INNOVATIVE TECHNOLOGY
Summary Report

DOE/EM-0347

Surface Contamination Monitor and Survey Information Management System

Deactivation and Decommissioning Focus Area

Prepared for
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Office of Science and Technology

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INNOVATIVE TECHNOLOGY
Summary Report

DOE/EM-0347

Surface Contamination Monitor and Survey Information Management System

OST Reference # 1942

Deactivation and Decommissioning Focus Area

Demonstrated at
Chicago Pile 5 (CP-5) Research Reactor
Large-Scale Demonstration Project
Argonne National Laboratory - East
Argonne, Illinois

INNOVATIVE TECHNOLOGY
Summary Report

Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine if a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available online at http://em-50.em.doe.gov.

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SECTION 1

SUMMARY

Technology Summary

Shonka Research Associates, Inc.'s (SRA) Surface Contamination Monitor and Survey Information Management System (SCM/SIMS) is designed to perform alpha and beta radiation surveys of floors and surfaces and document the measured data. The SRA-SCM/SIMS technology can be applied to routine operational surveys, characterization surveys, and free release and site closure surveys. Any large nuclear site can make use of this technology.

How it Works

SCM consists of a position-sensitive gas proportional counter mounted to a motorized cart as shown in Figure 1. Data are typically measured for each 5-cm^2 region along a survey strip defined by the width of the proportional counter and the distance the cart travels forward in a straight line. Detector widths can vary between 0.5 and 5 m. The system records the data from each region and provides a visual indication of the measured activity to the operator on a Liquid Crystal Display (LCD) screen.

The large amount of data automatically recorded by the system are processed in SIMS. This software combines the data from individual strips into a uniform grid that covers the surveyed area. The data within this grid can be viewed and analyzed by a wide range of image-processing algorithms. In addition, the processed data can be exported into standard facility drawings as shown in Figure 2. Finally, the software can automatically generate a data report that can be used to meet regulatory requirements for unrestricted release.

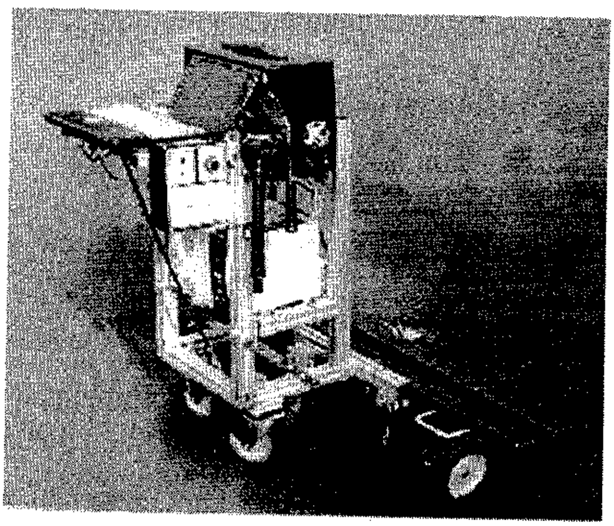

Figure 1. Shonka Research Associates, Inc.'s surface contamination monitor.

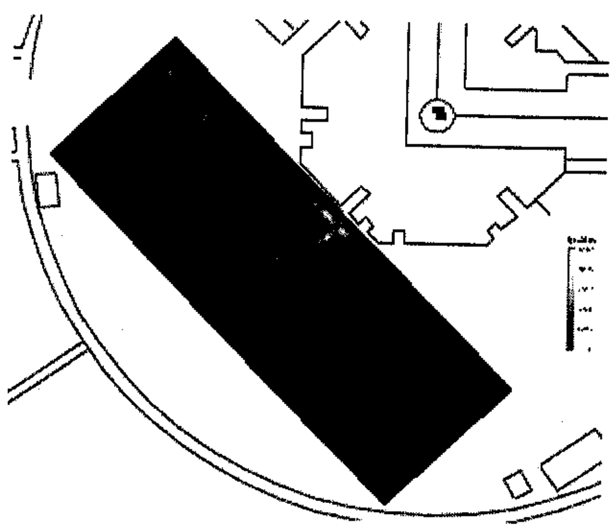

Figure 2. Sample survey output from Shonka Research Associates, Inc.

Demonstration Summary

This report describes a demonstration of the SRA-SCM/SIMS technology. This demonstration is part of the Chicago Pile-5 (CP-5) Large-Scale Demonstration Project (LSDP) sponsored by the U.S. Department of Energy (DOE), Office of Science and Technology (OST), Deactivation and Decommissioning Focus Area (DDFA). The objective of the LSDP is to select and demonstrate potentially beneficial technologies at the Argonne National Laboratory-East's (ANL) CP-5 Research Reactor Facility. The purpose of the LSDP is to demonstrate that by using innovative and improved deactivation and decommissioning (D&D)

technologies from various sources, significant benefits can be achieved when compared to baseline D&D technologies.

