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CONFIDENTIAL 8

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OF RADIOACTIVELY CONTAMINATED SITES

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USE OF A COMMERCIAL RANGING SYSTEM IN FIELD SURVEYS OF RADIOACTIVELY CONTAMINATED SITES

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Introduction

The monitoring and subsequent cleanup of radioactively contaminated land areas must be performed in an accurate and timely manner to minimize potential human exposure and to restore the land to normal use. This is, at best, an arduous task often performed under unfavorable environmental conditions and, until recently, utilized radiation survey instruments based on 1950's and 1960's technology and classical, labor intensive, land survey techniques. Development of state-of-the-art microcomputer-based radiation survey instruments by the Los Alamos National Laboratory and others over the last several years has greatly advanced field survey data collection capabilities. [1,2,3]

Now, the adaptation of a commercial ranging and tracking system interfaced to these instruments and to an advanced computer graphics system promises another major improvement to the automation of data collection. Contour maps with radiation isopleths and the x-y position of up to eight instrument operators superimposed thereon can be displayed in near real time. A bidirectional data link offers a further improvement in simulation of, and training for, field surveys since previously collected or computer simulated radiation data as a function of position can be transmitted back to the same survey instrument and displayed to the operator in a manner indistinguishable from real-time data. Additionally, simulated instrument malfunctions such as low battery, detector failure, or total failure can be commanded to occur to evaluate operator response to unusual occurrences under the stress of field conditions. This training mode will greatly improve the ability to simulate situations and to train and evaluate operations personnel while eliminating the need to use special sites and potentially hazardous contamination simulants as are used now.

Microwave Ranging System

The position-determining equipment used in this system is the Mini-Ranger Falcon 492, manufactured by Motorola Government Electronics Group of Tempe, Arizona. It is comprised of a rack-mounted Range Processor, a tabletop Control Display Unit (CDU), a base station receiver/transmitter (RT1 and RT2), one to three Coded Fixed Repeaters (CFR) and up to eight mobile units, each with a unique ID code. The system operates in the microwave C-band (5.4, 5.45 and 5.6 GHz) and uses a pulse position coding scheme to accomplish both specific repeater and mobile unit selec-

tion and identification and digital data transmission. Range information is obtained by measuring the interrogation/response time from the base RT1 to the selected mobile(s) and the subsequent loop time from the mobile(s) through the selected CFR and back to the base RT2. See Fig. 1. This information is then processed by the Range Processor to include previously obtained calibration data and correction factors. Position on a selected or arbitrarily assigned rectilinear grid is then calculated either internally by the Range Processor or externally by a separate computer interfaced via a serial data link. Results may be displayed numerically on the CDU or on a terminal/printer or in pictorial form on a color display monitor.

Figure 1

The range processor and CDU are rack/tabletop units which operate from either 115VAC or 28VDC and are suitable for operation in a sheltered environment only. The base station RT units, the CFR's and the mobile units are sealed weatherproof units 11.5 inches high, 8 inches wide, and 5.5 inches deep and weigh 9.5 pounds, not including battery. Base station RT units are powered by

the Range Processor. The CFR's and mobile units require a 24-Volt battery which weighs 10.5 pounds and provides 8 hours of continuous operation. The maximum range of the present system is 18.5 km with ± 1 meter range accuracy and best-case x-y position accuracy of ± 2.8 meters.

Radiation Survey Instruments

Two types of radiation detection instruments are used with the system: a multipurpose radiac and the pulse-height analyzer/FIDLER detector combination called Violinist. Both of these instruments are described in other papers. [1,2]

The radiac [2] consists of detectors sensitive to alpha, beta, gamma, and neutron radiation coupled to scalars which are read and controlled by a microcomputer. The data thus obtained are scaled and presented in common health physics units to the operator on a liquid crystal (LCD) display. The data are also sent via a serial RS-232 data link to the ranging system mobile unit worn on a backpack by the operator for subsequent transmission back to the command computer, using the data link of the ranging system. The data link is bidirectional, allowing for a command sequence to be sent to the radiac, putting it in the "training" mode. In this mode simulated radiation data can be sent to and presented by the radiac to the operator in a manner indistinguishable from actual field radiation levels.

The Violinist [1] is a combination of a thin NaI detector and an electronics package containing a 256-channel multichannel analyzer (MCA) and a microcomputer. The data from the MCA are processed by the microcomputer and a value computed for the amount of contaminating material (e.g. plutonium) in the field of view of the detector. This value is displayed on the LCD display and communicated to the ranging system, also via a serial RS-232 link and back to the command computer via the ranging system data link. This instrument may also be placed in the training mode similar to the radiac for reception and display of simulated data.

Ranger Computer System and Graphics

The computer for this system is a MICRO/PDP-11 manufactured by Digital Equipment Corporation (DEC) of Maynard, Massachusetts. The computer, rack-mounted along with the Range Processor, includes a central processing unit (CPU) with floating-point instruction set, 512Kb of memory, two serial I/O ports, a 10MB fixed disk, and two 400Kb floppy disk drives. One serial port is used for the computer's terminal, and the other is used as the data link to the Range Processor. A serial line printer/plotter is daisy-chained to the terminal. A standard RGB video monitor is used to display the color graphics produced by the graphics processor, manufactured by Parallax Systems of Sunnyvale, California, which is installed on the bus of the computer.

