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APPLICATION OF COMPUTERS IN A RADIOLOGICAL SURVEY PROGRAM*

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ABSTRACT

Computers have become increasingly important in data analysis and data management as well as assisting in report preparation in the Oak Ridge National Laboratory (ORNL) Radiological Survey Activities (RASA) Program. The primary function of the RASA program is to collect, analyze, report, and manage data collected to characterize the radiological condition of potentially contaminated sites identified in the Department of Energy's (DOE) remedial action programs.

Three different computer systems are routinely utilized in ORNL/RASA operations. Two of these systems are employed in specific functions. A Nuclear Data (ND) 682 is used to perform isotopic analysis of gamma spectroscopic data generated by high-purity germanium detectors for air, water, and soil samples. The ND682 employs a 16,000-channel analyzer that is routinely used with four germanium spectrometers. Word processing and data management are accomplished using the INtext system implemented on a DEC PDP-11 computer.

A group of personal computers are used to perform a diverse number of functions. These computer systems are Commodore Business Machines (CBM) Model 8032 with a dual floppy disk storage medium and line printers (with optional X-Y plotters). The CBM's are utilized for: (1) data analyses - raw data from

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radiation detection instrumentation are stored and manipulated with customized computer programs; (2) data reduction - raw data are converted into report-ready tables using customized programs; (3) data management - radionuclide data on each air, water, and soil sample are stored on diskettes along with location of archived samples; and (4) program management - site surveys and report status are tracked by computer files as well as program budget information to provide contemporary information of program status.

INTRODUCTION

The Radiological Survey Activities (RASA) Group in the Health and Safety Research Division at Oak Ridge National Laboratory (ORNL) has been involved in the Department of Energy's (DOE) remedial action programs since 1975. The purpose of the ORNL/RASA program is to perform various types of radiological surveys at sites identified by DOE.

There are two predominant types of radiological surveys conducted by ORNL/RASA, mobile gamma scanning and site characterization. A mobile gamma scanning survey is performed to identify locations of anomalous gamma radiation levels from accessible streets, alleys, and roadways in a community. Residual radioactive material has been typically transported onto a property in the following ways: (1) environmental forces (wind and water) moving radioactive material from a contaminated site into previously uncontaminated sites, or (2) removal from a contaminated site (such as uranium mill tailings piles) for use in construction as fill material, concrete mix, mortar, etc. The mobile gamma scanning van is used to locate properties suspected of having radioactive contamination and identify the gamma-emitting radionuclide.

Site characterization radiological surveys are conducted in order to fully evaluate the radiological condition of a property. Information gathered during a survey confirms the presence (or absence) of residual radioactive material, specifically identifies the type and location of radioactive material, determines the areal and vertical extent of contamination, and provides sufficient data to assess an estimate of potential health risks to property occupants. Site characterization radiological surveys usually determine alpha, beta-gamma, or gamma radiation levels at various locations on a property, and obtain environmental samples of air, water, or soil. The environmental samples subsequently undergo analyses for radionuclide concentration.

Computers have become increasingly important in the ORNL/RASA program to acquire data during radiological surveys, to store, analyze, and manipulate the data, and to prepare reports using the data. The following discussions provide a brief overview of computer usage in this survey program. Detailed technical reports on various aspects of this program are provided as references to this paper. The following discussion outlines computer systems used by ORNL/RASA, followed by a description

of the applications of these systems.

Discussion

Three different types of computer systems are primarily used by ORNL/RASA. Two of these systems have dedicated functions: the Nuclear Data (ND) Model 682 system is used for radionuclide analysis of environmental samples, and the INtext system software is implemented on a DEC PDP-11 computer using remote access terminals used for word processing. The third computer system is a group of Commodore Business Machine (CBM) Model 8032 personal computers used to perform a variety of functions.

ND682 Computer System

The ND682 is a programmable, floppy disk-based, gamma spectroscopy system. Data acquisition systems include a distributive memory with a running memory containing a 16,384-channel analyzer, and a 28,000-byte analytical memory. The dual floppy disk system holds one megabyte of data. In addition, the ND682 contains six megabytes of hard disk storage with 13,000 file blocks. The operating language is FORTRAN which is compiled into machine language except for specialized routines programmed into machine language. The ND682 is used with high-purity Germanium (HPGe) or lithium-drifted Germanium (GeLi) detectors for gamma-emitting radionuclide analysis of environmental samples (air, water, and soil). Detailed hardware description is provided by Nuclear Data, Inc. (Nuclear Data 1981).

