Enhanced Spatial and Spectroscopic Resolution for First Responders: The DTRA Demonstration at Kirtland Air Force Base

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Abstract

The Defense Threat Reduction Agency (DTRA) procured technologies and systems for rapid deployment at four military bases with the stated purpose of reducing the threat of smuggling of an unconventional nuclear or radiological weapon onto a military base. Their vision was rapid mobilization of "off-the-shelf" radiometric detection instrumentation to provide near term threat reduction results. BNFL Instruments, Inc. (BII), as a teaming partner with Westinghouse Safety Management Solutions, was selected for the Kirtland Air Force Base (KAFB) Test Bed in Albuquerque, NM. This paper presents the results of the demonstration and testing conducted at the KAFB with the RadScan®: 800 4pi Gamma Imager. This instrument is a sodium iodide based gamma detection system that overlays a gamma count rate map, using isocontours, onto a video image of the survey area. This unique capability allows first responders, both Security and Health Physics personnel, to rapidly map and evaluate not only the location and intensity, but, through the integrated spectroscopic capability of the instrument, also the type of radioactive material present so that the overall threat can be better understood. This key information is available near real time, enabling better response management with respect to the tactical threat as well as addressing ALARA concerns. The instrument was outfitted for the KAFB Test Bed to provide threshold alarm capability. The alarm threshold was designed to be set for target radioactive materials or for total count rate. The RadScan® 800 is a fast emerging radiometric detection technology that has been proven in the demonstration scenarios as a potentially invaluable tool in the War on Terror.

Introduction

The BNFL Instruments, Inc.'s (BII) RadScan®: 800 4pi Gamma Imager remotely locates and characterizes gamma hotspots in a wide variety of environments. Typical applications include survey of building surfaces, soils, hot cells, glove boxes, process vessels, and transport containers, including the cargo holds and surfaces of trucks, trains, or boats.

The RadScan®: 800 has been used as a planning tool to initiate cost savings and reduce dose uptake by supporting optioneering studies and reducing the requirements for manual area monitoring, particularly in unknown or high dose radiation fields (OENHP # 2002-33 Version A). This instrument has the potential to lower cost and dose uptake in any environment in which the spatial distribution, intensity, and isotopic identification of gamma emitting radioactive material is needed. A complete product specification including applications, deployment and operation, and a description of the data acquisition and analysis packages is available on the BII website (www.bnflinstruments.com).

With the advent of the War on Terrorism and the very real potential for nuclear or radiological attacks on military bases, urban centers or communities, the Defense Threat Reduction Agency (DTRA) has initiated the search for effective "off-the-shelf" technologies that could potentially identify and therefore prevent smuggling of such weapons of mass destruction and terror.

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Equipment Description

Overview

This instrument maps and records the distribution and intensity of measured radiation using radiometric data and real-time color video images that are viewed from a workstation at a safe distance, thus increasing worker safety and minimizing worker dose uptake. The inspection head can be deployed rapidly by a single user; on a lightweight, collapsible and height adjustable tripod, supplied as standard. It can also be mounted on many other platforms including fixed or mobile stands, crane or Remote Operated Vehicle (ROV). Alternatively, it can be mounted directly to the building structure using its integral quick release coupling and flange.

Description of hardware

Figure 1 below is an illustration presenting the RadScan® 800 hardware components.

The detector head contains a collimated (angle of collimation variable) gamma detector, a combined camera/zoom lens and laser range finder. The gamma detector is a NaI (Tl)

scintillation crystal with a miniature PMT located within a tungsten collimator. The detector will measure gamma radiation in the energy range of 30-1500 keV. The camera is a compact, 3 lux, high definition color CCD type. The 16x optical zoom lens has motorized zoom, auto focus and auto iris. The focusing, iris control and zoom can be controlled from the workstation. The range finder comprises a red laser diode (class II laser product) and has a range measurement (with a visible laser "spot") of 0.3-30 m (natural surfaces) and 0.3-100 m (brown reflective surfaces) having an accuracy of ±5 mm or better.

