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Abstract

Following assessments that attacks with radiological and nuclear weapons are possible, detection system deployments are being supported at national and local levels. Detection systems include both, highly sensitive but non-discriminating detectors, as well as detectors and algorithms capable of distinguishing and identifying gamma rays by energy. The latter systems, usually handheld systems based on sodium iodide detectors, also provide analysis of the specific radionuclides present and are referred to as radioisotope identifiers (RIIDs). Studies have shown that sodium iodide based RIIDs fall far short of 100% accurate identifications. The U.S. Department of Homeland Security (DHS) initiated the Regional Reachback (RRB) Program in 2006 to provide rapid expert interpretation of gamma spectroscopic data from radiation alarms from detection systems deployed by state and local authorities. With expert specialists on call 24/7, RRB provides an avenue for local and state authorities to verify routine results, interpret unknown identifications, and notify national response assets if needed. This paper will provide details of the RRB program, an outline of the analysis process, a description of the drills and training systems used to maintain specialists' response performance, and examples of drills and incidents from the first full year of operation.

Introduction

After the terrorist attacks of September 11, 2001, numerous systems for addressing any and all threats were considered. Following assessments that attacks with radiological and nuclear weapons were possible, and with extremely dire consequences, it became apparent that radiation and nuclear detection systems needed to be deployed at both the national and local levels. The Domestic Nuclear Detection Office (DNDO) within the U.S. Department of Homeland Security (DHS) has been tasked with the development of a Global Nuclear Detection Architecture that integrates detection systems operating at different government levels, including international, domestic, state and local.

Detection systems include highly sensitive but non-discriminating detectors, used for rapid screening applications, as well as detectors and algorithms capable of distinguishing and identifying gamma rays by energy. The latter systems, usually handheld systems based on sodium iodide detectors, also provide identification of the specific radionuclides present and are referred to as radioisotope identifiers (RIIDs). RIIDs are used by police, hazmat teams, and other first responders when alarms sound from screening systems (drive-through portals or car-mounted systems) or from pagers carried by police officers.

Studies from 2004 and earlier have shown that sodium iodide based RIIDs are less than 50% accurate in identifying radioactive sources. Even with these shortcomings, there are programs to improve the portal-sized and mobile systems (e.g. the Advanced Spectroscopic Portal, ASP) by incorporating RIID technology into these larger detection systems. These advances represent a new generation in detection systems, and deployment of these newer technologies is forthcoming. To improve RIID identification accuracy, advanced handheld systems using higher-energy-resolution lanthanum halide detector materials are in production, but the algorithm developments to improve identification have not been tested to date.

As state and local authorities deploy more detection systems, the number of alarms needing additional adjudication assistance will also increase. In 2006, DHS initiated the Regional Reachback Program (RRB) to provide rapid expert interpretation of gamma spectroscopic data from radiation alarms from state and local authorities. RRB's technical adjudication is complemented by the DNDO Joint Analysis Center (JAC) which performs operational adjudication in the form of performing license checks, fusing available intelligence, and maintaining situational awareness. Together RRB and the JAC comprise the initial reachback layer of DNDO's alarm adjudication process for state and local requests for assistance. With expert specialists on call 24/7, RRB provides an avenue for state and local authorities to verify routine results, interpret unknown identifications, and enter the national level of reachback that can notify national response assets if needed.

Mission, Components and Communications
RRB's prime mission is to adjudicate alarms by reviewing and interpreting gamma spectroscopic data collected at detection sites operated by state and local authorities. Two regional teams of scientists and spectroscopists have been assembled from Oak Ridge National Laboratory and Savannah River National Laboratory in the Southeast (SE), and from Brookhaven National Laboratory and the Environmental Measurements Laboratory in the Northeast (NE). On-call teams consist of two scientists for each region, who confer during a call after performing individual analyses. Calls will be answered at any time, and are made through the JAC, which functions as a fusion node for data correlation, transmittal, and analysis in addition to providing operational adjudication. [Telephone 877-DNDO-JAC (877-363-3522) or E-Mail DNDO.JAC@dhs.gov. A secure web portal is currently in development.] After initial phone contacts, state and local authorities transmit spectral data and incident information via e-mail or, in the future, through the secure web portal. The JAC alerts and sends the data to on-call RRB specialists, who are expected to provide an analysis within 30 minutes of receiving the data.

Members of the RRB team have experience in gamma spectroscopy and related areas of radiation detection technology, and undergo training in threat detection and identification focused on radiological dispersal devices (RDDs) or improvised nuclear devices (INDs). Training includes extensive familiarization with detection systems in use at DHS and at state and local facilities, understanding threats and their signatures, and radioactive materials used in industry and medicine. Reachback specialists also undergo training in

the use of three software tools, GADRAS (Gamma Detector Response and Analysis Software), Cambio, and PeakEasy, intended specifically for the identification and quantification of radioactive materials. These tools were developed at Sandia National Laboratory and Los Alamos National Laboratory, respectively, and have been modified in recent years to address the larger number of radioisotopes and physical forms to be found in naturally occurring and legal applications of radioactive materials.