Data analysis by the ND682 is provided by interlaced ND and ORNL/RASA software. Characteristic gamma energy spectrums detected by the HPGe crystals identify the radionuclides present in ORNL/RASA gamma spectrum "libraries" stored on file. The amounts of radionuclides present are determined through the use of NBS-traceable standards. The dual floppy disks provide data management by storage of raw and converted data.

The ND682 provides high-capacity hardware with flexible, easy-to-use software for analysis of environmental samples. Presently, three HPGe's and one GeLi detector are connected to the ND682 for simultaneous use. The ORNL/RASA program typically processes approximately 1500 soil samples per year (for 17 specific radionuclides) using this system.

INtext System

The INtext system is the application of IS/1 UNIX Text Management System (UCCND 1981) on a DEC PDP-11 computer through remote terminals. The INtext system is a shared logic, time-sharing system that provides word processing and text editing capabilities for document preparation. In addition, it performs communication functions, file comparison, data archiving, and pattern searches. Input is performed on any micro or minicomputer that may communicate with the DEC PDP-11 network. A generic coding scheme allows files to be output on most devices (i.e. correspondence printers, typesetters, laser printers, or microfilm devices).

The INtext system is used in a variety of modes by the ORNL/RASA group. Its most frequent function is as a full-function word processor capable of a wide range of tasks including word processing, text formatting, creation of tables, and equation formatting. Because the INtext system operates on a centralized computer, it is also ideally suited for networking between the various users. Within the ORNL divisions that support the INtext system, common uses include the sending and receiving of electronic mail, and transfer of data and information files. Because the RASA group maintains offices in both Oak Ridge, Tennessee and Grand Junction, Colorado, these networking capabilities are extremely valuable. The Grand Junction office can avail itself of the INtext system by use of a high-speed modem and the existing Federal Telecommunications System (FTS) telephone lines with no adaptation.

CBM Minicomputers

Commodore Business Machines (CBM-Model 8032) personal computers are used for a variety of functions in the ORNL/RASA project. The console's main logic board is a 6502-based microprocessor with 32,000 bytes of Random Access Memory (RAM). The 8000 Series CBM incorporates a 12-in. video display for a maximum of 80 characters per line. Three ports are available to the user which consist of an IEEE-488 BUS, a Parallel Users Port, and two cassette ports. A memory expansion port is also included for RAM upgrade. The dual-drive floppy disk unit (Model 8050) is an IEEE-488 device which is used for storing information from and entering information into the computer's memory.

One of the main uses of the CBMs is for data analyses. These minicomputers have been particularly useful with the mobile gamma scanning van and NaI gamma spectroscopic analysis.

The gamma detection system now employed in the scanning van consists of three 4 x 4 x 16-in. NaI(Tl) Polyscin log crystals, each with an integral 3.5-in. photomultiplier tube. The crystals are housed in a lead-shielded steel frame to provide a 12 x 16-in. detector surface area for acceptance of gamma radiation through one side of the survey van. The detector output is transferred to a computer-controlled eight-channel discriminator and interface, designed and fabricated at ORNL. This unit provides for continuous analysis of data inputs for correlation of system location with count rate information. Six separate energy regions-of-interest are analyzed and a ^{226}Ra-specific algorithm is employed to identify locations containing residual radium-bearing materials. Data on other naturally-occurring radionuclides (such as ^{40}K and ^{232}Th) are obtained for comparison as part of the analysis. Multichannel analysis capabilities are included in the system for additional qualitative radionuclide identification. The system is operator-controlled through keyboard instructions to the CBM minicomputer. Data output is provided on the computer video screen, dual channel strip-chart recorders, and a dot matrix printer. Data storage is provided by a dual floppy disk system. The floppy disk unit maintains a continuous permanent record of all raw data obtained during the scan. These data are retrieved by one of the following: (1) at the end of each scan the system automatically provides a computer-analyzed summary of

the anomaly locations, or (2) by command at a later time, a complete listing of the raw data or a listing of the reduced data used in comparison with the anomaly identifying criteria. Detailed descriptions of the mobile gamma scanning van are provided in Myrick et. al. 1982 and 1983.

