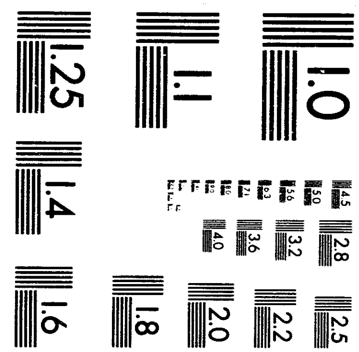

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SAFEGUARDS EQUIPMENT OF THE FUTURE - INTEGRATED MONITORING SYSTEMS AND REMOTE MONITORING

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SAFEGUARDS EQUIPMENT OF THE FUTURE
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INTEGRATED MONITORING SYSTEMS AND REMOTE MONITORING

1. Abstract

From the beginning, equipment to support IAEA Safeguards could be characterized as that which is used to measure nuclear material, Destructive Assay (DA) and Non Destructive Assay (NDA), and that which is used to provide continuity of knowledge between inspection intervals, Containment & Surveillance (C/S). C/S equipment has often been thought of as Cameras and Seals, with a limited number of monitors being employed as they became available. In recent years, technology has advanced at an extremely rapid rate, and continues to do so. The traditional film cameras are being replaced by video equipment, and fiber optic and electronic seals have come into rather widespread use. Perhaps the most interesting aspect of this evolution, and that which indicates the wave of the future without much question, is the integration of video surveillance and electronic seals with a variety of monitors. This is demonstrated by safeguards systems which are installed in several nuclear facilities in France, Germany, Japan, the UK, the USA, and elsewhere. The terminology of Integrated Monitoring Systems (IMS) has emerged, with the employment of network technology capable of interconnecting all desired elements in a very flexible manner. Also, the technology for transmission of a wide variety of information to off-site locations, termed Remote Monitoring, is in widespread industrial use, requiring very little adaptation for safeguards use. This paper examines the future of the Integrated Monitoring Systems and Remote Monitoring in International Safeguards, including technical and other related factors.

2. Introduction

Containment and Surveillance (C/S) devices and Non Destructive Assay (NDA) tools are routinely used by the IAEA in the conduct of its safeguards activities. These technologies are being incorporated in unattended Integrated Monitoring Systems that have the capability to collect and store information on site or to provide remote transmission, either automatically or on command. This is demonstrated by safeguards systems which are installed in several nuclear facilities in France, Germany, Japan, the UK, the USA, and elsewhere.

A key element of state-of-the-art integrated systems is a modular nodal system which accepts information from sensors and provides information to both an on-site date storage unit as well as to a transmitter. The information from the sensors is processed within the nodal elements for authenticity as well as for sensor identification. Since the processing for authenticity occurs within the nodal elements, existing communication wiring (e.g. twisted pairs, coaxial cables) can be used. Intelligent nodes, nodes which can send command information to other nodes, allow information from one sensor to trigger another.

There are many examples of everyday applications of remote monitoring: security sensors monitor homes and businesses; data from seismic stations are remotely transmitted; land-mobile satellite communication systems send and receive test messages to and from mobile vehicles as well as determine the location of the vehicles. In general, these systems were not designed to provided authenticated messages from their location through the system center to the customer's communications center; however, encryption techniques are readily available and can be employed to secure text information. Decryption could be performed at the customer communications center; the text message could not be intercepted by the system center.

This paper examines the future of the Integrated Monitoring Systems and Remote Monitoring in International Safeguards, including technical and other related factors.

These technologies are very important elements of the US Department of Energy's International Safeguards Program.[1] A principal goal of this program is to enhance verification techniques and capabilities of international, regional, and bilateral regimes to support US Non

Proliferation objectives. It promotes technology exchanges in a broad range of technologies to insure improvement in the effectiveness and efficiency of domestic and international safeguards, and international acceptance of new developments.

