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TECHNICAL IMPLEMENTATION IN SUPPORT OF THE IAEA'S REMOTE MONITORING FIELD TRIAL AT THE OAK RIDGE Y-12 PLANT

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Abstract

A remote monitoring system (RMS) field trial will be conducted for the International Atomic Energy Agency (IAEA) on highly enriched uranium materials in a vault at the Oak Ridge Y-12 Plant. Remote monitoring technologies are being evaluated to verify their capability to enhance the effectiveness and timeliness of IAEA safeguards in storage facilities while reducing the costs of inspections and burdens on the operator.

Phase one of the field trial, which involved proving the satellite transmission of sensor data and safeguards images from a video camera activated by seals and motion sensors installed in the vault, was completed in September 1995.

Phase two involves formal testing of the RMS as a tool for use by the IAEA during their tasks of monitoring the storage of nuclear material. The field trial to be completed during early 1997 includes access and item monitoring of nuclear materials in two storage trays. The RMS includes a variety of Sandia, Oak Ridge, and Aquila sensor technologies that provide video monitoring, radiation attribute measurements, and container identification to the on-site data acquisition system (DAS) by way of radio-frequency and Echelon LONWorks networks. The accumulated safeguards information will be transmitted to the IAEA via satellite (COMSAT/RSI) and international telephone lines.

Introduction

A remote monitoring system (RMS) field trial will be conducted in cooperation with the International Atomic Energy Agency (IAEA) on highly enriched uranium materials in a vault at the Oak Ridge Y-12 Plant.

The field trial will evaluate a variety of technologies from different commercial firms as well as from two national laboratories. The system design was accomplished with input and review by all parties to the field trial. Additional input was provided through collaboration with the DOE Office of Safeguards and Security and the operations department at the Oak Ridge facility. The system has been in an ongoing installation process limited by facility access during standard IAEA site inspections. This has contributed to delays in the completion of the system installation and the start of the field trial. Technologies that are being evaluated include video monitoring, radiation attribute measurements, container identification, item motion, and active access seals. The RMS sensor subsystem communicates via the Echelon LONWorks network technology.

A description of the system will be provided and then the components of the system will be discussed in greater detail.

System Design

The RMS design is shown in Figure 1. Tray #1 includes a radiation measurement and a container ID for the individual containers. Tray #2 includes two radiation measurements and a container ID for each container. In addition, both tubes include two active seals and motion detection technologies for access monitoring to each tube.

Sensor data is transmitted by a radio frequency link from the motion sensors and the tray #1 radiation sensors to a receiver. The rest of the sensor suite and the receiver are hardwired to the LONWorks network.

The LONWorks network forms the backbone of sensor data transmission and collection at the data node. The data node is interfaced to a Data Acquisition System (DAS) computer for local data display and storage.

The DAS is interfaced to off-site communication for data transfer to the IAEA Headquarters in Vienna, Austria; to the IAEA field office in Toronto, Canada; to Oak Ridge facilities; and to Sandia facilities for data review and analysis. Two forms of communications will be evaluated during the field trial. Commercial telephone dial-up will be available for all of the facilities to use. Also, a satellite link will be available from the Y-12 storage facility to the IAEA headquarters. Each facility has a Data and Image Review Station (DIRS) available for the data review and analysis.

Sensors

The sensor technologies will be discussed in four areas; tray #1, tray #2, access monitoring, and video monitoring.

Tray #1

Tray #1 includes radiation attribute measurements and a container ID for each container within the tube. The radiation sensor is the Oak Ridge RadCouple sensor. RadCouple is a gross gamma-ray detector that functions similarly to a thermocouple; i.e., with a constant voltage placed across the photodiode, the current varies directly with gamma-ray radiation flux. The detector head is composed of a cesium iodide (CsI) crystal optically coupled to a photodiode. The detector head and electronics are connected in multiples of three to an Authenticated Item Monitoring System (AIMS) radio frequency (RF) node for transmission to the AIMS receiver and interface to the LONWorks network.

The container ID is an implementation by Aquila Technologies Group (ATG) of the Dallas Semiconductor touch memory devices. ATG has a commercial implementation of this technology available as the AssetLAN. A touch memory device is attached to each stored item for identification. The touch memory device is connected to a unique addressable switch for the particular container position with the tray. The addressable switches are interfaced to a LONWorks node. The node contains intelligence to provide periodic monitoring of the status of containers. Messages resulting from the monitoring include faulty interconnections of the touch memory devices and the addressable switches, missing or new touch memory devices (implying missing or new containers), and a State of Health message indicating general status of the sensor and node combination. The node is then interfaced to the LONWorks network.

Tray #2

Tray #2 includes two radiation attribute measurements and a container ID for each container within the tube. One radiation sensor is the Oak Ridge RadCouple sensor. RadCouple is the same sensor unit as described in tray #1. However, the detector head and electronics are wired directly to a sensor concentrator panel that digitizes the signal and transmits the radiation data through the LONWorks network to the central data acquisition system (DAS). The second radiation sensor is the Oak Ridge RadSiP. RadSiP is a single p-i-n diode that is capable of energy resolution for gamma ray energies up to approximately 100 keV. The RadSiP sensor is composed of a Si p-i-n diode, a preamplifier and pulse height discriminator. The gamma radiation flux that is measured results from the Compton scattering from the 186 keV gamma ray interacting with the silicon. The magnitude of the flux in the energy bandwidth measured is directly proportional to the enrichment of the uranium. RadSiP serves as an independent gamma-ray measurement to that of the RadCouple because the sensors provide two different methods of measuring radiation attributes of the uranium. The RadSiP sensor is directly wired to a sensor concentrator panel that transmits the data through the LONWorks network to the DAS.

