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BN-350 "Mirror System"

A. Thornton
Los Alamos National Laboratory, Group N-1
Los Alamos, NM, USA

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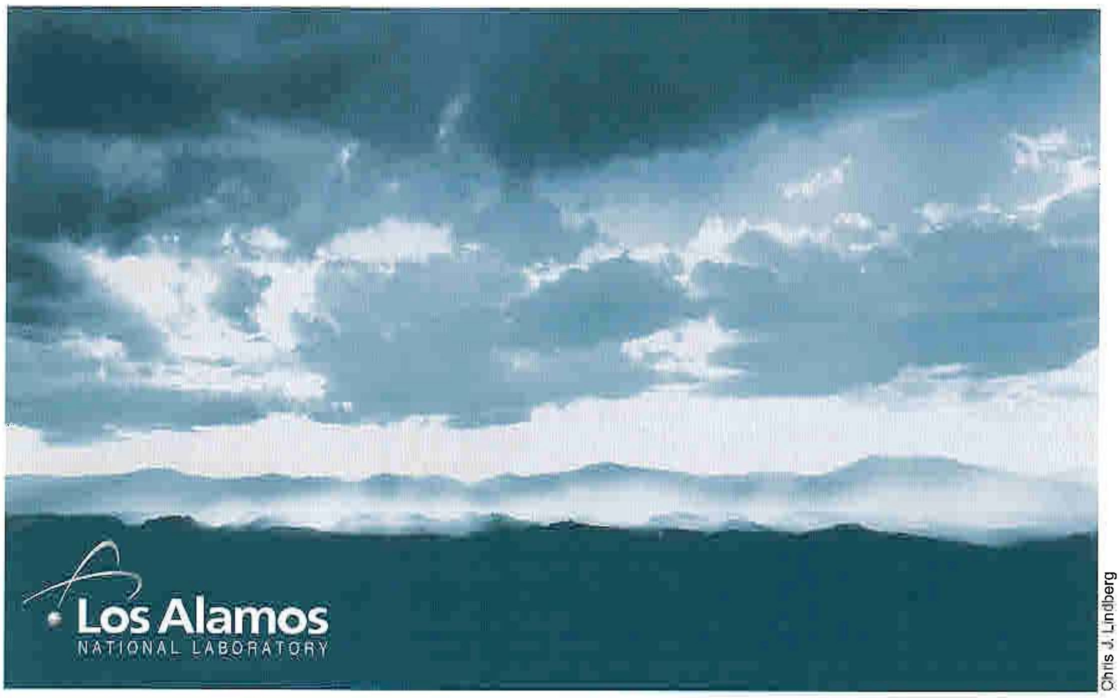

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Abstract
The BN-350 Unattended Monitoring System plays an important role for the Safeguards Department of the International Atomic Energy Agency (IAEA). In 1998, the Los Alamos National Laboratory, in conjunction with the IAEA and sponsored by the U.S. Department of Energy, designed and installed an integrated multi-instrument safeguards system at the BN-350 reactor in Aktau, Kazakhstan, to monitor spent-fuel and blanket assembly conditioning and canning activities. The purpose of the system was to provide effective safeguards at this facility while reducing the manpower load on the IAEA. The system is composed of many individual nondestructive analysis and surveillance components, each having a unique function and working together to provide fully unattended measurement of spent-fuel assemblies.

The BN-350 "Mirror System" was built to provide a similar system with like components at the IAEA Headquarters in Vienna to facilitate analysis and/or simulation of problems that might occur in the field and for training inspectors and other technical staff in preparation for their work in the field. In addition, the system is used to test new equipment and qualify new or modified software. This paper describes the main components of the Mirror System, how the components are integrated, and how the Mirror System has benefited the IAEA.