3. Integrated Monitoring Systems

In the 1980's, under the US Program of Technical Assistance to IAEA Safeguards (POTAS) and the DOE International Safeguards Program, Sandia National Laboratories (SNL) developed and successfully tested an Integrated Monitoring System (IMS)[2], which monitored the movement of spent fuel shipping casks to/from light water reactors to reactor or away-from-reactor storage facilities. The system used a crane location monitor and gamma radiation detectors, and recorded the information in a tamper-detecting, tamper-resistant enclosure for later inspection, and triggered a camera for photographic assessment of anamolies. An outgrowth of this system is the SNL/LANL-developed Channel Monitoring System in use by Euratom at the THORP facility in the UK.

A number of "unattended monitoring systems" are currently in safeguards use or under development, some of which are the subject of other papers in this symposium. These include Unattended High Level Neutron Coincidence Counters, Candu Fuel Bundle Counters, Unattended Data Loggers, the Neutron-Gamma Unattended System, Consulha, Grand, as well as the previously mentioned Channel Monitoring System.

It is important to note the classic difference between the concept of simple triggering of optical surveillance devices and systems which log all information (apart from the optical device) as well as trigger these devices. This latter dual function was in fact incorporated in the IMS of the 1980's previously described. From an engineering point of view, information from detectors, absent any optical surveillance data, could lead to identification of an anamoly which could form the basis for investigation by an inspector.

3.1 Technical Factors

In the past several years, under the US Department of Energy's International Safeguards Program, SNL has developed a network-based Integrated Monitoring System. A new flexible technology is now available to design sensor and control networks based on a protocol embedded in an intelligent communications processor. The flexibility allows a system designer and/or system installation personnel to make appropriate tradeoffs between simplicity, function, and cost in the design of network nodes and their installation. This is especially important in designing the installation scenario for a safeguards network. The network technology permits several choices of installations with the same basic node hardware, providing the ability to interconnect a number of different types of sensors and control devices into a simple network which can communicate over a single cable at a relatively low cost. Network technology exists to meet these features by providing each node of the IMS with distributed intelligence capable of handling both the communication protocol and the data processing requirements of the individual sensors. Most sensors for safeguards and security systems seldom need to transmit messages since the sensors are not activated very frequently. The messages sent by the sensors are generally very small amounts of data consisting of a very few bits indicating things like "alarm", "tamper", or "status ok". Infrequent messages with low data content can easily be handled by the IMS, which can communicate over a number of different physical media making it possible to configure different network configurations with interconnecting bridges. The same basic nodes can be configured to provide data collection in any number of different types of facilities and from networks varying in size from a very few sensors to a large number, including unattended NDA equipment, as well as a variety of detectors from the physical protection area. A network can be installed using network management software and a computer, referred to as a Network Management Tool, which offers full flexibility to change the network during installation. Such tools can provide different degrees of complexity depending upon the safeguards applications and the amount of changes that need to be made during installation.

The low cost integrated communications processor upon which the Integrated Monitoring System (IMS) is based contains all the software for communications protocol and additional applications processing power to accommodate a large number of the safeguards sensor and control requirements.

Another microprocessor can also be added if still more processing power is required. An important feature of the IMS is the capability to authenticate all of the data transfers over the network.

From this description, it is clear that much care must be taken in the configuration of an IMS, and numerous adjustments will have to be made before full safeguards implementation in a particular facility will be possible. This is quite sensitive to facility configurations and environments. This task is not likely to be one that the IAEA should be expected to perform alone - rather, significant support will be required by the system developers, facility operators, and the State.

3.2 Other Related Factors

The transition from conventional C/S and unattended NDA to Integrated Monitoring Systems raises issues of cost and facility/State acceptance. Important features of the IMS described above are both low cost and the capability to install the same basic types of sensor nodes in many different facilities. The simple interconnection of all the sensors through one cable is very important to minimize installation costs.

