complex, integrated systems, which may include active seals, nondestructive assay (NDA) instruments, video cameras, and other sensors. These systems operate autonomously. They send analytical data to IAEA headquarters where it can be reviewed. These systems present challenges to the goals of improved system performance, standardization, reliability, maintainability, documentation, and cost effectiveness. One critical lesson from past experiences is the need for cooperation and common objectives among the IAEA, the developer, and the facility operator, to create a successful, cost effective system. Recent USSP C/S activities include Rokkasho Reprocessing Plant safeguard systems, production of a new shift register, numerous vulnerability assessments of C/S systems, a conduit monitoring system which identifies tampering of IAEA conduit deployed in the field, fiber optic seal upgrades, unattended monitoring system software upgrades, next generation surveillance system which will upgrade existing camera systems, and support of the IAEA's development of the universal nondestructive assay data acquisition platform.

1. INTRODUCTION

This paper summarizes the United States Support Program (USSP) Containment and Surveillance (C/S) priority. The main objective of this priority is to improve the capabilities, reliability, and cost-effectiveness of C/S systems for unattended and remotely monitored use. IAEA requests applicable to this priority are sealing systems, containment systems, vulnerability assessments, video surveillance, equipment factory maintenance, workshops, unattended monitoring, remote monitoring, cost free experts (CFE), junior professional officers (JPO), and nondestructive assay (NDA) hardware/software. The USSP provided over $4 million funding, in 2007, for more than forty projects under this priority. The Subgroup on Safeguards Technical Support and the International Safeguards Project Office established priority statements to allow the USSP to more effectively categorize IAEA requests, to establish strategies to address these requests, and for goals to measure performance on an annual basis.

2. C/S GENERAL DISCUSSION

Many of the IAEA's C/S systems have evolved to become complex, integrated systems, which may include seals, instruments, video cameras, and other sensors. Increasingly, these systems operate autonomously and send analytical data to IAEA headquarters. These systems present challenges to the goals of improved system performance, standardization, reliability, maintainability, documentation, and cost effectiveness. The individual containment and surveillance subsystems are evolving continually as well. One critical lesson from past product development experiences is the need for cooperation and common objectives among the IAEA, the developer, and the facility

operator, to create a successful, cost-effective system. The USSP ensures IAEA and commercial entity participation in the design review of the product prototype, prior to commercialization, in product development projects. This gives the IAEA the opportunity to ensure that the prototype meets their needs. It lets the commercial entity provide input to the developer, so that the product can be commercialized effectively, to maximize reliability and cost effectiveness.

Containment strategies are vital to ensuring that IAEA safeguarded facilities (including equipment and storage areas) have not been compromised by a break in the continuity of knowledge (CoK). These strategies are most often satisfied through the use of tamper indicating devices, such as seals. Most of the IAEA's seals have been in use for many years. Some seals are being upgraded or replaced, with the intent of reducing vulnerability and increasing the ability to verify the seal either in situ or remotely. New concepts which have not been implemented yet are the use of the intrinsic properties of a container, or building it to make it tamper resistant, or by incorporating tamper indicating mechanisms into the container or building design.

Video surveillance has long played a critical role in maintaining CoK on safeguarded nuclear material, to avoid the need for frequent re-measurements that would otherwise be needed to detect certain diversions. There are longstanding problems of system reliability and occasional performance problems, which cause anomalies that are difficult to resolve.

NDA related work includes all equipment and software from the instrument making the measurement, processing this information, and presenting the data to the inspector. NDA hardware and software require upgrades continually to present data more effectively to the inspectors to minimize their workload, especially during on-site inspections. NDA equipment has focused on the detection of gamma ray and neutron sensors, due to the ability to identify and quantify most forms of nuclear material. NDA systems are evolving continually to keep pace with the improvements in sensors and electronics and to address the changing requirements of nuclear materials and facilities. [1]

The USSP supports the development and implementation of technologies for increasing the number of standardized containment and surveillance systems operating in unattended and remotely monitored configurations. Associated challenges are the reduction in the number of unique types of equipment and regular updating and verification of system documentation for inspectors and maintenance staff. In the near future due to the expected nuclear renaissance, safeguards will have to address the growth of complex fuel cycle facilities under integrated safeguards, the spread of nuclear power stations to new states and, very likely, the monitoring of facilities in states of IAEA interest. All of these will require the continued use of C/S systems. The continuing demands on the IAEA to implement more effective safeguards subject to constrained resources will require technical solutions that do not come with a considerable maintenance cost.