RRB specialists maintain their response skills by participating in weekly drills issued by the JAC. Spectroscopic capabilities are honed by preparing and solving sample problems at regular weekly and monthly meetings, quarterly regional meetings, and yearly national meetings. Software updates, new products for radiation detection, and new applications of radioisotopes are also discussed at these meetings. The two active RRB teams respond to calls from all over the nation as assigned by the JAC, and have a regional outreach component. In regional outreach, the specialists will meet with local police and state and local authorities to explain the reachback program, to encourage response through the JAC, and to provide additional training, especially on the data download and transmittal procedures. RRB also participates in related homeland security activities. In the NE, a regional effort funded by the DHS known as the Securing the Cities (STC) program is deploying thousands of radiation detection "pagers" and more than 100 RIID units. NE RRB personnel sit on the planning and organizing committees of STC to ensure proper coordination. The same is true in the SE, where the SE Transportation Corridor Pilot (SETCP) deployed radiation portal monitors and handheld RIIDs at truck weigh stations. SE RRB has worked with the SETCP in deployment, training, and exercises. RRB specialists often also work within other DNDO assignments and programs across the country that support enhancing the radiological and nuclear capabilities of state and local responders.

RRB Response Scenario and Examples

The process for RRB response begins with notification by state and local responders to the JAC of a radiation alarm and response per the state and local protocols. The decision to call the JAC generally occurs after the local responders have some data about the identity of the radioactive material from a RIID, or radiation portal monitor. Duty officers at the JAC collect all information from the local responder, request digital spectroscopic data files, and review all the information while contacting the RRB. The initial part of the RRB involvement is a conference call between the regional specialists and the JAC officer where information about the scenario and spectroscopic data are transmitted from the JAC to the specialists. In addition to spectroscopic files from the RIID or portal, information such as the distance from the detector to the source and possible shielding materials reduce uncertainty in the calculation of the quantity of radioactive materials.

After the two-to-three minute conference call, the specialists may work independently while analyzing the data. The spectroscopic files from the detection equipment are opened and reviewed in Cambio or PeakEasy. Cambio and PeakEasy have been designed to speed the specialist's access to gamma emission peak libraries, automatic calculations

of data such as peak centroid, Compton edge, backscatter, peak, sum peak, and single and double escape peaks. PeakEasy also offers an option to search for specified gamma energy values and list isotopes with energies near that value. At this stage it is customary to look for clear spectral signatures for "routine" commercial radioisotopes. In addition, the RRB specialist is also scanning for indications of the presence of special nuclear material or neutron emissions which could indicate a threat. Special nuclear materials (uranium, plutonium, and neptunium) are very closely regulated and should not be seen in commercial or private vehicles. Neutron emissions may be reported when neutron detectors are in the detection system, but evidence of neutrons may also be present in the gamma spectrum if levels are high enough and/or if materials with strong neutron interactions, such as plastics, are present with a lower-level source.

Whether or not a radioisotope is unequivocally identified, the analysis continues with the GADRAS program, which has automatic identification schemes. GADRAS is a useful tool because, in addition to radionuclide identification, it can calculate what quantity of radioactive material is present based on some geometry assumptions and input on shielding and distance. GADRAS calculations include the effects of scattering and other photoelectron interactions and this requires characterization of the detector geometry and response parameters. This is very important as it allows the specialist to perform a continuum analysis which brings out information on the shielding, and, more importantly, allows the specialist to examine the data for weak signatures of possibly hidden or masked nuclides. GADRAS is also able to calculate and plot spectra if radioisotope composition and shielding assumptions are inputs to a basic one-dimensional model geometry. [Note that GADRAS and PeakEasy are not available to the general public. Only employees of or contractors to the U.S. Government may use them.]

Figure 1 shows a spectrum submitted in February 2008. In this event the police were testing new (but not spectroscopic) mobile equipment and requested an explanation as to why the helium-3 neutron detector reported the presence of neutrons above background. They also wanted to know why the RIID that was being used identified cobalt-57 (^{57}Co) when the manifest for the shipment indicated that only cobalt-60 (^{60}Co) was in the shipment. The shipper was well known to the police and had a history of similar legal exclusive use shipments. This event was similar to one that occurred in September 2007, where slightly elevated neutron counts and a wrong identification of ^{60}Co were reported using a mobile mounted spectroscopic system.