Introduction
The International Atomic Energy Agency (IAEA) is the organization at the heart of nuclear cooperation worldwide. The purpose of this organization is to ensure safe, secure, and peaceful use of nuclear technologies. In order to verify peaceful use of nuclear technology, it is necessary for the IAEA to monitor activities at various facilities. An Unattended Monitoring System is one widely used method in attaining this goal. An Unattended Monitoring System is an automated system set up at a facility which provides internal and external data, mainly radiation and digital video data. Over an inspection period, the system collects both radiation and video data which are later collected and analyzed to verify that activities within the facility comply with the Non-Proliferation Treaty (NPT) and with other non-proliferation agreements. The system in place at the BN-350 facility is an example of an Unattended Monitoring System. Because the system operates in an unmanned mode, it must be a very secure and extremely reliable system, almost without a doubt, meaning it requires a very intricate design. Many instruments are involved in such an integrated system, and thus the focus of this paper is dedicated to explaining these instruments and how they are interrelated to create an Unattended Monitoring System. The BN-350 Mirror System was used as a reference for this paper.
General PlanThe Mirror System consists of sensors (cameras, radiation, and physical protection), support electronics (DCM-14s, MiniGRANDs, ILONs), and generally a central collection system composed of network nodes and a collect computer(s). Generally speaking, data flow from the radiation detectors and cameras to the MiniGRANDs and DCM-14's, then to the ILON, and then across the ILON network to a collect computer where it is saved on a hard drive. The following

diagram, Figure 1, represents the big picture. These are the main components of the system. The MiniGRAND and/or the MiniADC provide the electronic packages for the detectors, which are the components used to detect radiation. The MiniGRAND and the detector are located inside a dotted box showing these two components are the most important, as they can maintain safeguards, for a limited length of time, without the help of any other components. This will be explained in greater detail later. The ILONs provide the communication for the entire system. The collect computers extract and store data while a failover box maintains computer power. There are also a DCM-14 and camera, which provide the digital video data for the UMS. Each component is explained in greater detail below.

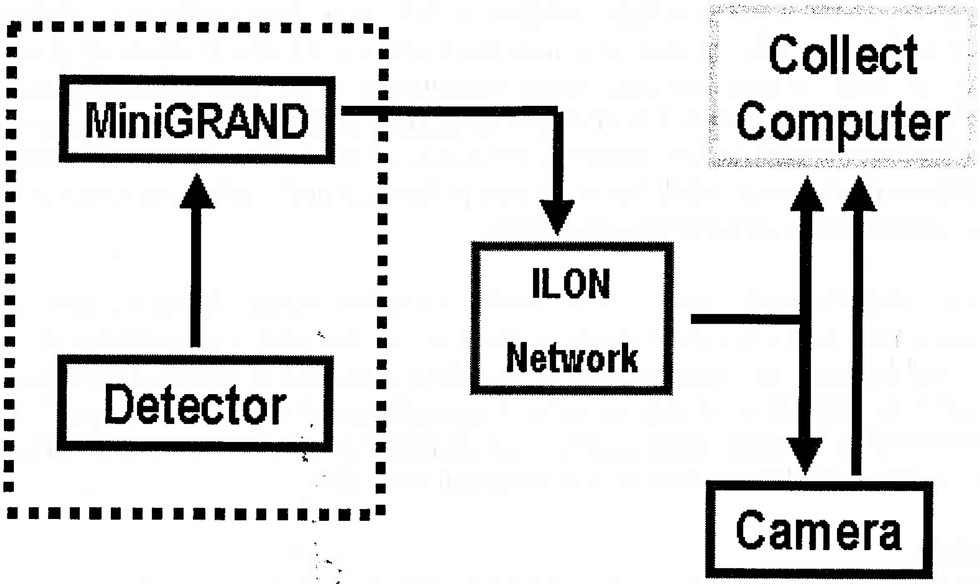

Figure 1. The general setup and data flow of the Mirror System.

Components

Radiation Detectors

There are basically 3 types of detectors (radiation sensors) in the Mirror System. The He-3 tube and the ion chamber are connected to a MiniGRAND, while the sodium iodide scintillation detector is connected to a MiniADC. The He-3 tube is used to detect neutrons. Neutron detection is critical for the safeguarding of spent fuel. The ion chamber and the sodium iodide detector are both used to detect gamma radiation. The ion chamber uses a current pulse to generate a signal and typically reports radiation in dose units. It is used primarily in high radiation fields. The sodium iodide detector is a scintillation detector that detects gammas, and since the energies can be detected, the SI detector can generate a gamma spectrum allowing easy identification of the radiation source. There is some redundancy in this system, for example, the ion chamber and the SI detector, but for Safeguard purposes, redundancy is sometimes necessary.