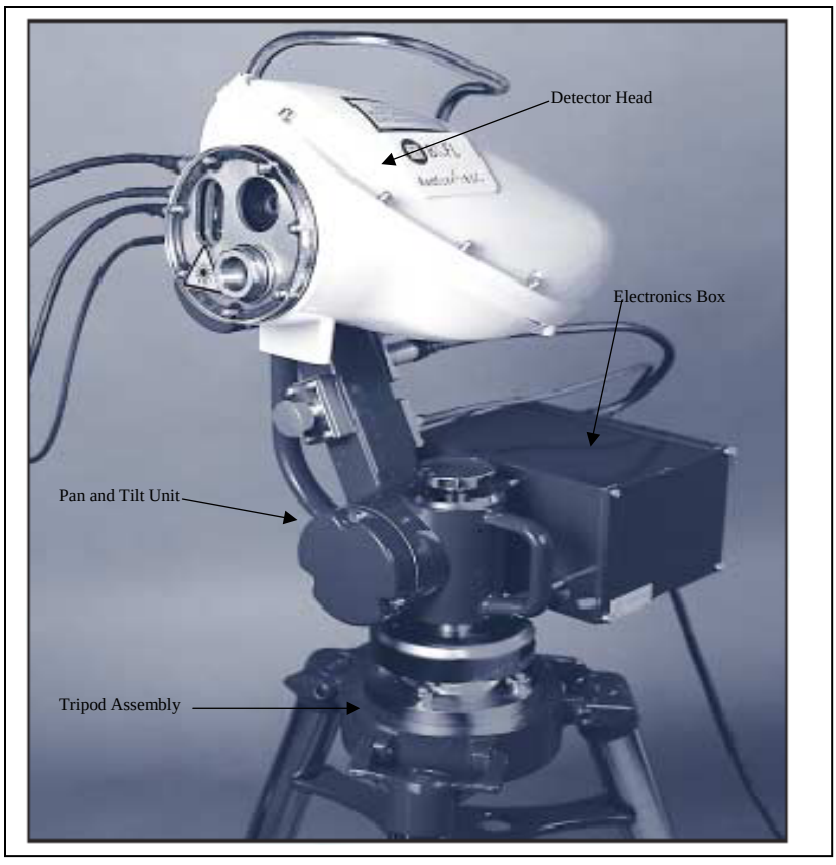

Figure 1. RadScan® 800 Hardware Components

The Pan/Tilt unit, apart from providing structural support for the detector head and electronics box, allows the detector head to pan (rotate about a vertical axis) and tilt (rotate about a horizontal axis). Both axes of rotation pass through the gamma detector, which is located at the center of gravity of the detector head, thereby reducing the torque required for rotation. The Electronics Box contains the communication and power supply electronics. Movement of the inspection head is controlled by a telemetry unit, which communicates with the workstation via an RS-485 communication link. An amplifier allows the output signal from the detector to be connected directly to the Multi-channel Analyzer (MCA) system located within the workstation. Further description of the RadScan® 4pi Gamma Imaging System's equipment and operation can be found in the User's Manual (BII-5140-UM-001).

Safety

In September 2002, team members from the Operating Engineers National HAZMAT Program (OENHP) conducted an occupational safety and health assessment of the RadScan® 700 Gamma Imaging System via a review of documentation for the equipment at the Department of Energy (DOE's) West Valley Demonstration Project (WVDP) in West Valley, NY. A What-If analysis, a standard tool for hazard analysis, was used to generate a Human Factors Assessment Report (OENHP #2002-33 Version A) and a corresponding Technology Safety Data Sheet (TSDS DOE OST TMS # 1793). Though the human factors assessment and TSDS were conducted on a previous model of the RadScan®, they are still generally applicable to the new system model, with the main changes being redesign of the system to be lighter and more compact improving ergonomic concerns. Copies of the Human Factors Assessment Report and

corresponding TSDS developed by the Operating Engineers National Hazmat Program can be found on the internet at www.iuoeiettc.org.

Demonstration Scenario

The RadScan® 800 was set up at a secondary check point (primary checking was performed via a large area plastic scintillation system deployed at the main gate). Radioactive sources of different composition were distributed through the back of the cargo van/truck as shown in Figure 2. Upon stopping at the secondary check point, a scan of one side of the truck was initiated. The system operator had no prior knowledge of the type or location of the radioactive material within the truck.

