Field Testing of a Portable Radiation Detector and Mapping System

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INTRODUCTION

Researchers at the Savannah River Site (SRS) have developed a man-portable radiation detector and mapping system (RADMAPS) which integrates the accumulation of radiation information with precise ground locations. RADMAPS provides field personnel with the ability to detect, locate, and characterize nuclear material at a site or facility by analyzing the gamma or neutron spectra and correlating them with position. The man-portable field unit records gamma or neutron count rate information and its location, along with date and time, using a an imbedded Global Positioning System (GPS). RADMAPS is an advancement in data fusion, integrating several off-the-shelf technologies with new computer software resulting in a system that is simple to deploy and provides information useful to field personnel in an easily understandable form. Decisions on subsequent actions can be made in the field to efficiently use available field resources. The technologies employed in this system include: recording GPS, radiation detection (typically scintillation detectors), pulse height analysis, analog-to-digital converters, removeable solid-state (Flash or SRAM) memory cards, Geographic Information System (GIS) software and personal computers with CD-ROM supporting digital base maps. RADMAPS includes several field deployable data acquisition systems designed to simultaneously record radiation and geographic positions (1). This paper summarizes the capabilities of RADMAPS and some of the results of field tests performed with the system.

WORK DESCRIPTION

RADMAPS consists of two major components, a field data acquisition system (FDAS) and a nuclear information system (NIS) for data analysis. The FDAS includes the radiation detector and electronics, a GPS, a control computer and a removeable mass storage device (Flash or SRAM card) for programs and data. The NIS consists of a portable computer with GIS software and a CD-ROM for digital maps, etc. and a PCMCIA interface for data input from the memory cards. Depending on the application, the FDAS may include a pulse height analyzer and multichannel analyzer for recording radiation spectra or may include a simple analog to digital converter for recording detector count rates and GPS data. For either application, the FDAS is preprogrammed with a set of instructions on the memory card to control all operations (count time, number of channels, delay times, etc.) after a simple start command. The commercial grade GPS receives the Standard Positioning Service (SPS) radio signals, including Selective Availability, which guarantee a position accuracy within 100 meters, 95% of the time. The use of a field base station can be employed for increased accuracy. When
the field survey is complete, the Flash or SRAM card is removed from the FDAS and downloaded to the NIS for analysis.

RESULTS

All components of the RADMAPS have been extensively field tested at SRS and have been modified for rugged, field operation. Surveys of SRS have been performed using both hand-carried FDAS and vehicle mounted FDAS units. Typical surveyed areas include the riverbanks near the confluence of several streams originating on-site with the Savannah River, closed seepage basins which received aqueous discharge from chemical separations, locations near pilot-scale high-level shielded facilities, processed fuel storage area, production reactors, solid radioactive waste burial grounds, and several temporary radwaste storage areas. As an example, count rate and position data were taken during a survey of a temporary storage area for contaminated components using a hand-carried FDAS with a 1" x 1" NaI(Tl) detector. The gross count rate and GPS locations were recorded every 1 second. The results are displayed on a site facilities map as shown in Figure 1. The open circles show locations where the count rates were three times the average background count rate. The same survey data can be georegistered on any digital image (e.g., aerial photographs).

As another example, a recording GPS and the 1" x 1" detector were installed on an unmanned aerial vehicle (UAV) provided by Georgia Tech. The results of these tests are shown in Figure 2 (open symbols) when the system was flown over Steed Pond (a holding basin which received runoff from the uranium fuel and target preparation area). The details of this rotary-winged UAV platform have been described. (2,3) This survey was performed with the UAV flying about 2 meters above the ground at speeds < 2 m/sec. Data were collected every second. The position data were transformed to distance coordinates relative to a second GPS at a fixed location. Also shown on this figure are the locations recorded during a later manual survey walking near the edge of the pond as recorded with the standard GPS using SPS coordinates (closed data points). These data are overlayed onto a standard USGS digital map using a standard commercial software graphing product. While the relative locations from the UAV survey are more precise than the absolute SPS coordinates during the walking survey, the absolute location imperfections could be attributed to mapping inaccuracies as well as Selective Availability offsets. Other applications of this technology have been tested using a recording GPS and a recording radiometer to map thermal plumes of L-Lake, PAR Pond and the Savannah River.

Off-site testing of RADMAPS has been performed at the Fernald Environmental Restoration site (Ohio), the Comanche Peak Reactor (Texas), and other locations to demonstrate the capability and portability of the system. The Fernald demonstration was performed at 11 selected test sites to evaluate the possibility of detecting uranium in contaminated soil using scintillation detectors. Eight small test sites (50m x 50m) and three 2-3 acre sites were surveyed. The RADMAPS detector systems used to survey the small test sites included hand-held and cart mounted 1" x 1" and 3" x 3" NaI(Tl)
detectors, and a 5" diameter X-Ray detector (FIDLER). Two vehicle mounted 4" x 4" x
16" NaI(Tl) detectors along with a 5" diameter FIDLER detector were used to survey the
large test sites. The limits of detection and positional accuracy were compared to the
ground truth data determined by rigorous sampling and analysis at surveyed locations. As
an example of the RADMAPS survey capabilities, Figure 3 shows the positions recorded
during a vehicle survey of one of the 2-acre test plots at Fernald. These data were taken
at 1-second intervals and show that multiple data points are easily obtained within each
100 m² test grid. The contour plot was generated using a weighted, inverse distance
interpolation algorithm. The plot shows areas of depressed count rate which are due to
the installation of a road and fresh overpack over the contaminated area.

CONCLUSION AND DISCUSSION

RADMAPS is a viable technology for performing radiation surveys of contaminated
sites, locating and quantifying radioactive material, and for mapping specific occurrences
to an exact time and location. A man-portable system has been developed to
simultaneously store radiation spectra and GPS locations on a solid-state memory card
using an on-board processor. The battery-powered, field data acquisition system operates
autonomously from a preprogrammed protocol resident on the memory card. The
position and spectral data are easily downloaded from the memory card to a personal
computer via a PCM-CIA interface. GIS software resident on the personal computer is
used to georegister the data onto digital images. The entire system can provide field
personnel with information in a readily understandable form for prompt, efficient follow-
on actions.

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Figure 1. Count rates recorded with a hand-carried 1” x 1” NaI(Tl) detector at various locations in a temporary contaminated storage for large components at SRS overlayed on a site facilities map.
Figure 2. Count rates observed at various locations around Steed pond as determined by a low-flying UAV (open symbols) and hand-carried surveys. Both surveys were conducted with a small NaI(Tl) detector. The UAV positions are determined relative to a fixed GPS base station in the area.
Figure 3. Contour plot of gross count rates taken with a pair of 4" x 4" x 16" NaI(Tl) detectors on a 2-acre test plot at Fernald. Note the depression running diagonally across the plot caused by clean fill roadbed overpack.