Acceptance will clearly depend on what benefits will be achieved by the IAEA and the State/facility operators. There will always be the question of "why additional measures?". The answer that is apt to be found to be most acceptable is that the additional measure(s) will mean less inspector effort/presence. That in turn may require another look at the current safeguards procedures and criteria.

4. Remote Monitoring

Remote monitoring of nuclear facilities is not a new concept, nor is it a severe technical challenge. We need only to recall the images presented on a daily basis on the television networks throughout the world. Also, as stated in the introduction, there are many examples of everyday applications of remote monitoring: security sensors monitor homes and businesses; data from seismic stations are remotely transmitted; land-mobile satellite communication systems send and receive test messages to and from mobile vehicles as well as determine the location of the vehicles.

In 1978, the US Arms Control and Disarmament Agency (ACDA) developed and tested a secure system for remote verification of the status of containment and surveillance instruments employed at nuclear facilities by the IAEA; it was called RECOVER (Remote Continual Verification).[3] As many will remember, this was at a time when the failure rate of the Minolta Camera Systems was quite high; it was, perhaps more important, at a time when many in the international community were simply not willing to accept the concept of transmitting safeguards data across national borders.

Shortly after the RECOVER program, the Japanese developed the TRANSEAVER (Transportation by Sea Verification) System as a potential safeguards measure.

More recently, the US and Japan jointly developed the prototype Containment and Surveillance Data Authenticated Communication (CASDAC) System.[4] This was a feasibility test of remote monitoring of unattended sensors conducted by SNL and the Japan Atomic Energy Research Institute (JAERI) under a bilateral agreement between the ACDA and JAERI. The system's purpose was to perform remote monitoring of sensor status through the international telephone network; it was a prototype developed by JAERI for nuclear safeguards and physical protection. The design was based on experience gained from RECOVER and TRANSEAVER.

Under the US Department of Energy's International Safeguards Program, SNL is engaged in an active project termed "Remote Monitoring - System Integration and Field Trials". The objectives of this project are to (1) demonstrate that remote monitoring techniques can save inspection resources while at the same time maintain or even strengthen the effectiveness of safeguards, and (2) promote international acceptance of remote monitoring for safeguards applications.

The first field trial in this project is underway in Australia and is the subject of the a paper in this symposium, IAEA-SM-333/107, "ASO/SNL Cooperative Activities in Advanced C/S Technologies". Future field trials are expected to be conducted at several facilities in Europe, North America, and in the Far East.

4.1. Technical Factors

Technology exists to enable the IMS to be interrogated via various communication links such as telephone, satellites, or radio frequency tranceivers. The data can be collected from storage devices on the network or the individual sensors can be polled to determine their status. Data management, including presentation, will present a technical challenge when a large number of facilities are to be monitored.

The block diagram in Fig. 1 shows an example of the equipment that could be installed at facilities for remote monitoring systems. A network of nodes would collect data from a number of different sensors and security devices. Detection devices would be installed to complement each other for C/S applications. In addition, unattended NDA equipment, as well as simple gross attribute, yes/no, radiation detectors could be used.

Referring again to Fig. 1, the Authenticated Item Monitoring System (AIMS)[5] could be used to monitor drums or other storage containers. AIMS Sensor Transmitters (ASTX) could be attached to the items with Velcro. The number of AIMS transmitters used would be determined by the items being monitored. Several infrared motion detectors (IRMD) with AIMS transmitters could be installed to detect motion in selected areas. Single ASTX's could be installed on other items of safeguards interest to detect their movements. The data from the AIMS devices can be collected in two different ways. A Receiver Processor Unit (RPU) could operate independently to collect AIMS information. An AIMS receiver node could also collect the same information for storage in the data logger and for remote interrogation.

Microwave motion detectors connected to the network could be used to determine if any activity is occurring in the area. Detection of any activity could trigger video recordings to be made on the video recording module. The number of microwave motion detectors would be determined by the requirement of the selected area.