MiniGRAND/ MiniADC

The MiniGRAND and the MiniADC are both what are called an electronics package for the detectors. Aside from the fact that the MiniADC provides energy spectrums, and the MiniGRAND provides gross gamma counts, the two function the same. Therefore, only the MiniGRAND will be

referred to from here on. The main functions of the MiniGRAND in this system are (1) to provide the supporting electronics for the detector, such as the bias; (2) to temporarily collect and record the radiation data from the detector; and (3) to control data acquisition.
As mentioned before, the MiniGRAND, along with the detectors, provides an autonomous system sufficient for safeguarding. The idea is to have a fail-safe system so that data are not lost during an unexpected event, such as network or power failure. The MiniGRAND can maintain the data from the detector when necessary; however, data will, if not removed periodically, overload the MiniGRAND causing data to be lost.

Another capability of the MiniGRAND is to filter the data. This allows the MiniGRAND to take all the data points, within a given length of time, and save only 1 statistically representative data point for that group. This cuts down on the amount of memory used for data that does not change. Still, the memory of the MiniGRAND is too short, possibly only holding a few days worth of data. The next generation MiniGRAND will be capable of storing about 100 days worth of data and will include removable storage. This will help further isolate the impact of a PC failure.

Additionally, alarming is an important function. The MiniGRAND sends an alarm via ILON when radiation levels exceed the predetermined thresholds set in the MiniGRAND. This alarm then triggers the camera to begin collecting more rapid video images. It is important to note that during an alarm, filtering stops and data is no longer condensed. Because the MiniGRAND provides the logistical support for the detector, and because it can maintain the data, it is an essential component to this system, without which safeguards may not be upheld

ILON

All signals that the MiniGRAND generates are sent over an ILON network to the PC. The ILONs are the key to networking communication. They are set up in a free topography configuration, meaning they can be linked anywhere and still have communication with the entire system. Because of the "free topography" setup, the ILONs easily provide the communication for the entire system, and can be independent of the PC. ILONs allow data transmission to and from different components of the system. Although an ILON can be configured for many different purposes, the ones used in this system include the failover, collect, instrument, and the master timer node. When an ILON is configured to a specific mode, it is basically being told which function it is to perform, whether waiting for a ping, collecting data, transmitting data, or time synching the system. One really important function of an ILON is to trigger a camera. An ILON can be configured to trigger a camera in the event that radiation levels exceed the predetermined thresholds in the MiniGRAND. Video images are helpful in determining the cause of increased radiation and, therefore, are important during an event. Another important function of the ILON is that it authenticates all communication packages transferred over the network. Right now, this authentication is fairly weak, but the next generation will be stronger, increasing from the current 32 bits to 128. It is important to note that if communications were to temporarily fail (1 or all of the ILONs), safeguards would still remain controlled. The only problem this really poses is stopping the data transfer to the collect computer.

Collect Computer/ Failover Box

The collect computer is the simplest component of the system; however, it is a very necessary piece. The computer has the sole purpose of pulling data off the instruments and storing them on a hard drive. The importance of the collect computer is seen, for instance, if the PC itself fails. When this happens, the data can no longer be extracted from a MiniGRAND. The MiniGRAND then acts as its own storage facility, keeping all the data it receives from the detector in its memory. After a short period of time the memory fills up, and any data coming after this are lost. This is not acceptable safeguard performance. Because the PC is considered the most unreliable component of this system, it is worth mentioning another component called the failover box. Its purpose is to make sure there is a functioning collect computer extracting data from the MiniGRAND at all times. If for some reason a computer lost communication with the rest of the system, the failover box would shut off power to that computer and power up a backup computer. It would continue this process, flipping from one PC to the other, until it received a signal from a functioning collect computer.

Camera System

Quickly, the camera system consists of two main components: the digital camera module, or DCM-14, and the camera itself. The DCM-14 performs the same tasks for the camera as the MiniGRAND does for the detector. They all share the same relationship. However, the DCM-14 can in fact store all the data taken during an inspection period, meaning a collect computer is not needed to constantly pull the data off.