Integrated safeguards involve less frequent, randomized inspections. These inspections are ineffective unless they are coupled with unattended and remotely monitored equipment to maintain CoK, requiring extremely reliable and easily maintained C/S equipment.

Complex and sensitive fuel cycle facilities will likely require combinations of C/S devices working together with radiation monitors and other sensors, possibly for joint use by the State and the IAEA.

The spread of power reactors to a wide spectrum of States requires surveillance systems that provide clear information regarding spent fuel pool operations. These systems will need to be designed to tolerate ambient radiation levels, to work in poor lighting conditions, to operate with radiation and other sensors, to provide high resolution-images based on a number of triggering modes, and to operate for long periods of time with extremely high reliability.

3. PRIORITY STRATEGIES

The USSP priorities were written to document the policy and guidelines of the USSP. When determining the acceptance of an IAEA request, the SSTS considers whether it is addressed by the USSP priorities. Each USSP priority contains implementation strategies. The C/S priority included NDA, prior to submittal of the abstract for this paper. The USSP has created a separate priority for NDA recently. The author has decided to include the NDA priority in this paper. The strategies for the C/S and NDA priority are:

1) to support the implementation of improved C/S systems, which increase the inspectors' efficiency and ability to perform effective C/ S safeguards,
2) to support the development of C/S systems, including advancements in system performance, standardization, reliability, and cost-effectiveness,
3) to support the maintenance and improvement of existing sealing and containment systems,
4) to support the implementation of improved NDA systems, which increase the inspector's efficiency and ability to draw accurate safeguards conclusions,
5) to support the development of NDA systems, including advancements in system performance, standardization, reliability, and cost-effectiveness, and
6) to support the maintenance and improvement of existing NDA systems.

3.1 PRIORITY TACTICAL GOALS

Each priority has a number of tactical goals which address priority strategies. Each tactical goal contains a list of performance measures. The performance measures list activities which are expected to be accomplished in the following year. Each year, the USSP evaluates the results of the previous year's performance measures. The tactical goals for this priority, brief descriptions of some active projects, and pending requests applicable to each are provided below.

3.1.a Continue support for the development of the Next Generation Surveillance System (NGSS)

The IAEA is developing NGSS to replace the digital camera module (DCM-14) video surveillance systems. The USSP has provided funding for the development of NGSS, under task E.137, which includes a consultant to assist the IAEA with project management. The DCM-14 was first implemented for safeguards use in 1998. After ten years of reliable performance, the DCM-14 is nearing the end of its lifecycle, with critical components disappearing from the market and more advanced components becoming commercially available. The IAEA plans on retiring the DCM-14 as soon as NGSS development and production are complete. [2] NGSS is designed to cover the future IAEA surveillance needs for both current and new safeguards verification regimes. The development of NGSS is divided into four phases, to facilitate effective and efficient project management and to allow for phased funding. These phases are:

1) conceptual design,
2) detailed design,
3) prototype development, and

4) prototype construction and testing.

Phases 1 and 2 have been completed. Phase 3 is near completion. [3]

3.1.b Continue manufacturer factory support for the Digital Imaging System (DIS), the Server Digital Imaging System (SDIS), and the General Advanced Review Software (GARS)
The USSP provides funding for manufacturer factory support to the IAEA for GARS (subtask E.119.01), DIS (task E.133) and SDIS (task E.133). These tasks allow the IAEA to receive quick manufacturer responses to requested essential software and hardware upgrades. GARS provides a flexible and user friendly inspector interface for the review of images from numerous types of hardware. GARS has advanced features, which can be used to reduce an inspector's review effort. Some of these features include image and data authentication verification, image and data decryption, scene change detection of recorded digital images, digital enhancement, and multiple camera display options. SDIS was developed initially for remote monitoring applications. Its primary function is the collection of images and data from multiple DCM-14 surveillance cameras. It may also be used for the direct interrogation of certain IAEA seals. The system is designed to collect various forms of data, such as instrumentation, video, trigger, and environmental. The SDIS server sorts and classifies this data and has the capability to transfer images and data to IAEA headquarters securely. [4]

