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REMOTE MONITORING FOR INTERNATIONAL SAFEGUARDS

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ABSTRACT

Remote monitoring is not a new technology, and its application to safeguards-relevant activities has been examined for a number of years. On behalf of the U.S. Department of Energy and international partners, remote monitoring systems have been emplaced in nuclear facilities and laboratories in various parts of the world. The experience gained from these field trials of remote monitoring systems has shown the viability of the concept of using integrated monitoring systems. Although a wide variety of sensors has been used in the remote monitoring field trials conducted to date, the possible range of instrumentation that might be used has scarcely been touched. As the technology becomes widespread, large amounts of data will become available to inspectors responsible for safeguards activities at the sites. Effective use of remote monitoring will require processing, archiving, presenting, and assessing of these data. To provide reasonable efficiency in the application of this technology, data processing should be done in a careful and organized manner. The problem will be not an issue of poring over scant records but of surviving under a deluge of information made possible by modern technology. Fortunately, modern technology, which created the problem of the

data glut, is available to come to the assistance of those inundated by data. Apart from the technological problems, one of the most important aspects of remote monitoring is the potential constraint related to the transmission of data out of a facility or beyond national borders. Remote monitoring across national borders can be seriously considered only in the context of a comprehensive, transparent, and open implementation regime.

1. INTRODUCTION

Remote monitoring is not a new technology, and its application to safeguards-relevant activities has been examined for a number of years. In light of the new Model Protocol for the Strengthened Safeguards System, remote monitoring will likely assume a highly visible presence at the International Atomic Energy Agency and at other international monitoring agencies in the near future. It is valuable at this time to examine the record produced by the field trials of remote monitoring at nuclear facilities in order to anticipate future needs that may likely result from the widespread application of this technology in International Safeguards. There have been a number of papers and reports on field trials of remote technology from the U.S. and from other participating nations and organizations, and these will not be repeated here. Rather, the purpose of this paper is to summarize the field trials conducted by the U.S. in cooperation with certain international partners, to speculate on the consequences of large-scale implementation of this technology in safeguards, and to draw conclusions about the steps necessary for the smooth and effective implementation of the technology into the active world of International Safeguards.

2. U.S. FIELD TRIALS OF REMOTE MONITORING

Sandia National Laboratories (SNL), along with other U.S. national laboratories and international partner organizations, has emplaced remote monitoring systems in nuclear facilities and laboratories in various parts of the world. This effort has been supported by the US Department of Energy DOE/NN-44 and by various organizations in the host countries. The sites at which the remote monitoring field trials have been conducted include a variety of nuclear and laboratory facilities. The particular facilities, and the functions of the remote monitoring systems at those facilities were chosen deliberately to represent a wide range of possible safeguards applications.

The technical basis for these field trial remote monitoring systems included several fundamental assumptions: each system operated with a local data communication network that enabled the various components to transmit data to a central location for storage and retrieval; each sensor or component operated independently such that loss of a single item on the network would not interfere with the functioning of the remainder of the system; and all video collection would be made on the basis of front-end triggering in which selected sensors were used as triggers.[1] The sites at which remote monitoring systems have been installed and tested are listed in Table 1.

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[1] See Stephen A. Dupree, et al., "Remote Monitoring in International Safeguards," *INMM* XXIV, January 1996, p. 19; and S. A. Dupree, et al., "Seminar on Integrated Monitoring Systems and Remote Monitoring," SAND 97-0687, Sandia National Laboratories, Albuquerque, NM, to be published, 1997.

Table 1. SNL Remote Monitoring Field Trials

Partner	Facility	Date of Installation
Australia	Australian High-Flux Test Reactor, Lucas Heights	February 1994
Sweden	Barseback Light Water Reactor, Malmo	August 1994
Japan	JAERI Safeguards Laboratory, Toka-mura	December 1994
Russia	Kurchatov Institute, Moscow	March 1995
U.S.	Argonne National Laboratory-West, Idaho	March 1995
Argentina	Embalse Nuclear Power Plant, Cordova Province	March 1995
U.S.	Y-12, Oak Ridge	July 1996
Japan	PNC, Joyo Breeder Reactor, O-arai	October 1996

It is important to keep in mind that the remote monitoring systems discussed here were field trials, not operational safeguards systems. The system configurations and sensor selections were not necessarily optimized for the applications involved. Nevertheless, except for a few interruptions related to system upgrades or facility operations, and an extended power outage at one site, all but one of these remote monitoring systems have operated continuously since installation. These interruptions experienced at the field trial sites required various periods of time for correction, and in one case several months elapsed before a damaged component, a camera power supply, was replaced. However, in an operating safeguards system, with scheduled maintenance and adequate spare parts, the problems could have been fixed rapidly.