The SRA system demonstrated at CP-5 (December 1996) is commercially available and has been previously demonstrated at facilities in which the area to be surveyed consisted of several thousand square meters. The demonstration at CP-5 was designed to measure the performance of the SRA system in facilities with small, irregularly shaped rooms. The baseline technology for comparison is a standard manual survey. Three types of surveys were considered for demonstration. The first was the use of the system for standard radiological surveys in support of normal surveillance activities. The second was using the system to survey and document the results for subsequent use by cleanup crews or by personnel planning decommissioning activities. The third was in surveying and documenting a survey area to meet regulatory requirements concerning free release of the area; however, this type was not performed as part of the demonstration.

CP-5 is a heavy-water moderated and cooled, highly enriched, uranium-fueled thermal reactor designed to supply neutrons for research. The reactor had a thermal-power rating of 5 megawatts and was continuously operated for 25 years until its final shutdown in 1979. These 25 years of operation have produced activation and contamination characteristics representative of other nuclear facilities within the DOE complex. CP-5 contains many of the essential features of other DOE nuclear facilities and can be safely utilized as a demonstration facility for the evaluation of innovative technologies for the future D&D of much larger, more highly contaminated facilities.

An SRA engineer operated SCM and performed the data analysis using SIMS for the CP-5 demonstration. ANL personnel from CP-5 and the Environment, Safety, and Health (ESH) Division provided support in the area of health physics (HP). Argonne National Laboratory personnel prepared the test plan and generated a data report describing the information collected. Cost analysis was performed by the U.S. Army Corps of Engineers (USACE), and benchmarking activities were performed by ICF Kaiser.

Key Results

The key results of the demonstration are as follows:

- The SRA system provides significant time and cost advantages over manual surveys even in facilities with small, irregularly shaped rooms. This is true for surveys involving general surveillance and routine documentation requirements. For free-release surveys, the cost advantage of the SRA system will be even greater, although these tests did not explicitly address this case.
- The use of the SRA system will significantly increase the quantity and reliability of the collected survey data.
- Training in the setup and use of SCM is relatively easy and can be done in less than half a day. SIMS is also easy to learn for users familiar with standard Windows® programming.
- The automatic report generation feature of SIMS is fast and provides a detailed summary of the survey that would meet regulatory needs for documentation.
- The SRA-SCM/SIMS technology performed well during the demonstration by successfully detecting alpha and beta surface contamination and producing high quality data reports. No significant problems with the system were identified.

Technology Status

SRA is developing several new counter shapes that could improve performance. The most interesting one is a right-angle counter that would measure the corner area between floors and the adjacent walls. SRA is also developing the ability to actually record data from the standard 100-cm^2 manual detectors into their database for subsequent analysis. This would be used in small non-standard areas that cannot be directly surveyed by the survey monitor. In addition, the SRA survey monitor can be viewed as a movable platform that can record data from any detector system mounted on it. Thus, it should be relatively easy to upgrade the system by adding gamma-ray detectors to measure general background at the same time that alpha and beta contamination is being measured.

Potential markets exist for the SRA-SCM/SIMS technology at Sandia National Laboratory and the Savannah River Site. This information is based on a revision to the OST Linkage Tables dated August 4, 1997.

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Licensing Information

No licensing or permitting activities were required to support this demonstration.

Web Site

The CP-5 LSDP Internet address is http://www.strategic-alliance.org.

Other

All published Innovative Technology Summary Reports are available online at http://em-50.em.doe.gov. The Technology Management System, also available through the EM50 Web site, provides information about OST programs, technologies, and problems. The OST Reference # forSCM/SIMS is 1942

SECTION 2

TECHNOLOGY DESCRIPTION

Overall Process Definition

SRA-SCM/SIMS is designed to survey and document floor and surface areas for alpha and beta contamination. The purpose of the CP-5 demonstration was to measure the performance of SRA-SCM/SIMS in a facility with relatively small and irregularly shaped rooms as compared to standard manual survey techniques.

The survey monitor consists of a position-sensitive gas proportional counter mounted on a motor-driven cart. The width of the proportional counter is variable (typically 0.5 to 5 m) and can be readily interchanged with other lengths. These tests used a 120-cm-wide counter although a smaller counter would have been more efficient. All data are recorded automatically and can be correlated to a particular geometric position in the survey, resulting in a considerable improvement in data reliability.