The computer program, running under DEC's single user/multijob RT-11 operating system, has three principal concurrent functions: 1) control of the Range Processor, 2) interpreta-

tion of data from the Range Processor, calculation of mobile unit positions and logging of position and radiation data, and 3) real-time graphic display of the mobile unit positions and radiation data. At user-specified intervals, the position of each mobile unit is displayed in a different color on a map shown on the graphics display. The X-Y position of the mobiles, along with the gamma, alpha, beta, and neutron radiation data, are displayed on both the graphic display and on the console terminal. They may optionally be printed on the line printer and logged into a file on the computer's disk. Post-processing of data, which may be concurrent with acquisition of new data, includes calculation of radiation isopleths and displaying them as a contour map on the graphics display or the printer/plotter.

In the training mode, the computer operator can bypass the radiation detectors in the survey instruments and control their displays directly. Gamma and alpha radiation levels as a function of location can be specified, along with flags indicating presence of beta radiation or neutrons, alarm conditions, detector failure, or low-battery indication. The person carrying the mobile unit cannot distinguish between real data and those data simulated by the computer operator. Future plans include complete computer simulation of scenarios which may be total fabrications or reproductions of previously logged real events.

Mobile System

To facilitate mobile operations in various field environments and to transport the equipment and personnel, a 1-ton, 4-wheel drive van has been outfitted with a mast for the base station transceivers, a console and work surface for the electronics and display units, a 2200-Watt portable generator, communication radios, and other miscellaneous support equipment and tools. See Figs. 2 and 3.

Field Experiments and Results

In order to verify the system accuracy and to gain operational experience, the base station RT's and two CFR's were mounted on a meteorology tower and two water towers, respectively, within the boundaries of Los Alamos National Laboratory. These sites were carefully surveyed to locate them accurately on the New Mexico State Plane and, after including all pertinent corrections for the grid, atmospheric conditions, and electronic calibrations, the system was proved to be accurate to well within the advertised 1 meter.

Since these sites provided potential coverage to most of the Laboratory areas, a mobile unit was mounted on a vehicle to investigate the use of the system to track vehicles in this terrain. Los Alamos is located in an area of approximately 45 square miles of mountain plateau, at an average altitude of 7200 feet MSL but is cut by erosion canyons of up to 600 feet deep. This posed a real challenge to a line-of-sight system and the result showed that only about 10% of the Laboratory roads could be reliably

Figure 2

Figure 3

tracked. More complete coverage could possibly be achieved by networking several systems with each system covering a pertinent area and all reporting in to a central control point.

Upon completion of the assembly of the vehicular "base station," the units were removed from the fixed towers and local small-area tests were conducted. The first of these was to determine the minimum stand-off distance required for the fixed points of the system from the boundaries of a desired survey area. This was determined to be 300 feet, which is consistent with both the minimum range gate of the electronics and the geometry that provides stated system accuracy.

The second set of tests was to devise a "fixed-cable" calibration scheme. Electronic delays inherent in the CFR's and mobiles must be calibrated out using a known layout. This could be difficult to do under some survey conditions so the use of a known length cable between the units in the calibration mode, along with a carefully kept log of both range and loop range calibration error factors, has been successfully adopted.

Using information and experience gained from these tests, we then moved to another area and conducted a third set of tests. After carefully laying out equilateral triangles using tapes and accurate optical range-finders, it was determined that the system range accuracy (1 meter) and x-y position tolerance (2.8 meters at 90 degree look angle) were within those specifications.

Finally, to conclude this first series of tests, a CFR and the base station were arbitrarily set up to establish an unknown baseline and man-carried mobiles were deployed to locations chosen by the base operator based upon printed data presented on the CRT. Then the mobiles were recalled, redeployed under control of the base via radio and guided back to the initially chosen locations. The distance from the point to which they were guided back and the previous location which had been unobtrusively marked was then measured. In no case was the error greater than about 10-12 feet.

Future Efforts and Other Applications

System testing will continue through 1985 at selected field sites to refine operational techniques and to optimize system performance. The results of these tests will then guide us in refining the data acquisition/analysis and system control software.

Since the basic radiac instrument is really a generic counting/data transmission device once past the radiation sensor, it is a logical extension of this project to investigate the use of other sensors. For example, a specific chemical sensor could be incorporated in place of the radiation detector and then the system could be applied to a variety of chemical threats. Other similar adaptations are envisioned.

The ranging frequency (5.4 - 5.6 GHz/C-band) limits its application to line-of-sight situations. Los Alamos plans to investigate

other transmission frequencies that may ameliorate such problems. Additionally, we are considering miniaturization of the mobile unit through the use of custom VLSI circuitry, solid-state RF signal sources, and advanced batteries, to reduce the size and weight of the man-carried unit.

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