All off-site communication with these sites has been via commercial telephone lines. Data from these systems have been collected periodically, and the total quantity of data available from these field trials is significant. Unfortunately, not all of the data produced by this program are available in one place or on a single computer, in part because the data file formats have changed as software upgrades have been implemented. This situation emphasizes the need for up-front planning for data formatting and processing in any remote monitoring endeavor. There will be a large amount of data coming from remote monitoring instruments after use of the technology becomes commonplace in International Safeguards. Effective use of remote monitoring under these conditions will require processing, archiving, presenting, and assessing of the data. To provide reasonable efficiency in the application of this technology, data processing should be done in a careful and organized manner, with full utilization of modern data processing technology.

The DOE field trials have provided a significant amount of experience in the use of remote monitoring at nuclear facilities for safeguards-related purposes. A wide variety of sensors have been used in the field trials, as listed in Table 2. The approximate number of hours of field experience with the different sensors is also shown in that table. The systems have functioned as designed with only a few problems. Results of analysis of the data retrieved from the individual remote monitoring sites have indicated that the systems have been reliable and have provided data appropriate for safeguards purposes.[2]

[2] S. A. Dupree, C. S. Sonnier, and Gordon Washburn, "Remote Monitoring Operational Experience, INMM Annual Meeting, Phoenix Arizona, 1997.

Table 2. Summary of Instrument Operational Experience

Instrument	Sites	Instrument Hours[3]
Motion sensor (Authenticated Item Monitoring System)	Australia, KI, ANL-W, Argentina, Y-12	1520 khrs
AIMS Fiber Optic Seal	Australia, KI, ANL-W, Argentina, Y-12	310 khrs
VACOSS_ seals	Y-12	4 khrs
Microwave motion sensors	Australia, Sweden, JAERI, Joyo, KI, ANL-W	183 khrs
Balanced magnetic switch	KI, ANL-W	31 khrs
Radiation sensors		
Ludlum G-M	Argentina, Joyo	38 khrs
ORNL Si	Argentina[4]	20 khrs
RadSip_	Y-12	50 khrs
RadCouple_	Y-12	100 khrs
Ludlum He^3 neutron	Joyo	0.7 khrs
Camera, analog	Australia, Sweden, JAERI, KI, ANL-W	106 khrs
Camera, digital	Y-12, Joyo	4 khrs
Photoelectric beam break	KI, ANL-W	31 khrs
Laser beam break	Joyo	8 khrs
Infrared motion sensor	KI, ANL-W	47 khrs
Facility power monitor	Sweden, Y-12, KI, ANL-W	53 khrs
Power status alarm node	Sweden	17 khrs
Lamp node	Y-12, KI	21 khrs
Echelon network and components: Neuron chips Models 3120 and 3150	Australia, Sweden, JAERI, Y-12, Joyo, KI, ANL-W	823 khrs

[3] Approximate total instrument hours as of January 1, 1997.
[4] Removed in May 1996.

Although a wide variety of sensors have been used in the remote monitoring field trials conducted to date, the possible range of instrumentation that might be used in remote monitoring applications has still scarcely been touched. Plans are currently in place to add Non-Destructive Assay (NDA) instruments to an on-site communication network as used in the field trials in order to collect signatures of spent fuel.[5] A Global Positioning System location capability has been used in conjunction with tracking of materials in a range of circumstances.[6] These applications could be supplemented by environmental sampling instrumentation, use of additional NDA instruments, sensors from the domestic safeguards arena, or by use of combinations of sensors custom designed for specific applications.

Digital video images require considerable storage capacity to maintain reasonable spatial resolution. Likewise, high-resolution gamma ray spectra include a significant amount of data. Both redundant and complementary instrumentation might be required for certain applications in which data continuity is required. Data from site-process monitoring instruments might be included in a monitoring record under certain circumstances to support the Strengthened Safeguards System. Processing sensors to be considered for this purpose could include flow meters, temperature sensors, power meters, radiation monitoring instruments, and other site instrumentation. Finally, it is possible that sensors associated with domestic safety and security at a site, such as personnel entry

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[5]Sigfried Schneider, "International Remote Monitoring Project Argentina Nuclear Power Station Spent Fuel Transfer Remote Monitoring System", INMM Annual Meeting, Phoenix, Arizona, 1997.
[6] J. Lee Schoeneman, "Authenticated Tracking and Monitoring System (ATMS)," INMM Annual Meeting, Scottsdale, Arizona, 1993.

monitors, seismic instruments, and area radiation and other interior monitors, could be included in future remote monitoring systems for safeguards application.

3. IMPLICATIONS OF REMOTE MONITORING

Regardless of whether the full range of possible instrumentation is included in remote monitoring, the large number of sites that may be subject to such monitoring, and the amount of instrumentation required to constitute an effective safeguards system at each site, will result in significant amounts of data being received from each site and clearly, overall, large amounts of data will be available to inspectors responsible for safeguards activities at the sites. Given the frequency at which new data can be collected via remote access to the site instruments, this will result in a "data-rich" environment for the inspectors. That is, the amount of data from each monitored site that is available to an inspector will grow to enormous proportions. The safeguards monitoring problem will become the mirror image of many of the safeguards problems from the past: instead of having a paucity of data, the monitoring agencies will have a glut of data. The problem will be not an issue of poring over scant records, but of surviving under a deluge of information made possible by modern technology.

