*INEEL/CON-02-00014*
*PREPRINT*

Idaho National Engineering and Environmental Laboratory

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**August 4, 2002 – August 8, 2002**

**Spectrum 2002**

# Demonstration of the Robotic Gamma Locating and Isotopic Identification Device


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## ABSTRACT

The United States Department of Energy (DOE) continually seeks safer and more cost-effective technologies for use in decontaminating and decommissioning nuclear facilities. To this end, the Deactivation and Decommissioning Focus Area of DOE's Office of Science and Technology sponsors Large-Scale Demonstration and Deployment Projects (LSDDP) to test new technologies. As part of these projects, developers and vendors showcase new products designed to decrease health and safety risks to personnel and the environment, increase productivity, and lower costs.

As part of the FY 2000 and 2001 LSDDP, the Idaho National Engineering and Environmental Laboratory (INEEL) collaborated with the Russian Research and Development Institute of Construction Technology (NIKIMT). This collaboration resulted in the development of the Robotic Gamma Locating and Isotopic Identification Device (RGL&IID) which integrates DOE Robotics Crosscutting (Rbx) technology with NIKIMT Russian gamma locating and isotopic identification technology. This paper will discuss the technologies involved in this integration and results from the demonstration including reduction of personnel exposure, increase in productivity, and reduced risk.


## I. INTRODUCTION

The LSDDP at the INEEL has generated a list of statements defining specific needs or problems where improved technology could be incorporated into ongoing decontamination and decommissioning (D&D) tasks. One of the stated needs was for developing technologies that would reduce costs and shorten D&D schedules by providing remote radiological characterization in buildings or areas with high radiation levels. The Russian gamma locating and isotopic identification technology was identified as being one such technology that could provide economic and safety benefits to the DOE D&D program. Benefits of using this technology include:

- Cost reductions for initial surveys in highly contaminated areas
- Improved presentation of data
- Accelerated D&D schedule (initial surveys are completed much quicker)
- In situ real-time radiological measurements
- Reduced personnel radiation exposure
- Wireless communication and control

Following is a description of a comparable baseline technology followed by a summary of the innovative Russian gamma locating and isotopic identification technology.

### A. Baseline Technology

Historically at the INEEL, a radiation control technician (RCT) and industrial safety personnel first enter a facility in order to establish accurate conditions within the facility for planning purposes. When performing an initial radiation survey, the RCT uses a standard Geiger-Mueller pancake probe to gather radiological information. Once this initial entry has been completed, a video technician may also be required to enter and collect video coverage. Finally a team of sampling technicians is sent into the facility to collect samples for accurately determining contamination levels and to identify which isotopes are present to aide in D&D planning activities (see Figure 1). This was the case at the INEEL Test Area North (TAN) 616 facility where this technology was demonstrated.

**Figure 1. Baseline Sample Collection for Laboratory Analysis**

B. Innovative Russian Technology

The Russian gamma locating and isotopic identification scan head (see Figure 2) provides three-dimensional characterization of radioactivity in areas ranging from moderate to high radiation activity. This system scans an area and quantifies the level of radioactivity while onboard cameras simultaneously video those areas being scanned. The radioactivity levels are overlaid on video and displayed at a remote PC monitor located outside the contaminated area.

**Figure 2. Russian Gamma Locating and Isotopic Identification Scan Head**

During a survey, the distance from the system to the hot spot is measured by a laser distance meter and can range from 0.5 meters to 100 meters. Exposure times vary from 5 to 60 seconds. Different levels of radioactivity are color coded to enable the viewer to pinpoint the hotspots.

This system can identify multiple isotopes that are generating the radioactivity being characterized and for this demonstration was programmed to identify cesium (Cs)-137, cobalt (Co)-60 and americium (Am)-241. This technology is unique to competing U.S. technologies because:

1. It operates completely non-tethered on radio frequencies allowing it to maneuver around corners and transmit over long distances,

2. It has a broader range of sensitivity (i.e., 60KeV to 6MeV compared to 100KeV to 2MeV), and

3. It has a broader scanning angle (i.e., 330?horizontal and 125? vertical compared to 73? horizontal and 55? vertical).

II. Integration Details

The integration of the Russian radiation characterization technology and the INEEL Rbx robotic platform took place at the INEEL prior to the demonstration of this technology. Following are the details of the resulting RGL&IID platform and the associated control station.

A. Remote Platform

The remote platform consists of the described Russian radiation detection and isotopic identification technology combined with a modified commercial ATRV-Jr robot available from I Robot (see Figure 3).