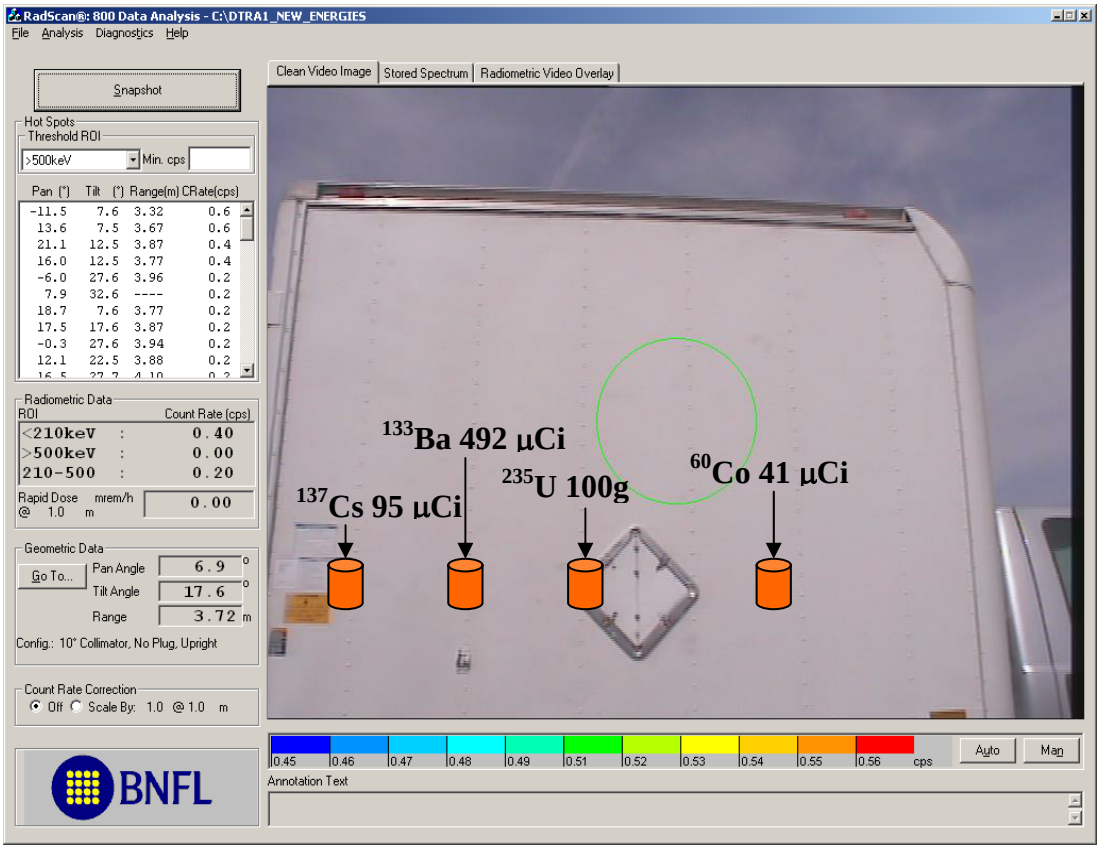

Figure 2: Location, type, and distribution of radioactive materials for DTRA KAFB Test Bed Demonstration

Demonstration Results

Figures 3-5 present the test results. The survey data was analyzed using three different Regions of Interest (ROIs). After a total scan time of 10 minute, the survey successfully identified the location as well as the type and intensity of radioactive material hidden within the truck.

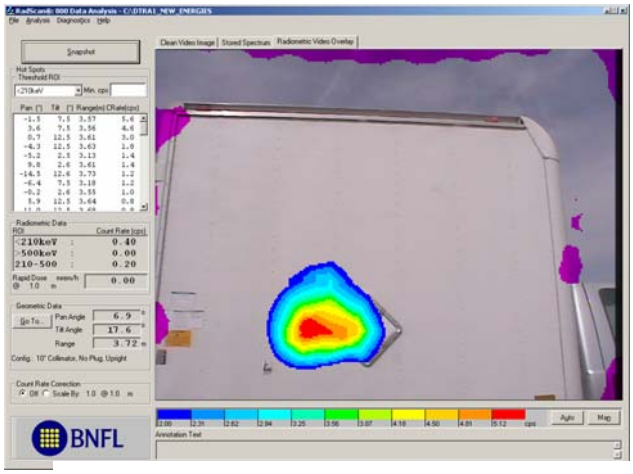

Figure 3. Energy Range < 210 keV

In Figure 3, the ROI was set for an energy range from 30-210 keV. Nuclides with principal gamma lines in this energy range include, ^{57}Co, ^{235}U. A 100 gram enriched uranium source was located.