3.1.c Continue support for the future development of sealing/containment and surveillance systems to increase performance, increase security, reduce inspector workload, and reduce costs
The USSP continues to fund requests under this tactical goal. Task E.158: "Testing of Secure Satellite Communication for Remote Monitoring Inspection Support" provides an information technology expert, who will perform a vulnerability assessment of a remote monitoring test system using satellites. The IAEA would like to use this system to reduce remote monitoring operating costs and improve system performance. Subtask E.122.19: "Equipment Security Technical Support" provides assistance to the IAEA on an as needed basis. An equipment security expert has assisted the IAEA with the training of a staff member and with project technical reviews, including the completion of outstanding equipment security related tasks. Task E.140: "Enhancement of the Cobra Fiber Optic Seal System" is improving the usability, and reducing the vulnerability, of the COBRA sealing system used by IAEA inspectors. Both the fiber optic seal and seal reader are being redesigned. The IAEA has submitted a request recently for an additional phase of this project to allow the new COBRA seal reader to also interrogate the electronic optical sealing system (EOSS) seals. Task E.150: "Development of a Conduit Monitoring System" provides for tamper detection of IAEA conduit and hardware, which is installed at safeguarded facilities. The USSP is evaluating requests from the IAEA including: "Reflective Particle Tags for the Verification of Welds," "Development of a Remotely Monitored Sealing Array," and the "Phase 5 of the Enhancement of the Cobra Fiber Optic Sealing System."

3.1.d Continue support for modernization and increased tamper resistance of the metal sealing system
The USSP has provided funding for the IAEA Metal Seal Modernization project. A national laboratory is developing an instrument capable of detecting the tampering of the two types of IAEA metal seal wires, under task E.144. The performance of the prototype instrument has been

documented by experiments, which provide estimates of the probabilities of failing to detect a tampered wire and misclassifying a non-tampered wire. This instrument will allow for a more thorough verification of metal seal wire integrity during IAEA inspections.

3.1.e Continue support for the development and maintenance of facility specific sealing systems

Task E.147: "Material Management System (MMS) Software Update" involves the upgrade of the MMS software used at the K-Area Material Storage facility in Savannah River. This system is used in conjunction with two–way radio frequency seals (TRFS), to provide containment of special nuclear material stored under international safeguards. The TRFS seal data is provided to the IAEA via remote monitoring. The USSP is waiting for the IAEA to submit a revised scope of work for this software upgrade, based on the results of the March 2008 Task Review meeting in Vienna.

3.1.f Continue support for containment verification requests

Task E.146: "Change Detection Software (CDS) Applied to a Containment Verification Application" involves the use of CDS technology to assist in tamper detection of equipment and facility containment. A national laboratory is in the process of submitting a video to the IAEA to demonstrate how CDS can be used for containment verification at safeguarded facilities. Funding can be requested from the USSP for continuation of this task, after the IAEA evaluates this video.

3.1.g Continue support for vulnerability assessments (VA) and advanced concepts related to the development of sealing and containment systems

The USSP continues to support IAEA requests for VAs of equipment and systems. The USSP has two active tasks at present. Task E.154 involves a VA on the upgraded ultra sonic sealing bolt (USSB), developed by the European Commission Joint Research Centre located in Ispra, Italy. The ECJRC USSB upgrade uses multiple independent, but spatially related, unique identity elements, which makes the bolt difficult to counterfeit. The new system reads the unique identify elements, using an ultrasonic transducer, and compares the spatial relationships between them. Task E.145 involves a VA of the IAEA adhesive seal. This task provides for the VA of the existing adhesive seal and input, with respect to vulnerability mitigation, on the design of the new adhesive seal under development by a private contractor.