**Figure 3. Combined Robotic platform and Russian Scan Head**

The Russian scan head weighs approximately 35 lbs. and measures 13 inches wide, 14 inches long, and 18 inches tall. The low-cost (~$20k) ATRV-Jr measures approximately 21 inches tall, 30 inches long, and 25 inches wide and can deploy up to 55 pounds. The robot weighs approximately 110 pounds and can operate for 3 to 6 hours between charges depending upon terrain conditions.

Integration of the Russian radiation detection and isotopic identification technology onto the robot required fabrication of a base plate that bolted onto the robot and mated to the existing four-bolt pattern on the detector's base. The only wiring requirements were 12-Vdc power leads that ran from the detector's base to a separate battery mounted on top of the robot.

The ATRV-Jr robot can be controlled via a wireless interface – a key factor in creating a total non-tethered system when combined with the Russian wireless radiation characterization technology. A control computer is housed within the robotic platform and runs the Linux OS. This allows for custom interfaces to be developed using the vendor provided software libraries. The INEEL robotics personnel used these features to develop a reliable wireless control interface that allows the robotic platform to be controlled via a remote computer keyboard. For safety reasons, a software watchdog was designed that automatically stopped all motion if communications were not received within a predetermined amount of time.

Overall, the RGL&IID platform has the following features:

- Collimator which is equipped with a spectroscopic sensor and electronic unit for preliminary processing of incoming signals
- Scanning electro-mechanical devices
- Electromechanical unit for remote screening of the collimator
- Camera with 3.4 GHz transmitter
- Laser distance meter
- Isotopic dosimeter unit
- 780 MHz data radio frequency receiver/transmitter
- Wireless local area network (LAN) at 2.4 GHz for independent robot control
- Onboard computer & navigation sensors

B. Remote control interface.

Separate control stations were maintained throughout the integration process to allow isolated control of the radiation characterization system and the robotic platform. This was necessary because only Russian scientific experts were allowed to operate the characterization system (the control software was in Russian) and only INEEL robotics experts were allowed to operate the deployment system. However, the two control stations were housed adjacent to each other in a single control trailer with an interpreter for translating instructions between the two international teams (see Figures 4 through 6).

**Figure 4. RGL&IID Radiation Characterization Station**

**Figure 5. RGL&IID Robot Control Station**

**Figure 6. Combined RGL&IID Control Stations**

The overall control station included the following features:

- Radiation Detection and Identification computer and printer
- Data radio frequency receiver/transmitter

- Video frame grabber with radio frequency receiver
- Software for data processing
- Robot control computer with wireless LAN access
- Remote camera control station
- Power supply sources

The general operation of the RGL&IID is as follows:

A. The robot platform is independently driven to a contaminated area to locations where the user chooses to perform a scan
B. Using an onboard video camera the RGL&IID collimator is oriented to the object of interest
C. Count times are established
D. Number of scanning points are selected
E. Scanning is initiated
F. Activity is measured at each scanning point
G. The background is subtracted from the measurement
H. Isotopic identification is performed
I. The data are stored on the personal computer for the user to evaluate.

The operator of the RGL&IID has the ability to remotely vary the scan times from 5 to 60 seconds. Additionally, the operator can select the number of scanning points ranging from 1 to 64 points evenly spaced over a selected scan area. Each scan covers as little as one square foot or as much as several square feet. Each point has a separate gamma radiation measurement and an overall isotopic identification for the scan. Figures 7 & 8 are examples of a survey from the RGL&IID.

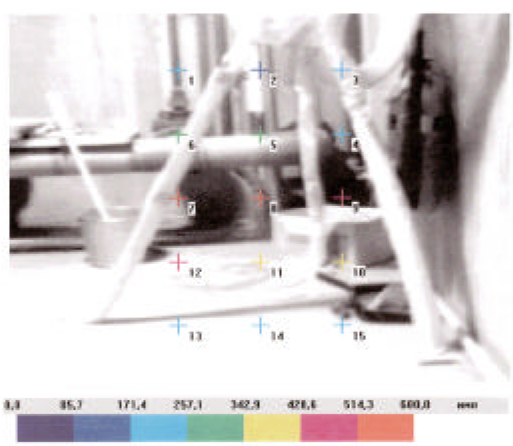


**Figure 7. Radiation scan using RGL&IID**

*Note: Each cross hair represents a separate scanning point. The color of the cross hair indicates the radiation level that correlates to the scale below the graph. The units are in total counts in a given 10-second scan time*

