

Three Dimensional Indoor Survey System

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Abstract -A new surface contamination monitor has been developed that automatically records scanning count rates or fixed-point integrated counts along with the associated x, y, and z coordinates. The data are logged by a hand held or laptop computer and then downloaded into ArcView GIS, AutoCAD, or other commercially available computer applications where the data can be processed and displayed. Single detector units with components placed in a fannypack are used in difficult to access areas or to perform long-term integrated measurements. A wall scanning unit consists of a computer controlled lift that moves an array of up to eight detectors up and down a vertical wall surface at a defined speed. Thirdly, a floor scanner moves the detector array over floors at a constant speed. Labor savings of more than 50 and 90 percent are evident when using the single unit and multiple units, respectively, when compared to conventional manual surveys. U.S. Patent No. 60642327 (Pending).

I. INTRODUCTION

A state-of-the-art 3-Dimensional Indoor Survey System (3-DISS) has been developed for conducting surface contamination surveys. The system uses off-the-shelf radiological instrumentation linked to an infrared laser positioning system to record the emission rates and associated x, y, z coordinates from radiologically contaminated surfaces such as walls and floors. The data are logged by a hand-held personal digital assistant (PDA) or laptop computer. The data can then be downloaded onto a computer with applications such as ArcView GIS or AutoCAD for data analysis and presentation.

Conventional scanning contamination surveys are performed by technicians holding a meter and moving the detector along the surface at a predetermined speed. The detector-to-surface spacing is normally less than 1 cm. The scanning sensitivity is highly dependent on both the speed and the detector spacing and thus controlling these two parameters is very important. Generally, fixed-point measurements are also required at certain locations, quite often at locations where the scanning data indicated the highest levels. These fixed-point measurements are made by placing the detector at a location and allowing the scaler option of the meter to count the detected events for a period of time, typically 60 seconds. Data loggers within conventional meters are normally capable of recording a few hundred readings and an associated parameter such as location name.

Documentation and presentation of data from conventional surveys is quite labor intensive and often not exact. A typical survey may include the following steps. One-meter square grids are marked on the surfaces and a grid numbering scheme developed. Scans are done within each grid block and the maximum and average count rate recorded. If the plan requires it, a fixed-point measurement made at the location where the technician remembered the highest scanning reading occurred within the grid block. The data are normally recorded manually by an additional technician in the area. Lastly, the data are entered into a spread sheet or other software application for presentation.

More recent survey plans incorporate the methods recommended by the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). Compliance with these requirements poses great difficulty when using conventional methods. In particular, system performance parameters must be evaluated prior to developing the plan. Some of these parameters are related to the technician's performance. In addition, fixed-point measurements must be made on a specified grid, with the grid size determined by the anticipated statistical variation in the final status survey measurements. A measure of this variation may be obtained from the scanning data if the data are available in a form where statistical analysis is possible. This is normally not the case for conventional surveys.

The 3-DISS overcomes the problems of complying with MARSSIM and vastly improves the quality of the

data. In addition, the labor savings range from more than 50 percent for handheld units to more than 90 percent for scanning units when compared to conventional surveys.

II. 3-DISS COMPONENTS AND CONFIGURATIONS

The 3-DISS was designed by integrating commercially available positioning, material transfer, and radiation measurement technologies. Only minor modifications were made to the radiological monitoring instrumentation. However, special electronics modules and software development were necessary for collecting and managing the radiological data and their associated position data.

II.A. Positioning System

The positioning system consists of infrared fan laser transmitters that are stationed in the work area; a position sensor that is mounted on the radiological survey probe; a fanny pack containing a PDA; the laser signal processing electronics; a radiological survey meter; and a laptop computer with software designed for managing of the various components. Each transmitter is placed on a tripod where the fan laser has a horizontal field of view of approximately 300 degrees and vertical field of view of 60 degrees. The sensor detects the directions and frequencies of the laser transmitters. The signals are then amplified and processed to determine position through triangulation. Line of sight to a minimum of two transmitters is required. There is no limit on the number of sensors that may be placed in the work area although a maximum of five transmitters may be used. The sensor coordinates in x, y, z format may be determined to sub-millimeter accuracy although under normal field operations, sub-centimeter accuracy is expected.

II.B. System Configurations

Three configurations of the system currently exist: a single handheld detector configuration, a multiple detector wall scanner configuration, and a multiple detector floor scanner configuration. For all configurations while in the scanning mode, the radiation data and position coordinates are automatically recorded at the end of a scaler counting interval, which is user determined in multiples of 1 second. Normal counting intervals are less than 5 seconds in the scanning mode. In addition, fixed-point measurements may be made for any predetermined time interval. Again, the data are recorded at the end of the counting interval. Software provisions exist for multiplying each datum by a constant to convert to surface activity per unit area. In addition, coordinates may be loaded into the PDA and the sensor used to guide