3.1.h Continue providing professional technical support (CFE/JPO) for remote monitoring and sealing/containment activities

The USSP funds CFE and JPO requests to provide assistance to the IAEA for C/S. A CFE is providing technical assistance to the Seals Unit, under task E.148. The CFE's work includes containment verification, sealing systems development, vulnerability countermeasures training development, and evaluations of vulnerability assessments. Another CFE is providing technical assistance to the Remote Monitoring Unit. The CFE's work includes overseeing the integration of surveillance, unattended radiation monitoring, and remote monitoring systems. The USSP provided subject matter experts and a facilitator for the 2007 Seals Workshop, held at the IAEA, in February 2007, under task S.079. The workshop participants included experts from government, academia, and private industry. They offered recommendations to assist the IAEA to field the most effective and secure sealing and containment verification systems.

3.1.i Continue to support existing NDA systems including hardware and software
After funding the development of NDA software and hardware systems, the USSP has supported the extensive maintenance and upgrading of these systems. The USSP interprets NDA related work to include all equipment from the instrument making the measurement, the equipment processing this information, and all software that receives the data and presents the data to the inspector. A few active projects are provided below with a brief description.

The unattended and remote monitoring (UNARM) software is updated periodically. The UNARM software processes data from nuclear safeguards instruments, evaluates the data, and presents it to the inspector in a format to minimize inspector effort in determining nuclear safeguards conclusions. This software allows for a more comprehensive review of the data by the inspector, which would not ordinarily be possible due to time constraints. In response to an IAEA request, the current UNARM software upgrade (subtask E.122.20) includes the capability of addressing the Electro Optical Sealing System (EOSS) in unattended mode (subtask E.122.21) and increased functionality of the Digital Video Review (DVR) software. The DVR software processes pictures from safeguarded facility cameras.

The USSP funded the development and commercialization of the mini gamma ray and neutron detector (MiniGRAND), under task A.242. The MiniGRAND is used by the IAEA primarily for measuring and monitoring gross gamma rays and neutrons. This instrument can be used in the unattended mode. The following work is in progress, or has been recently completed, in support of this instrument: new shift register, master processor upgrade, and diagnostic testing including service.

The USSP is funding, under task A.267, the upgrade of the In Situ Object Counting System (ISOCS), planned for use in safeguards applications for the quantification of nuclear material by passive gamma spectrometry, with a particular focus on nuclear waste and nuclear material hold up measurement applications. This task is divided into three phases:
1) improve functionality and understanding,
2) improve accuracy of U/Pu measurements, and
3) Advanced ISOCS (A-ISOCS) software upgrade.

Phase I has been completed. Phase 2 is in progress at present. This project will result in the development of a new software code, which will provide the IAEA with the capability to assess more accurately, and within specifically evaluated modeling uncertainties, the quantity of nuclear material present in nuclear waste and/or hold-up assays. The successful implementation of an A-ISOCS capability will improve the reliability of ISOCS calibrations for safeguards verification. It will reduce the work load of IAEA experts who presently provide support to inspectors for the determination of nuclear safeguards conclusions from ISOCS data.

The USSP is supporting the "Sustainability and Maintenance of Software for Pu-Isotopics and U-Enrichment," under task A.274. The U.S. Department of Energy has two action sheets which are evaluating NDA software codes with a very similar scope to this task. The results of these action sheets may be used by the IAEA to plan a strategy for addressing this task.

3.1.j Support the development of new NDA systems which increase the accuracy of nuclear conclusions and minimizes the workload on inspectors

The USSP has funded the development of a prototype NDA detector, under task A.258, with the intended capability of in situ reverification of the nuclear material inventory inside dry storage casks (both concrete and metal) in the event of loss of CoK. Presently, IAEA relies on C/S after verifying the material during initial loading into the storage casks. This detector can be used to make an in situ initial nuclear measurement of a cask. This initial measurement can be compared to a future measurement to reverify the container contents, in the event of a future loss of continuity of knowledge. The prototype detector has been produced. Field testing on spent fuel casks is ongoing.