Fortunately, modern technology, which created the problem of the data glut, is available to come to the assistance of those inundated by data. A bit of up-front thought about the possible means of handling a safeguards data glut will quickly point up the desirability of having an automated processing procedure for screening and assessing the data expected from remote monitoring. The exact nature of such a processing procedure will have to evolve over a period of time and will require experience with the new techniques, but certain desirable features of such a system can be envisioned ahead of time.

First, any near-term system should be upwardly compatible with any future systems or with improvements in the basic system. Just as responsible software houses provide for compatibility between new software versions and old data files, a safeguards data management system for remote monitoring should follow the basic rule that old data can always be accessed and used by each new generation of software.

Another rule should be that the management software can screen data to the level that an inspector desires. That is, the detailed tests by which the processing procedure accepts or rejects certain conditions as "normal" or "anomalous" for a given site should be adjustable by the inspector. After all, the inspector knows best what is supposed to happen or not happen at a site. However, whatever criteria an inspector chooses to use for screening, all data, whether in parts or as a whole, should always be available for his scrutiny.

Finally, all operations of data management should be easy, convenient, and unambiguous. Whether current data or archived data are being examined or compared, the process should be straightforward and reliable.

From the beginning of the DOE remote monitoring field trials, no emphasis was placed on the rapid acquisition of data from the site. Remote monitoring in a safeguards context will require an open and cooperative environment that is fundamentally different from that of a physical security application. That is, a monitoring agency will not and should not maintain the means of responding rapidly to discrepancies in the data. They will be unable to invest major effort in resolving minor discrepancies. Thus, immediate access to the communication link of an on-site monitoring system is not necessary, and no requirement exists for extremely rapid data transfer or for extreme reliability in the data transfer link. Data collected should be entered into the processing system and be available to the inspector on demand, but whether such data were one hour old or one day old should not be of major issue. Either of these delays appears timely compared with monthly or quarterly inspections.

The experience gained from the DOE field trials of remote monitoring systems has shown the viability of the concept of using integrated monitoring systems with front-end triggered video and of providing off-site data communication through commercial telephone lines. Since the effort of evaluating remote monitoring in safeguards-relevant applications was begun in 1994, numerous organizations in the U.S. and around the world have been working on or testing remote monitoring technology. Notably, this includes the evaluation of remote monitoring since 1995 by the DOE field-trial participants and the recent installation and use of remote monitoring by the International Atomic Energy Agency. The technology is advancing rapidly, and significant improvements in capabilities and cost reductions are expected in the future.

It is probable that the implementation of the remote monitoring system architecture used in the DOE field trials will continue for the near future, although alternate designs will also continue to be tested. Further improvements in the technology and the software, with resulting cost reductions through standardization, are expected and should make the concept of the integrated collection of safeguards information with remote access to the data even more useful for safeguards purposes than at present.

One of the most important aspects of remote monitoring is the potential constraint related to the transmission of data out of a facility or beyond national borders. Such transmission has been a long standing issue directly related to the rules and rights of worker associations and to the sovereign rights of nations. When remote monitoring is used in International Safeguards, it is generally assumed that the data must be encrypted before transmission in order to protect against unauthorized access by unwanted parties. In this case, it becomes important to consider the specific form of the encryption. In addition, the entire subject of encryption key management and procedures requires careful examination.

Another issue related to remote monitoring relates to the requirements of the facility or State having access to the information transmitted. In the past, concern has been raised regarding the facility or State having access to the data acquired by the IAEA. This subject is related to the question of openness and transparency and will become important when large amounts of data possibly containing a few minor discrepancies have to be processed. If the facility or State has access to the data, such discrepancies can often be easily resolved in a climate of cooperation and openness. It is quite clear that remote monitoring across national borders can be seriously considered only in the context of a comprehensive, transparent, and open implementation regime.

The overall cost effectiveness of remote monitoring must also be considered. The most important issue that must be addressed in determining the cost effectiveness and, therefore, the efficiency of remote monitoring for all parties is whether acceptable safeguards assurances can be achieved through acquisition of data from remote monitoring in combination with a reduced level of inspection effort.

4. CONCLUSION

As the range of instrumentation available for remote monitoring increases and as the agencies responsible for International Safeguards implement the technology, data from remote monitoring systems will be available in ever increasing amounts. These data will be of value, and the entire concept of remote monitoring for safeguards will be effective, only to the extent that the data are processed and evaluated. The traditional "hands-on" evaluation of data will not be possible because of the sheer volume of such data that will be collected after remote monitoring is established at a large number of sites.

We believe the utility and functional reliability of remote monitoring for International Safeguards has been shown. However, effective use of this technology at a large number of sites and maximizing the utility of the technology by including a wide range of instrumentation at each site will require attention to system maintenance as well as efficient and reliable automatic processing and screening of the large volume of data that will result. It should be kept in mind that openness and transparency, including some form of short-notice inspections, are likely to be prerequisites to the safeguards implementation of remote monitoring in any State.

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