Two issues raise concerns from these events: elevated neutron counts and isotope misidentification. Elevated neutron counts are a concern because commercial uses of neutron sources are limited to well-logging and soil moisture-density gages. The threat potential of neutron alarms is higher because plutonium emits high levels of neutrons. In the earlier alarm, the neutron levels were attributed to variations in instrument background readings, a conclusion consistent with RRB experience with that particular detector. The neutron issue was resolved after the JAC determined in the second event that the shipping casks used for the shipment were constructed with depleted uranium shielding. There were three casks with a total weight of 7,000 lb. A review of nuclear science sources verified that depleted uranium has a low but measurable neutron emission

rate, between 0.011 and 0.016 n-sec^{-1}g^{-1}. Using the higher rate, 7,000 lb (or 3,182 kg) will emit about 5 x 10^4 n/sec. This quantity, emitted isotropically, is lower than levels emitted by commercial sources. It is detectable with the larger detectors found in portals or mobile applications if they are brought close enough to the mass of depleted uranium.
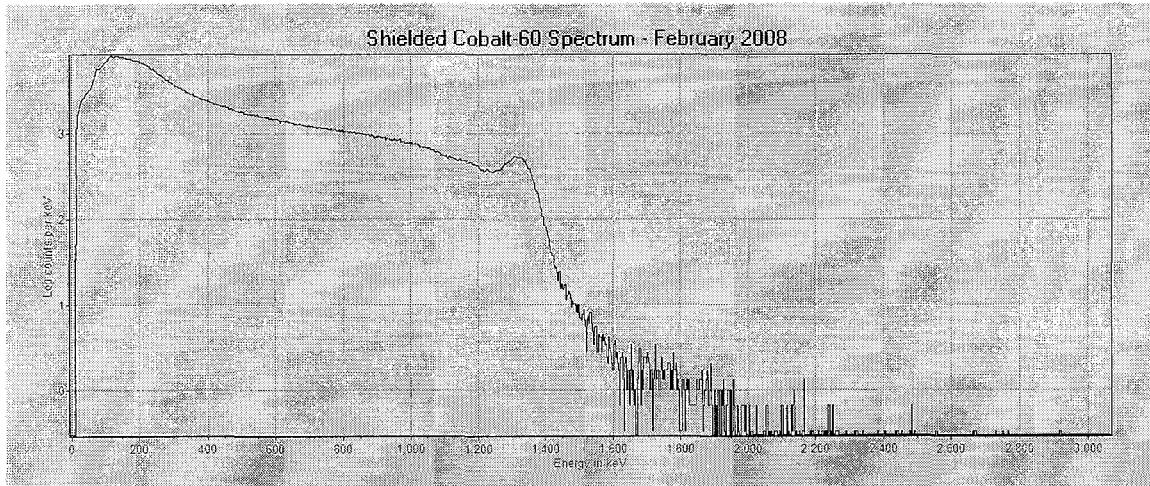

Figure 1. Unknown Spectrum with background subtracted

The issue about a wrong identification was less complicated. Figure 2 shows a gamma spectrum from a small unshielded ^{60}Co source, taken with a similar RIID as the spectrum in Figure 1. Note the distinctive double peak pattern, indicating gamma energies at 1173 and 1332 keV, a pattern almost completely obscured in Figure 1. Figure 1 shows a single peak with a centroid at about 1332 keV, but no indication of a second one. The preferential attenuation of lower energy gamma rays by shielding materials is well known and was one of the demonstrations in the training sessions for the RRB specialists. In this particular case, massive amounts of shielding were required to make this source safe for shipment, and this large amount of shielding was sufficient to eliminate the signature of the 1173 keV gamma ray from ^{60}Co.
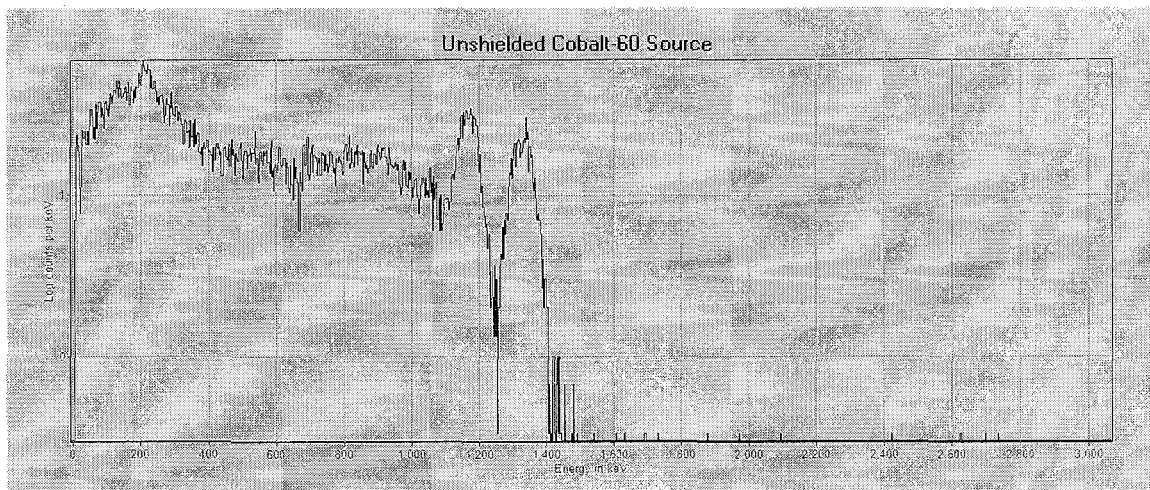