Ultra-wide band Radar Motion Sensors could also be installed to detect activity. The pulses emitted from these sensors are well below one microwatt and are spread over several Giga Hertz (GHz). Their coverage consists of a spherical shell around the sensors that has an adjustable radius.

Other types of sensors such as photoelectric sensors could be used on the network depending on the area to monitored. Door switches, temperature sensors, radiation detectors, etc. could be connected to the nodes. Computer data interface devices with RS-232 data outputs or inputs can also be connected through the network.

Dual video systems could be utilized to collect video images. An analog recording system, like the Portable Surveillance Unit (PSU) could be connected to the network. It could be programmed to record when certain sensors or combinations of sensors detect activity in the area under safeguards. A second video system using digital compression technology and connected to data logger/system controller could collect digital images and store the images on removable data discs or accessed for remote transmission. The "Digital Video Recorder" should also contain an internal hard drive for storing images. Data and images from the area under safeguards can be remotely accessed via telephone lines from a distant monitoring center. Similarly, this information could be accessed via satellites where such a media is required. Periodically it would be necessary to remove data discs from the data logger and video tapes from the video recording modules.

4.2 Other Related Factors

One of the most important aspects of remote monitoring is the potential constraints related to the transmission of data out of a facility or beyond national borders. If used, must the data be encrypted?; in what form must it be encrypted?; will the facility or State require all information transmitted?, etc. In addition to the transmission of data from an IMS beyond national borders, there will be uses for remote monitoring in large facility complexes and from facilities within a State. This latter application was, in fact, the principal objective of the German Local Verification (LOVER) project of the 1980's. Another important factor which must be considered is the overall cost effectiveness of remote monitoring. Here, very important issues must be addressed; e.g., can acceptable safeguards assurances be achieved through acquisition of data from remote monitoring and reduced inspection effort?

5. Summary

This paper, as well as other papers in this session and in poster sessions, clearly demonstrates the abundance of technology that supports the configuration of Integrated Monitoring Systems and Remote Monitoring Systems. The technology presents a rather minimal challenge, except in the area of standardization. The situation with Remote Monitoring Systems is further complicated by policy issues related to State rights, transparency, safeguards criteria, and other issues.

It is quite clear that much care must be taken in the configuration of an IMS, and numerous adjustments will have to be made before full safeguards implementation in a particular facility will be possible. This is quite sensitive to facility configurations and environments. This task is not likely to be one that the IAEA should be expected to perform alone - rather, significant support will be required by the system developers, facility operators, and the State.

As the IAEA and the International Safeguards Community address the current safeguards procedures and criteria and all that it means in today's world, it is necessary to realize that technology offers the potential of making significant contributions to the goals of safeguards.

However, it is doubtful that these contributions can be realized to their maximum benefit unless much more importance is placed on the qualitative parameters that could contribute to safeguards.

[1] U.S. DEPARTMENT OF ENERGY, OFFICE OF ARMS CONTROL AND NONPROLIFERATION, INTERNATIONAL SAFEGUARDS DIVISION, International Safeguards Program Strategic Plan, October, 1993

[2] FIENNING, W. C., McKNIGHT, R. P., Sandia Report SAND 84-1439, Integrated Monitoring System (IMS) Deveopment and Demonstration Activities: Summary of POTAS Task E.45, Apr. 1986.