In Figure 4, the ROI was set for an energy range from 210-500 keV. Nuclides with principal gamma lines in this energy range include, ^{239}Pu, ^{133}Ba. A 492 µCi ^{133}Ba source was located.

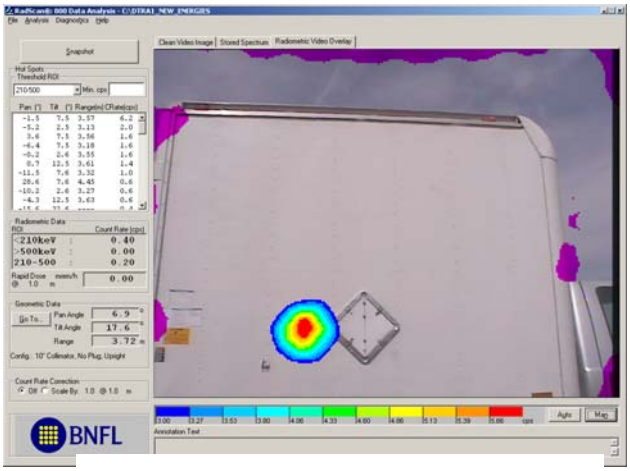

Figure 4. Energy Range 210-500 keV

In Figure 5, the ROI was set for an energy range for >500 keV. Nuclides with principal gamma lines in this energy range include: ^{60}Co, ^{137}Cs. A 95 µCi ^{137}Cs source and a 41 µCi ^{60}Co were identified.

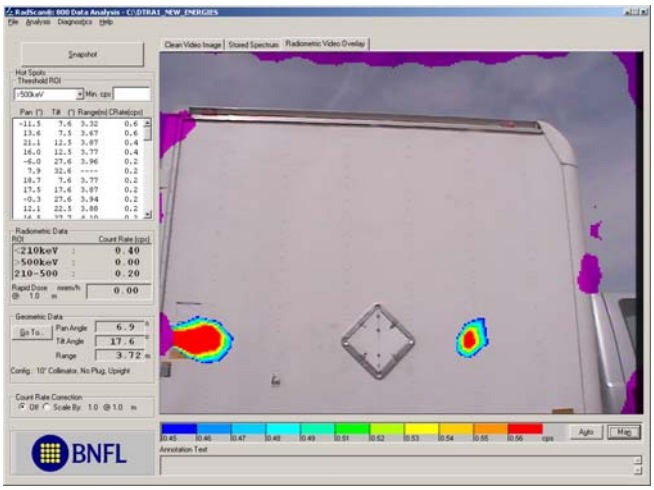

Figure 5. Energy Range >500 keV

Conclusion

The scans presented in Figures 3-5 are screen snap-shots using the RadScan®: 800 analysis software. These images demonstrate the systems ability to assist first responders in rapidly locating the spatial and spectroscopic distribution of radioactive materials in a threat situation.

This capability compliments the traditional survey methods (using hand-held instrumentation or portal monitoring) by providing:

- Portable and rapid deployment and analysis
- Automated remote operation (reducing responder risk)
- Video images with gamma radiation map overlays
- Hot spot identification with spectroscopic capability

References

BNFL Instruments, Inc., RadScan®: 800 User's Manual, (BII-5140-UM-001) BII, 4001 Office Court Drive #800, Santa Fe, NM 87507

International Union of Operating Engineers National Hazmat Program, Human Factors Assessment Report, OENHP#2002-33 Version A; 2002

U.S. Department of Energy, Office of Science and Technology, Technology Safety Data Sheet, DOE OST TMS#1793