The IAEA has indicated that the universal NDA data acquisition platform (UNAP) will be the next generation data acquisition system for IAEA attended and unattended NDA. The IAEA plans on using UNAP for safeguards at the Japan Nuclear Fuel Limited mixed oxide (JMOX) fuel fabrication plant. The USSP has funded subject matter experts and a consultant, under task E.157, to assist the IAEA in preparing the user requirements for issuing an invitation to bid for the development of UNAP. The IAEA has estimated the cost of developing UNAP to be $1.5 million. The USSP is considering a decision to support the development of UNAP, due to its potential impact on projects already funded by the USSP. The USSP has requested that the IAEA provide additional information on the cost of the UNAP project and on how it will be integrated with the IAEA NDA equipment development and deployment strategy, in order to facilitate a timely decision. This information should provide the USSP with sufficient detail to make a future funding decision.

The USSP is evaluating numerous IAEA NDA requests, prior to making a funding determination. The SSTS indicated interest in the "Upgrade of the Continuous Enrichment Monitoring System (CEMO)" and "State of the Art NDA Techniques Applicable to Uranium Hexafluoride (UF6) Cylinders," at the 2008 USSP Annual Review Meeting. A meeting to discuss the CEMO request with other Member State Support Programs (MSSPs) will be held in July 2008.

3.1.k Continue support for the development and maintenance of facility specific NDA systems

The USSP is funding the revision of the Fork Detector Measurement System (FDMS) and Radiation Review software codes under task A.252. This software upgrade will enable the IAEA to perform FDMS analysis of spent fuel assembly data collected in unattended mode. The USSP funded the production of an inspector documentation package for FDMS. The package includes both a check list procedure and reference manual for software and instrumentation.

3.1.l Continue manufacturer support for existing NDA hardware and software systems

The IAEA has accepted the Integrated Inspector Information System (I3S) software delivery for the USSP funded multi-million dollar software development project for the Rokkasho Reprocessing Plant (RRP), under task A.247. The USSP has funded follow on maintenance support for RRP under two separate tasks: one for software (subtask A.247.21) and one for hardware (subtask A.247.22). This support is needed by the IAEA to troubleshoot issues, as RRP goes into full operation. Other ongoing tasks are software and hardware support for UNARM software (subtask E.122.15). This task provides the IAEA with technical support. Software issues identified by the IAEA are repaired, if possible, in the near term. If the software issue can not be rectified in the near term, the software developer documents the issue so it can be addressed in the next software release. An UNARM software control board (USCB) is funded under subtask E.122.13. The USCB consists of key software development personnel who meet periodically to discuss UNARM software issues.

The USCB coordinates the required revisions for the next software baseline release. All IAEA reported software issues are logged into a program to track their status.

3.1.m Continue providing professional technical support for NDA hardware and software

The USSP funds CFE and JPO requests to provide assistance with NDA software and hardware. A CFE is providing unattended and integrated monitoring support to the IAEA at present, under task A.266. The CFE's work includes technical assistance with neutron measurement instruments, a modern liquid scintillator feasibility study, RRP NDA instruments, and J-MOX measurement systems. A CFE is funded to manage and operate the data collection and evaluation of RRP software, under task D.172. This assignment involves project management for the RRP and J-MOX I3S and ensures the seamless transmission, authentication, and analysis of the instrumentation data from these facilities. A JPO is providing NDA nuclear physics assistance to the IAEA under task A.272. The JPO's work includes NDA evaluation and improvements to NDA software.

4. SUMMARY AND FUTURE

The C/S priority provides guidance to the USSP for the evaluation of IAEA requests and for the performance of funded tasks. This paper provides a description of the C/S tasks the USSP has funded recently to improve the capabilities, reliability, and cost-effectiveness of C/S systems for unattended and remotely monitored use. Each year, the USSP reviews the results of the previous year's priority tactical goals to measure priority performance. The priorities are revised each year to address the ever changing needs of the IAEA. The USSP will continue its effort to ensure that the IAEA has the tools and expertise necessary to fulfill its important mission.

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