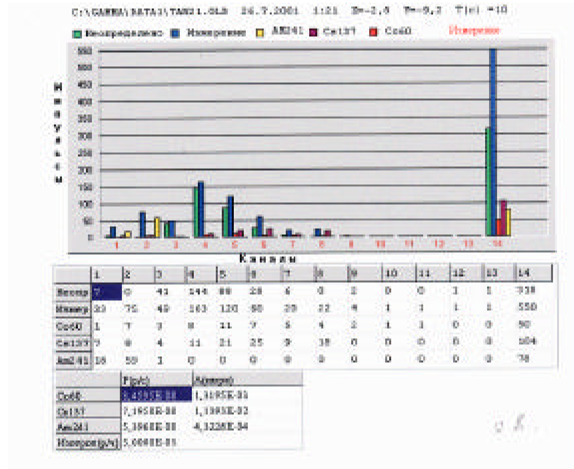

**Figure 8. Isotopic Identification using RGL&IID**

Further details on this technology can be found on the Office of Science and Technology website[1&2].

III. Demonstration of the RGL&IID

The RGL&IID was demonstrated in July of 2001. Following is a description of the test site and some of the resulting test data.

A. Demonstration Site

The demonstration occurred at TAN 616 (see Figure 9). TAN is located at the north end of the INEEL, about 27 miles northeast of the Central Facilities Area. TAN was established in the 1950s by the U.S. Air Force and Atomic Energy Commission Aircraft Nuclear Propulsion Program to support nuclear-powered aircraft research. Upon termination of this research, the area's facilities were converted to support a variety of other DOE research projects. TAN 616 was built in 1954 as a liquid waste treatment facility. As a result of treating thousands of gallons of liquid nuclear processing waste, there are various levels of contamination present in the facility.

**Figure 9. TAN 616**

Three rooms within TAN 616 were surveyed using the RGL&IID: the Operating Pump Room, the Control Room, and the Pump Room. All of these rooms are filled with process piping and equipment at various levels, which make a manual survey very difficult and time consuming to perform. The intent of this demonstration was to gather information helpful in deciding if the RGL&IID would improve D&D activities through a reduction in cost, accelerated schedule, improvement in safety, or more reliable data.

B. Demonstration Results

The RGL&IID was compared to the following baseline activities: the initial RCT entry, an entry to collect video, and a final entry to collect sample information. The RGL&IID was able to collect dose information, video coverage, and isotopes present in a single unmanned entry. The demonstration of the RGL&IID provided radiation survey results instantly and the complete facility survey was accomplished in 3 days. It took workers using baseline characterization methods 3 months to accomplish the same results. Much of this time was spent in waiting for results to be sent back from the laboratory. In addition, radiation exposure to workers supporting the RGL&IID demonstration was cut by more than a factor of 10 over baseline activities. During baseline characterization, workers received 82 mRem. During the demonstration of the RGL&IID, workers received 7 mRem of radiation exposure.

An example of a survey performed during the demonstration at TAN 616 comes from the Operating Pump Room. Baseline sample locations are identified by bold capital letters shown in Figure 10. The RCTs collected five smears (A,B,E,F,G) and recorded two dose measurements (C and D) at various locations in the room during the initial baseline entry. During the sampling phase of baseline characterization three additional smears were collected and four samples were collected (sludge, paint, and other materials). These seven samples were sent to a laboratory for gamma and isotopic analysis. The cost was $330/sample.

During the RGL&IID demonstration, 11 scans were made. The location of these scans is shown in Figure 11 by the bold numbers (1-11). Each of the 11 scans was composed of several point measurements that ranged from 9 to 25 points. Figure 11 shows a 9 point scan taken in the Operating Pump Room. Some of the points were on the walls, some on control valves, and one on the floor. In order to collect similar data using baseline measurements, nine separate samples or smears would have been collected, whereas using the RGL&IID, all nine measurement were made in less than 2 minutes. The RGL&IID uses a laser to measure distance to each surface being scanned. Therefore, each measurement has been corrected for distance away from the detector. A total of 120 point measurements were made using the RGL&IID in the Operating Pump Room. A single scan may cover several square feet on a wall or network of pipe, or may be a very detailed scan of a smaller area such as 1 square foot.

