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U.S. Government Capabilities to Support Analysis of Gamma Ray Data Submitted by Field Elements

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Abstract

As radiation detection in the interest of national security becomes increasingly commonplace, inevitable questions arise concerning the interpretation of data from handheld radioisotope identifiers (RIIDs). Field elements typically require fast answers to provide an effective defense and to minimize the impact on legitimate movement of people and goods. To support this need, on-call experts at Sandia, Los Alamos, and Lawrence Livermore national laboratories cooperate in resolving radiation alarms rapidly and accurately. We present an overview, describe the work in progress to improve capabilities, and report on some of the lessons learned.

With the increasing use of radiation detection equipment to screen port-of-entry and other sites for illicit materials, the U.S. government has recognized the need to analyze complex gamma ray spectrum information and assess for potential threats. This is particularly important because the tools now available to first responders have limited capabilities in isotope identification. A formal mechanism to enable emergency response teams to request assistance was established in 2002, and has been continually evolved in response to operational experience. Personnel from Sandia, Los Alamos, and Lawrence Livermore national laboratories are call 24 hours/day in a 7-day rotation. At least two different laboratories respond to each event to provide peer review. Specialists at the three nuclear weapons laboratories provide high-confidence answers when faced with questions affecting national security.

A primary focus for the responders is accurate identification of threats. To this effect, analysts train with a variety of threat materials, nuclear weapons, and potential designs for improvised nuclear explosive devices (IND's) and Radiation Dispersal Devices (RDD's). Training includes both detailed spectrum analysis and hands-on training with nuclear materials and typical field team hardware. All of the analysts are active in research and development in various aspects of nuclear detection, and all are experts with many years of experience in gamma spectroscopy, handling of nuclear materials, and nuclear weapons. Analysts maintain currency in world radiological issues, advances in nuclear medicine, and potential threats through frequent updates and training.

Field teams often require a reliable answer very quickly, so processes are streamlined and practiced. Analysts strive to resolve events as quickly as possible while applying appropriate diligence, and results are typically made available within 30-60 minutes. It is important to

minimize the impact on the legitimate movement of people and goods. A majority of alarms are innocent (for example, shipment of industrial isotopes or patients who have received recent radiopharmaceutical treatments), and processes are designed to minimize the time and cost of an innocent alarm. While it is important to provide a timely response, it is equally important to maintain control over sensitive trade and import data, personal information, and law enforcement information. A significant number of alarms have resulted in deployment of additional assets, confiscation of materials, or legal actions.

The analysis service is available to any US government agency at no cost. In descending order of usage, support has been provided to Customs and Border Protection (CBP), Department of Energy Radiological Assistance Program (RAP), Federal Bureau of Investigation (FBI), Department of Defense (DOD), United States Coast Guard (USCG), National Guard Civil Support Teams (CST), Transportation Security Administration (TSA), other government agencies, and local fire and police departments. To date, analysis support has been provided for 126 real-world emergent events. In many cases the primary reachback agency is the Customs and Border Protection Laboratories and Scientific Services (LSS) [1], who use the service to augment their own analysis capabilities.

Drills by field elements are supported and encouraged; these are quite valuable for maintaining smooth operations, and especially for early discovery and repair of communications problems. More than 200 drills have been supported since inception. "Courtesy" data, submitted by other agencies with which there is a cooperative relationship, is gratefully accepted. Most courtesy data is from real-world events that have already been resolved but are unusual in some way or teach a significant lesson. Such information is of great value and often helps to achieve rapid resolution of later emergent events. One effective means of sharing the lessons learned is bi-weekly expert drills, which are provided as a self-assessment tool to Sandia, Los Alamos, and Lawrence Livermore national laboratory responders and also are made available to the greater spectroscopy community. These drills are designed to reflect challenging real-world scenarios, and many use actual field data that has been sanitized to remove non-disclosable information.

Support is provided to US government teams within the continental United States (CONUS) and outside (OCONUS). OCONUS support accounts for roughly 15% of analysis requests. Even though most support is provided for CONUS teams, international issues play a very large role. A majority of radiopharmaceuticals and industrial isotopes used in the U.S. are produced in Canada or overseas and must cross a U.S. border at some point. A small fraction of these shipments produce alarms that are not resolved locally or by LSS. International passengers crossing the border may have received a radiopharmaceuticals treatment that leaves a detectable trace, and foreign nuclear medicine practitioners often use different drugs than are common in the US.

Special or alternative nuclear material (SNM/ANM) account for about 25% of events, either as a false positive detection, or (rarely) because it is actually present. As an example of a false positive, it is common for unshielded Ir-192, which has its strongest a peak at 316.5 keV, to be misidentified as Np-237, which produces its strongest peak at 312.0 keV from its daughter Pa-233. Low-resolution NaI detectors may be unable to tell the difference, especially if energy calibration is poor. Even high-resolution systems can confuse Lu-177m and Pu-239, which each have peaks at 413.7 keV. Another common occurrence is misidentification of uranium

enrichment. Natural or depleted uranium has some U-235, which is often misinterpreted as indicating highly-enriched uranium (HEU), especially by RIIDs with poor efficiency at the higher energies where U-238 signatures occur. Lawful shipments of SNM and ANM, including plutonium, are sometimes interdicted by field teams, who may request confirmation. An unlawful shipment of SNM or ANM is, of course, a significant finding and cause for law enforcement action.