[3] TRW Report, "RECOVER: Results of Independent IAEA Test Program, 3 Nov. to 24 Nov, 1980," prepared for the US Arms Control and Disarmament Agency, Jan. 23, 1981 (Draft)

[4] YSTESUND, K., LeGALLEY, KOYAMA, K, YAMAMOTO, Y., Containment and Surveillance Data Authenticated Communication (CASDAC) Project Final Report (Nov., 1993)

[5] SCHOENEMAN, J. L., JENKINS, C. D., TOOLEY, R. D., Universal Authenticated Item Monitoring System, 31st Annual Meeting Proceedings of the Institute of Nuclear Materials Management (Jul., 1990)

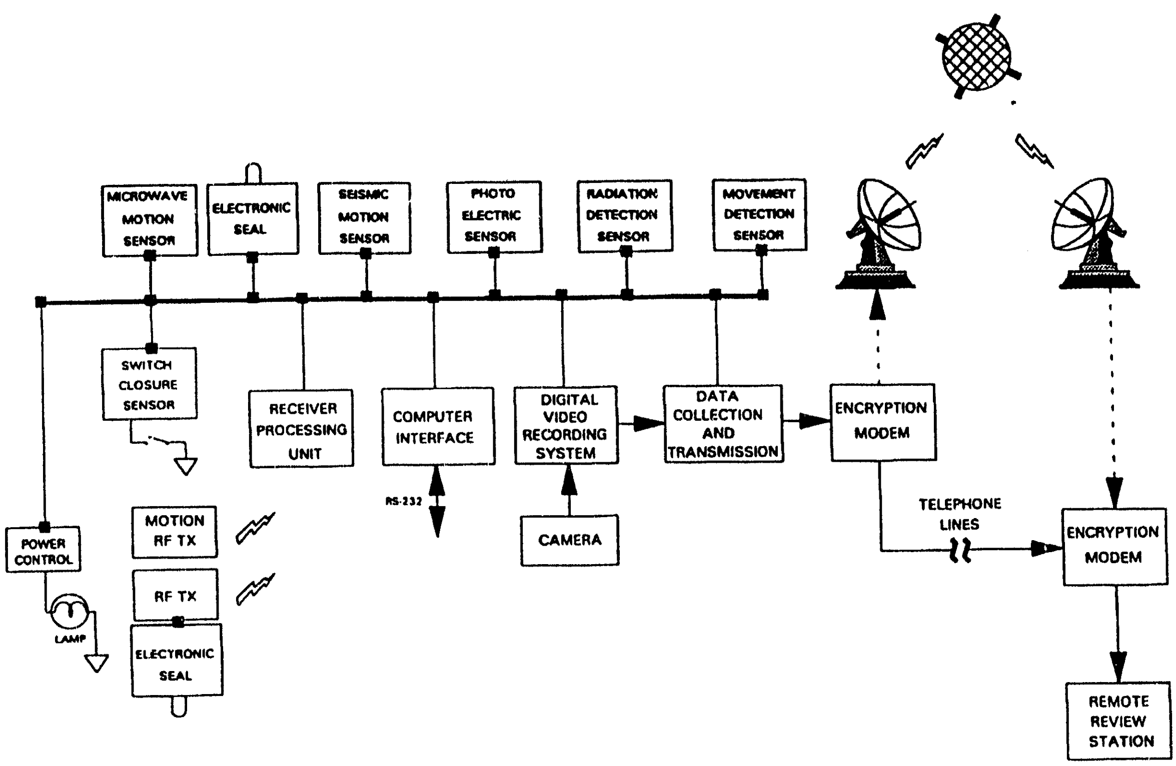
MICROWAVE MOTION SENSOR
ELECTRONIC SEAL
SEISMIC MOTION SENSOR
PHOTO ELECTRIC SENSOR
RADIATION DETECTION SENSOR
MOVEMENT DETECTION SENSOR
SWITCH CLOSURE SENSOR
RECEIVER PROCESSING UNIT
COMPUTER INTERFACE
DIGITAL VIDEO RECORDING SYSTEM
DATA COLLECTION AND TRANSMISSION
ENCRYPTION MODEM
RS-232
CAMERA
TELEPHONE LINES
ENCRYPTION MODEM
POWER CONTROL
LAMP
MOTION RF TX
RF TX
ELECTRONIC SEAL
REMOTE REVIEW STATION

Fig. 1 Remote Monitoring System

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