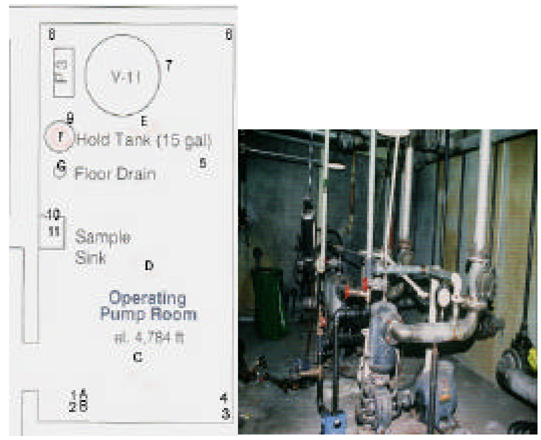


**Figure 10. Characterization of the TAN 616 Operating Pump Room.**

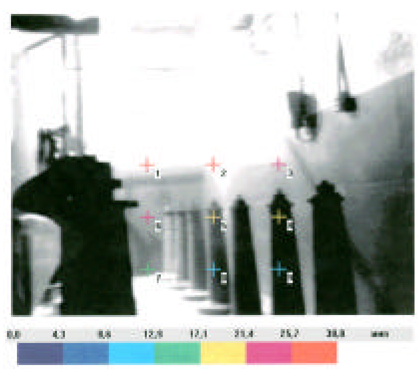

**Figure 11. Radiation scan using RGL&IID in TAN 616 Operating Pump Room**

*Note: Each cross hair represents a separate scanning point. The color of the cross hair indicates the radiation level that correlates to the scale below the graph. The units are in total counts in a given 10-second scan time*

IV. Conclusions and Acknowledgements

Following are the conclusions from the demonstration of the RGL&IID and acknowledgements of key programs associated with this technology and its demonstration.

A. Conclusions

The purpose of the demonstration of the RGL&IID was to show significant improvements in data acquisition and cost savings, and to increase worker safety. The most significant benefit of the RGL&IID is the quality of the results relative to the safety of the workers. Because the RGL&IID is operated remotely, fewer workers are required to enter the contaminated area.

The demonstration of the RGL&IID required more workers than the baseline characterization. However, during the baseline sampling activities, six entries with as many as six individuals per entry were made, totaling 60 work hours spent in the contaminated area. During the RGL&IID demonstration, only two technicians and one RCT were required to enter the contaminated facility for a total of 10 work-hours spent in a contaminated area. All others associated with the project were able to complete the objectives from outside the contaminated areas. As a result of workers spending less time in the radiation areas, they received 10 times less radiation dose than workers during baseline activities.

In addition, the two technicians and one RCT who did enter the facility during the demonstration did so only to assist the movement of the RGL&IID up and down a flight of stairs and to check air quality prior to entering the facility. These individuals maintained as much distance between themselves and the highest contaminated areas as possible. In contrast, the baseline samplers were required to come in direct contact with the contaminated material in order to collect representative samples.

A laboratory radiological analysis confirmed the presence of Cs-137, Co-60 and Am-241. This data was available within minutes after the RG&IILD performed the scan. The baseline activities began in August of 2000 and were not complete until November of 2000. Some of the results from the laboratory analyses were not available until January 2001.

The cost of collecting the radiation measurements using the RGL&IID was about half the cost of the baseline technology. In addition to the benefit of significant cost reductions, this technology also generates significantly more data. For example, there were ten baseline samples taken during the characterization work. The RGL&IID collected about 20 scans. Each scan covers as little as one square foot or as much as several square feet. Each scan may have as few as a single point measurement or as many as 64 point measurements. Even though there were only about 20 scans performed at TAN 616, there were over 200 point measurements that covered over 100 square feet of wall and floor area. The RGL&IID has the capability of providing 100% coverage if needed.

B. Acknowledgements

Demonstration and integration funding was provided by the DOE-HQ International Programs and the DOE Office of Science and Technology. Specifically the Deactivation and Decommissioning Focus Area, managed by the National Energy Technology Laboratory, funded the demonstration through the INEEL LSDDP and the integration through the Robotics Crosscutting program. The authors would like to acknowledge the significant contributions of the Russian Research and Development Institute of Construction Technology and their undying commitment to this collaborative effort. Also, special thanks to the INEEL Deactivation and Decommissioning project that allowed the demonstration to take place in their facility during deactivation activities.

V. References

1. Robotic Gamma Locator Device Innovative Technology Summary Report, to be published on the Office of Science and Technology website: http://apps.apps.em.doe.gov/ost/itsrall.html.

2. Robotic Isotopic Identification Device Innovative Technology Summary Report, to be published on the Office of Science and Technology website: http://apps.apps.em.doe.gov/ost/itsrall.html.