Data are encountered from many different RIID devices. Some of the most prevalent instruments are Identifier-Exploranium^{TM} GR-130 and GR-135; Nucsafe, Inc., Identifinder; Berkely Nucleonics Corp. SAM 935; Ortec Detective (an electrocooled HPGe), and a variety of LN_2-cooled HPGe systems. Some teams use other specialized equipment for specialized missions. Many new instruments are under development or just now available to customers, and nearly all established commercial models undergo frequent revisions and improvements. Overall performance of commercial RIIDs has been improving rapidly in recent years, but much room for improvement remains, and the services provided by expert human analysts will be required for many years to come [2]. We are committed to supporting any hardware used by field teams, and in no way attempt to influence the choice of equipment. We do however, provide recommendations on improvements to operations which would assist in our ability to characterize threats, and we cooperate with commercial RIID engineers in the hopes of aiding product improvements.

Some of the tools under development are described below:

> RADASSESSOR is an extensive database that is under continual development at LANL. It contains detector responses to a wide range of industrial, medical, natural, and threat radioactive sources. It is continually being expanded, and now includes more than 2000 examples from 15 different instruments. It includes useful examples of cases that have been encountered or are anticipated [3].
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> Analysts must support many different instruments. CAMBIO is software developed at SNL that can automatically read and display spectral data in any instrument format that the nuclear emergency response community encountered to date. This solves the problem that, with over fifty different formats used by fielded instruments, and with new variations appearing every month, it is impractical for every responder to maintain up-to-date versions of manufacturers' software. In addition, CAMBIO is able to convert field spectra into any one of several common formats that are used for analysis, saving valuable time in an emergency situation. It has several other features that are useful for file manipulation, correction of artifacts, and rapid analysis [4].
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> Some events require spectrum modeling in addition to peak identification. Two useful tools under development are GADRAS, developed by Dean Mitchell at SNL [5], and GAMMA DESIGNER, developed by Mark Rowland at LLNL [6]. Each of these software tools is capable of full-spectrum modeling, which is important for example when attempting to quantify shielded isotopes or for interpretation of features such as Compton scattering, backscatter, escape and sum peaks, and features resulting from neutron interactions. Each includes detailed response functions for common RIID detectors.

Each has extensive libraries, and incorporates considerable wisdom that has been developed from experience with real-world cases.

PEAKDOCTOR is a software tool under development by Scott Garner at LANL [7]. It is not a modeling tool, but uses fuzzy logic to identify spectral features and reject or support spectrum hypothesis with a high degree of automation while preserving a human interactive component where appropriate. It is particularly useful for interpreting complex spectra from multiple simultaneous isotopes.

Sandia, Los Alamos, and Lawrence Livermore national laboratories provide a key element in the national strategy for managing the large and growing number of radiation detectors and instrumented sites. We stand ready to assist with data analysis, 24 hours a day, 7 days a week, whenever a site official must determine whether an incident involves legitimate transport of radioactive material, or whether a licensing violation, criminal activity, or incipient nuclear terrorism is indicated.

We would like to thank the many individuals and agencies who have contributed to the program, who unfortunately can not be named here.

References

[1] Laboratories and Scientific Services coordinates technical and scientific support to all CBP trade and border protection activities. Working in labs in eight major cities, LSS scientists provide scientific advice to the rest of Customs. On December 8, 2003 LSS opened the Technical Data Assessment and Tele-forensics Center at the National Targeting Center. See http://www.dhs.gov/dhspublic/display?content=3989

[2] J. M. Blackadar, C. J. Sullivan, B. G. Rees, S. E. Garner, and D. J. Mercer, "Continuing Evaluation of Isotope Identifiers," proceedings of INMM 45th Annual Meeting, Orlando, FL, July 18-22, 2004; Los Alamos National Laboratory Publication LA-UR-04-4298.

[3] J. M. Blackadar, "RadAssessor Database," Abstract #305 in these proceedings.

[4] George Lasche, "Nonlinear Fitting of Nuclear Spectra," Proceedings of the Southwest Regional Chapter of the Institute of Nuclear Material Management, Taos Technical Meeting, 19 May 2005.

[5] GADRASw User Manual, Rev. April 2005, David R. Waymire and Dean J. Mitchell, Sandia National Laboratory (electronic distribution).

[6] Personal communications, Mark Rowland, 2005.

[7] Scott E. Garner, "PeakDoctor Spectral Analysis Software," Los Alamos National Laboratory Publication LA-UR-04-7187.

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