The container ID for tray #2 is an Oak Ridge implementation of the Dallas Semiconductor touch memory devices. Each container has a touch memory attached to it. Each touch memory has a unique identification code that can be read when touched by the sensor head. Each sensor head is connected to an addressable node that is in turn directly wired to a sensor concentrator panel that transmits item information (i.e., item identification, location) through a LONWorks network to the DAS. Whenever an item identification and location address are established or broken the DAS is notified. If the item is replaced in a different location than its assigned location, the new location for the item is recorded.

Access Monitoring

Access monitoring is accomplished with two different sensor technologies. The first is active seal monitoring and the second is motion detection.

Two active seal technologies are used in parallel for evaluation. One is the ATG VACOSS fiber optic seal. The other is the AIMS Fiber Optic Seal (AFOS). The VACOSS provides internal memory for the time tagging and local logging of seal opening and closing as well as seal tampering. The VACOSS is interfaced to a node that queries that VACOSS periodically and reports status of the seal via the LONWorks network. The AFOS provides monitoring of the fiber status on a once per second basis. If the fiber link has been broken or the case has been tampered with then the AFOS will report the status via RF to the AIMS receiver which relays the information to the DAS.

AIMS motion sensors are placed on each end of the tray in both tubes. Any movement of the tubes will result in motion events to be transmitted via RF to the AIMS receiver which will relay the information to the DAS.

Video Monitoring

An ICAM digital camera system will be used to capture event-triggered frames of video data. The video data will be used in the assessment of event alarms created within the RMS. The video frames are authenticated with the DSA authentication algorithm in the camera subsystem.

Data Acquisition System (DAS)

The DAS provides several functions at the monitored facility including event data display, on-site data storage, local data review, and off-site data transfer.

Event data from sensors is displayed in pseudo real time (a few seconds delay). The display of event data provides the capability to know the status of the RMS during installation and scheduled on-site inspections. The RMS has been designed to operate in an unattended mode.

Off-Site Communications

Data will be transferred from the DAS to the DIRS via two methods. Commercial telephone dial-up provides a technique which is used by review facilities at IAEA Vienna, IAEA Toronto, Oak Ridge, and Sandia. A satellite link will be installed for comparison evaluation of the two methods between the Y12 facility and the IAEA Headquarters facilities in Vienna, Austria.

During the installation phase, PCAnywhere (commercial software application) is being used to provide remote control of the DAS and file transfer from the DAS to the DIRS. The remote control capabilities are used to provide a method of updating software and monitoring the performance of the DAS from the remote data review systems.

When the satellite link has been installed between the Y-12 facility and the IAEA Vienna, the system will be upgraded to transfer data files via a Network File System (NFS). The NFS will be used on the DAS and all DIRS. In this mode the transmission media (telephone or satellite) will be transparent to the users.

The satellite communications will be provided by COMSAT RSI's TerraSat 200 USAT product. TerrSat is a complete, end-to-end networking solution for reliable, thin-route, bi-directional data communications over the satellite at Ku-band, C-band, or extended C-band. The satellite system includes a hub located at COMSAT RSI facilities and two remotes, one located at the Y-12 facility and the other located at the IAEA Headquarters in Vienna, Austria.

Data requests originated at the IAEA DIRS will be transmitted to the hub for relay to the remote at Y-12. Data files will then be returned to the DIRS via the hub. Data rates for this implementation are at

19.2 kilobits per second. Remote antennas are 1.2 meters while the hub antenna is 2.4 meters.

At the hub, a Network Management Subsystem (NMS) configures and monitors the TerraSat 200, in addtion to providing continuous performance evalaution. TerraSat 200 provides a means of performing system maintenance through functions such as upgrading software and configuring remote USATs from the Network Operations Center (NOC).

Data and Image Review System (DIRS)

A DIRS is located at each of the remote review sites. Data is transferred from the DAS via either telephone dial-up or the satellite link and then is available for review and analysis. The DIRS includes site images with approximate sensor locations. Specific sensor information is viewed by selecting the sensor icon. Daily data are appended to existing data files for review. Calendar display of days with sensor events allows the user to select a specific day for data review and analysis. Selecting a day on the calendar takes the user into an event review display for that day. The event list can be viewed as a composite of events or filtered for review of specific sensor types within the system. The event list indicates whether or not an image was triggered due to this event. If an image exists, the image may be displayed for assessment of the event alarm. Events are categorized into different levels of severity. The data can be reviewed for determination of activities on-going at the Y-12 storage facility.

Conclusion

The field trial will be operated for a six month period. The evaluation will consider trade-offs associated with the different communications links (telephone versus satellite); individual sensor technologies; sets of sensor technologies; and the application of the RMS to the safeguards mission of the IAEA.

Ancillary Systems

There are two ancillary systems deployed at the Y-12 field trial site to take advantage of the opportunity for deployment and evaluation in an operational facility. These two systems are not a formal part of the field trial. These systems are the Gemini digital camera system available from ATG, and the Fiber-optic Attribute Sensing Technology gamma radiation (FAST/gamma) sensor.

The Gemini camera system will collect images from two cameras installed on opposing walls within the storage facility. Images will be collected on an interval basis and can be reviewed at an on-site review station. The images are authenticated in the camera sub-system using the RSA algorithm.

The FAST/gamma sensor is composed of plastic scintillators coupled to optical fibers that are in turn coupled to a two-dimensional array photomultiplier tube. The FAST/Gamma sensor data will be collected on a separate computer system for analysis and review by the Oak Ridge personnel.

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