A NaI gamma spectroscopy system was developed by ORNL/RASA to provide a rapid estimate of ^{226}Ra concentration in soil samples. A 6 x 9-in. NaI crystal containing a 3.25-in. deep by 3.5-in. diam. well detects gamma radiation. Detector output is transferred to a computer-controlled discriminator and interface. Energy regions-of-interest are analyzed with automatic background subtraction, software algorithms which utilize linear and polynomial regression equations for data conversions, and internal tables for radon equilibration coefficients. The estimated concentration of radionuclides at the conclusion of a sample analysis is outputted to the minicomputer screen and line printer. Raw and converted data are stored on a floppy disk.

Another major use of the CBM minicomputers is for data reduction. The ORNL/RASA program processes large amounts of data for each of the many properties surveyed each year. In previous years, data manipulation (e.g., converting from cpm to μR/h) was performed using hand calculators. A system has recently been developed which largely automates the conversion of all field data and their tabulation for reporting purposes. The system consists of three items of hardware and two items of software. The hardware includes the CBM 8032, an 8050 dual 5.5-in. floppy disk drive, and a Gemini dot-matrix printer. The software includes a commercial data management system, Manager (Canadian Micro Distributors 1983), and an in-house program (DATA TABLES) written to read the Manager files and print the tables. Manager is a very flexible data management system that allows entry of data into sequential files which are sortable over any selected variable. Data are entered into the sequential file and stored on a floppy disk for use at a later time. When all data have been correctly edited and proofed, the DATA TABLES program is invoked to read the sequential files and print out report-ready tables. Efficiency and, especially, accuracy in preparing data for reporting have been greatly increased.

The CBM microcomputers are also used for data management in storing/archiving large amounts of data. Gamma exposure rates at specified locations, on a property, soil sample analytical results, in-house locations of archived samples are examples of the type of information that minicomputers can store. The ORNL/RASA soil sample data management system provides a specific example of this use. The property, location, and type of soil sample taken during a survey are entered into Manager, and, subsequently the radionuclide analytical results and location of storage for the archived soil sample. A software program is invoked to read, sort and print information about any sample or group of samples when that information is needed.

A final use of the CBM minicomputer in the ORNL/RASA program is for program management. The CBM minicomputer is used with the Manager software to maintain data on the program status. For example, the

number of properties to be surveyed in a community are filed on a floppy disk along with pertinent property information such as: owner name, property address, whether a right-of-entry form was obtained, survey status, location of survey data, report status, and location of contamination (if any). Other program management uses include tracking and predicting budget expenditures, word processing/editing, and maintaining reference files on relevant literature, using established computer software.

SUMMARY

The foregoing was a brief description of some of the applications of computers in a radiological survey program. This information is summarized in Table 1. It has been our experience that computers and computer software have allowed our staff personnel to more productively use their time by using computers to perform the mechanical acquisition, analyses, and storage of data. It is hoped that other organizations may similarly profit from this experience. This effort will ultimately minimize errors and reduce program costs.

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TABLE 1. ORNL/RASA Computer System Usage Summary

Function[a]	ORNL/RASA Computer System[b]		
	CBM/PC	INtext	ND682
DATA ACQUISITION			
Soil - NaI	X		
Soil - HPGe/GeLi			X
Gamma scanning van	X		
DATA ANALYSES			
Soil - NaI	X		
Soil - HPGe/GeLi			X
Gamma scanning van	X		
Radon	X		
Radon daughters	X		
Statistical applications	X		X
DATA REDUCTION	X	X	
DATA MANAGEMENT	X	X	X
PROGRAM MANAGEMENT			
Budget	X		
Status	X	X	
WORD PROCESSING	X	X	

[a]Data Acquisition - assimilation of raw radiological data
Data Analyses - manipulation/interpretation of raw radiological data
Data Reduction - reduce/convert raw data into report-ready tables
Data Management - archiving raw and reduced data
Program Management - storage and manipulation of useful information about program budget, vital statistics, site status, report status, etc.
Word Processing - generating letters, reports, tables, etc.

[b]CBM/PC - Commodore Business Machine (CBM Model 8032) personal computer
INtext - a software system utilizing a major computer network to provide word processing/editing and file sorting
ND682 - Nuclear Data (ND Model 682) programmable multichannel gamma spectroscopy system