Figure 2. Unshielded ^{60}Co Spectrum

Figure 3 presents a spectrum calculated using GADRAS with the characteristics of the specific RIID used by the responders. In this calculated spectrum with 300 curies of ^{60}Co shielded by about 7 cm of depleted uranium, there is still a vestige of the 1173 keV peak visible. However, the total levels of counts per channel are at least 10 times lower than those seen in Figure 1. Additional modeling to estimate more closely the quantities of ^{60}Co was not carried out because the incident in February 2008 involved three casks on the truck. A distributed multi-source geometry like this is not readily modeled with the one-dimensional simulation code embedded in GADRAS. In addition, the RRB team has not been able to determine why the RIID chose ^{57}Co using the data shown in Figure 1. No strong features in the collected spectrum correspond to the gamma peaks associated with ^{57}Co at 136 keV and 122 keV.
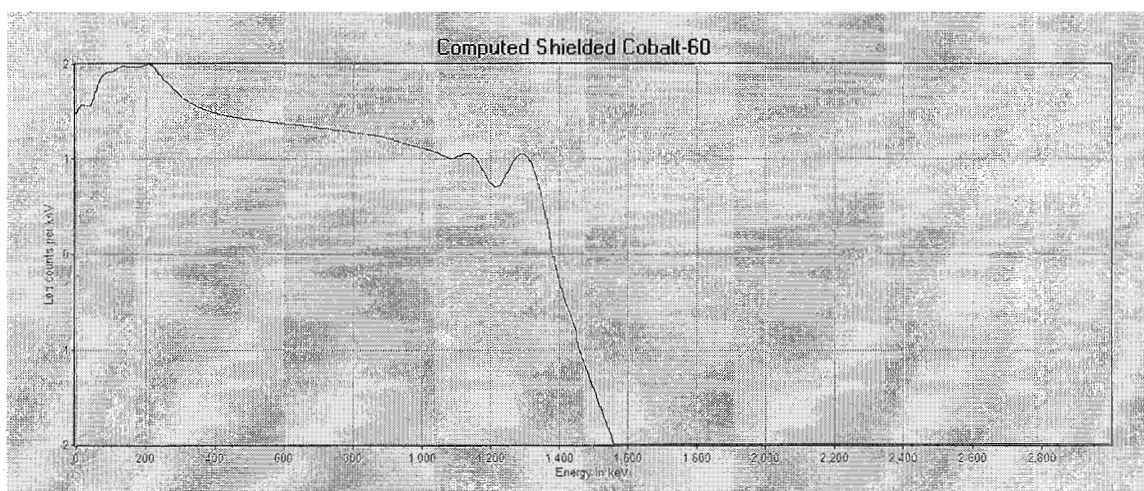

Figure 3. Computed Shielded ^{60}Co Spectrum (using GADRAS)

The RRB team interpreted this event as a non-threat because the gamma spectrum was consistent with the stated source and because the police, in their contact with the JAC, noted that the shipper was a known entity. The reported detection of neutrons was of great interest because it verified that the equipment being deployed on mobile platforms was highly sensitive to sources that could be a possible threat. More importantly, the nature of the call, requesting explanations for unexpected results obtained with the new equipment, demonstrated that the local users of the equipment were thinking about the results obtained and able to use response resources being made available at the federal level. They had familiarization and training not only with the detection systems but with the DNDO reachback program as well. The deployment of radiation detection equipment will only be successful if the local users understand the capabilities and the limitations of that equipment. The federal agencies can only have assurance that these deployments are effective in guarding against terrorist threats if the local users contact federal resources for alarms obtained outside of scheduled drill and exercise activities.

Conclusions

The RRB started operations in late 2006. Since then, the RRB and JAC components of the DNDO nuclear detection architecture have demonstrated responsive expert assistance

to state and local police department radiation detection alarms across the country. The technology of detection and the applications of isotopes continue to evolve, and RRB is committed to monitor the evolution to fulfill its mission as experts in radiation detection alarm response.