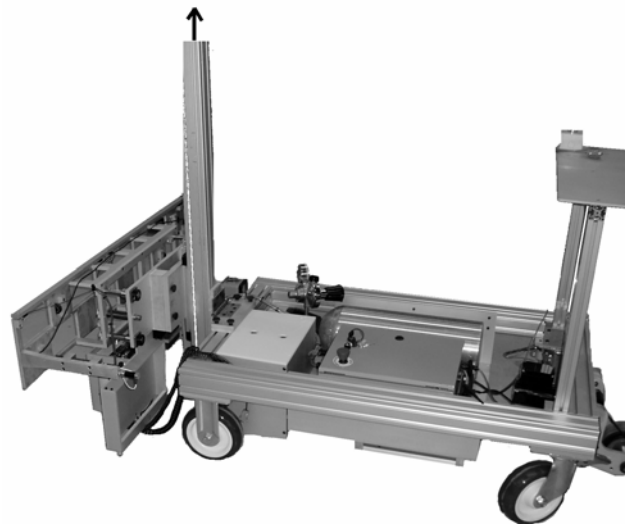
the user to a specific point in space. An audible alarm indicates when the position coordinates are not available due to not having line of sight to at least two transmitters.

One or more single detector units may be used in the survey area much like conventional surveys. The single detector configuration consists of a fanny pack and single handheld probe. The fanny pack contains a PDA, sensor electronics, and a radiation ratemeter/scaler. The position sensor is mounted on the radiation detector as shown in Figure II-a.



(Figure II-a)

The wall scanning unit consists of a computer controlled lift that moves an array of up to eight detectors up and down a vertical wall surface at a user defined speed as shown in Figure II-b.



(Figure II-b)

A position sensor is located on each end of the detector array. Using two sensors defines a vector from which each individual detector position can be calculated. The detector array is spring loaded to hold it against the wall at a fixed distance. This distance can be adjusted from 0 to 1.25 centimeters. Data from each detector, along with the associated coordinates are automatically recorded at user defined counting intervals. Specially designed electronics and software were necessary to synchronize and manage the data from the eight detectors, calculate the detector positions, and transfer the data to computer memory.

The wall scanning unit is controlled from a single laptop computer via a wireless local area network. A visual basic program is used to program the signals such as start, stop, speed, and direction to the step motor controller in the lift. All commands are initiated by the operator whose work station is near the scanning unit but not in the line-of-site between any of the transmitters and position sensors. A kill-switch bar is located on the forward edge of the detector array to stop the lift if it strikes an obstruction. The system may be powered by AC or DC current.

The third configuration is the floor scanner. The wall scanner lift is removed and the detector array is repositioned on the front of the platform. A wheel that is free to pivot is cranked down into place at the rear of the scanner platform so that it supports the weight on that end. The wheel is driven by a 48-volt DC motor. A variable speed control, forward and reverse switch, and kill switch is located near the operator. The operator controls and steers the scanner from a position near the driving wheel. The scanner can be moved manually after raising the drive wheel using the crank. Like the wall scanner, the location coordinates of the eight detectors are determined irrespective of the direction of motion.

II.C. Radiological Instrumentation

The radiological instrumentation uses dual-channel ratemeter/scalers coupled to either alpha/beta dual phosphor scintillation detectors or gas proportional detectors having an area of 100 cm². When using the single handheld configuration a single detector is used. When using the floor and wall scanning configurations there are two options for detectors. For the dual phosphor option, eight commercially-available detectors are staggered so that 100 percent coverage is obtained. If the gas proportional detector is desired, a specially-constructed gas proportional detector is used. This detector is a linear array of eight 100-cm² zones with no dead space between the zones. The ratemeter/scaler has adjustable threshold settings for both the alpha and beta

channels and an adjustable window for the beta channel. The system allows for the input of scaling factors for each ratemeter/scaler-detector combination to apply efficiency and/or area corrections to the alpha and beta output readings.

A modification has been made to the digital ratemeter/scaler output to increase the sensitivity and position accuracy of the measurements. Commercially available digital ratemeters have a count-rate smoothing feature that dampens the highly variable calculated count rate (in counts per minute) determined from a few events in a short time interval. For these low count rates, it takes approximately seven seconds for the meter to move from 20 to 90 percent of the true measured value. This normally results in an underestimate of scanning results for small contaminated areas. It also adds to the uncertainty in the position coordinates of the reported results. For this reason, the manufacturer reprogrammed the meters to provide a digital scaler output at one-second increments rather than the instantaneous count-rate data that is available on off-the-shelf units. The user can then select how many one-second readings will be summed before recording this sum and the associated position coordinates. In order to smooth the data, Kreiging or nearest-neighbor averaging may be used during the data processing and presentation phase of the project. This accomplishes the smoothing effect without producing the position bias discussed above.

III. CONCLUSION

This system is believed to have features that fully satisfy the requirements for making surface contamination measurements. These features are:

- a. Absolutely no data processing is necessary other than to perform statistical analyses or for presentation.
- b. Commercially available and professionally accepted radiation detectors are employed.
- c. Presentation of data may be performed using commercially available software such as ArcView GIS or AutoCad.
- d. Scanning speeds and detector-surface spacing are variable, consistent, and accurately defined.
- e. Data are automatically recorded essentially eliminating data entry errors.
- f. Single units may be used to navigate to desired coordinates.

g. Data are amenable to processing for statistical analysis (MARSSIM requirement).

h. Single units are available to make fixed-point measurements at grid points as defined in a MARSSIM sampling plan.

i. Labor savings of more than 50 and 90 percent are evident when using the single unit and scanning units, respectively, when compared to conventional manual surveys.