Integration

The following diagram, Figure 2, shows the system in more detail. Again, there are 3 detectors, all sending radiation data via signal cables to the MiniGRAND and/ or the MiniADC. Then the data is sent from the MiniGRAND/MiniADC to the instrument ILON, which then allows the collect computer to pull the data off the network, through a serial connection, and store them on the RAID. This diagram shows how the components communicate through the system.

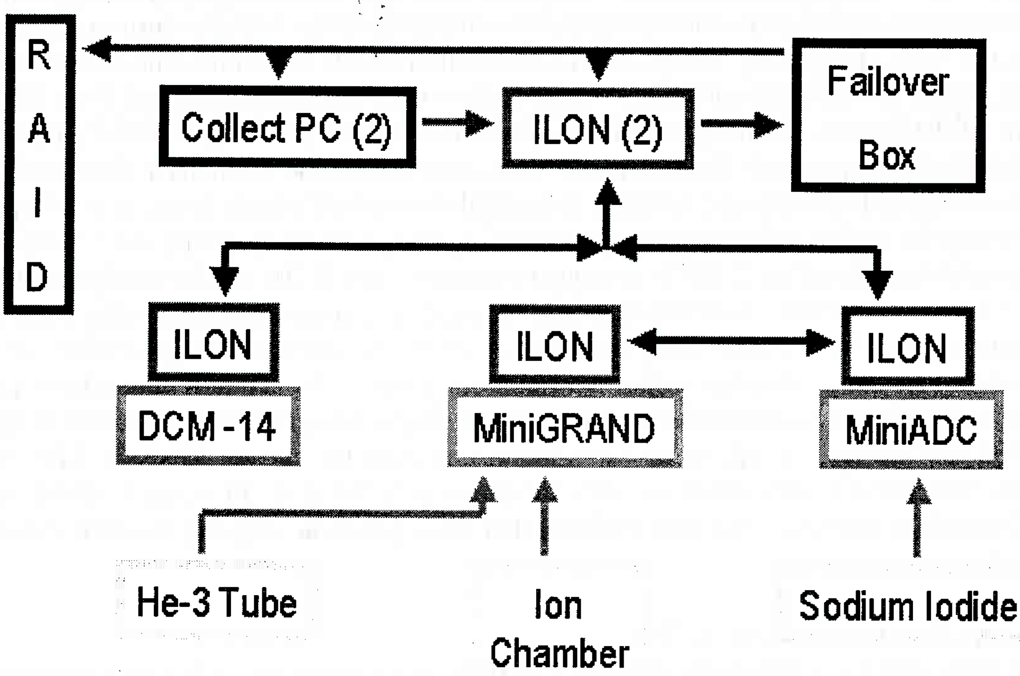

Figure 2. Instruments and network

Benefits
Even though this Mirror System is just a copy of another system, there are many advantages in being able to keep it at Headquarters within the department. Training, testing, and troubleshooting are three of the key factors. Inspectors often are unfamiliar with the equipment in the field and sometimes retrieving data is confusing. With this system, inspectors, as well as other technical staff, can familiarize themselves with the equipment that is in the field, making it easier to perform their duties while inspecting, upgrading, or maintaining a site. Secondly, new releases or versions of the software, firmware, and hardware used at facilities are constantly being received. It is obvious that these new items cannot be released into the field before testing or before they are approved. The Mirror System allows testing of these new versions of various components on a working system where it can be carefully monitored and/or debugged. One other nice thing about the Mirror System is that it can provide online troubleshooting. For example, if you have an inspector or a technician in the field, and they encounter some problem that they cannot fix, they can notify someone at HQ about the problem. The problem can be simulated on this system, and a solution can be found. This saves time and frustration.

Conclusion
It is important to understand the individual components of the Unattended Monitoring System and to be aware of how the Mirror System works as a whole, in order to recognize and appreciate how it benefits and supports the efforts of the IAEA. In conclusion, the BN-350 Mirror System has proved to be an excellent tool for the Safeguards Department of the International Atomic Energy Agency, contributing to improvements in training, testing, and troubleshooting.