SIMS is a series of software programs that processes and analyzes the collected survey strip data on an external Personal Computer (PC) system. The technician can use SIMS to analyze the data manually or use the automatic report generation feature to generate a standard data report that can meet the regulatory requirements for free release.

System Configuration and Operation

The SRA survey system uses a standard 120-V, 20-A power line to power the DC gear motor for moving the cart forward, the data electronics, and the computer equipment. This power can come from a standard AC socket or from a field generator. Future versions may include a stand-alone version powered by an attached battery. The P-10 gas used for the proportional counter is contained in a standard 20 ft^3 cylinder that can provide a 2-week supply of gas at normal operating conditions. The motorized cart weighs between 75-150 lb depending on specific configuration and can be easily lifted by two persons. The proportional counter detector can be detached from the cart for independent transport. If the gas lines are disconnected for an extended period, a gas purge is required.

The startup procedure consists of adjusting the gas flow to purge the gas proportional counter for approximately 15 min. The high-voltage plateau threshold is then set for alpha or alpha and beta measurements. A source of known intensity and area is scanned and this data is used to calibrate the detector. Information on the survey parameters are then entered into the data log and a scan begins. The system is capable of moving at scan speeds of 1 to 50 cm/s. Typical scan speeds depend on the level of contamination being measured and the accuracy required. A scan rate of 5 cm/s was used in the CP-5 demonstration.

A radiation survey is done by taking a series of survey strips (Figure 3). A survey strip is a rectangular region defined by the width of the proportional counter and the start and stop points of the motorized driven cart. Data within the survey strip is defined by the position of the event along the width of the counter and the distance the cart has traveled along the length of the survey strip. Data are typically collected over 5-cm^2 regions, visually displayed to the operator on a color LCD display (Figure 4 provides a black and white picture of the operator display screen), and stored on a disk for subsequent processing by SIMS. The entire motorized cart and data collection system is controlled by a standard PC. A standard video camcorder (keyed to the data) provides a visual record of the survey strip.

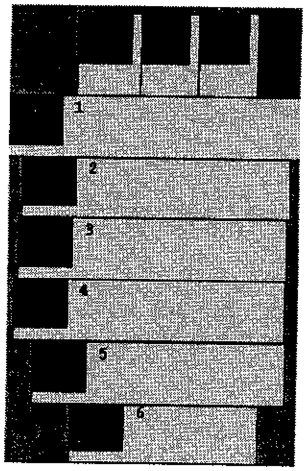

Figure 3. Strip layout for truck dock area.

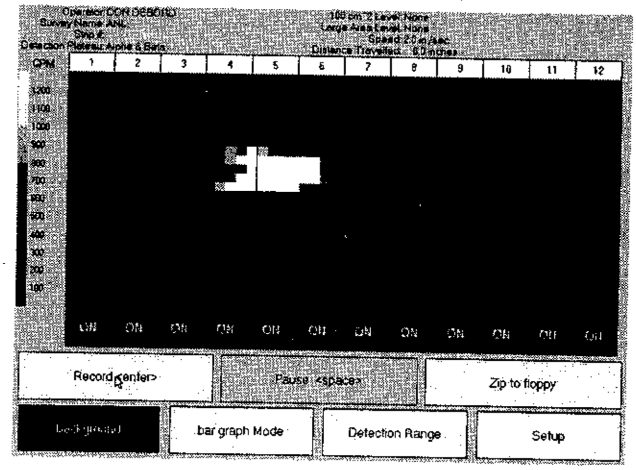

Figure 4. Operator display screen.

The software system, as currently configured, requires that all survey strips be either parallel or perpendicular to each other. This requirement can increase the number and complexity of the survey slices required.

The data collection system is easy to use and learn. The image-processing system is somewhat more complicated but persons familiar with the Windows® operating system can learn it in less than half a day. The automatic report generation worked well in these tests.

SIMS processes and analyzes the collected survey strip data. STITCHER© is a program that takes the individual survey strips and positions them relative to each other and the survey area. Once the strips are positioned, the program VISUSPECT© projects and averages the data from the strips onto standard 100-cm^2 areas typical of manual surveys. The data from this array can then be visually inspected using various image-processing algorithms (Figure 5 is a black and white picture of the data display options; SIMS actually provides the display options in color), or it can be used to generate a data report (see Table 3 in Section 3, Performance) that documents the average contamination present in each 1-m^2 area and the maximum contamination level in a given 100 cm^2 within this 1-m^2 area.

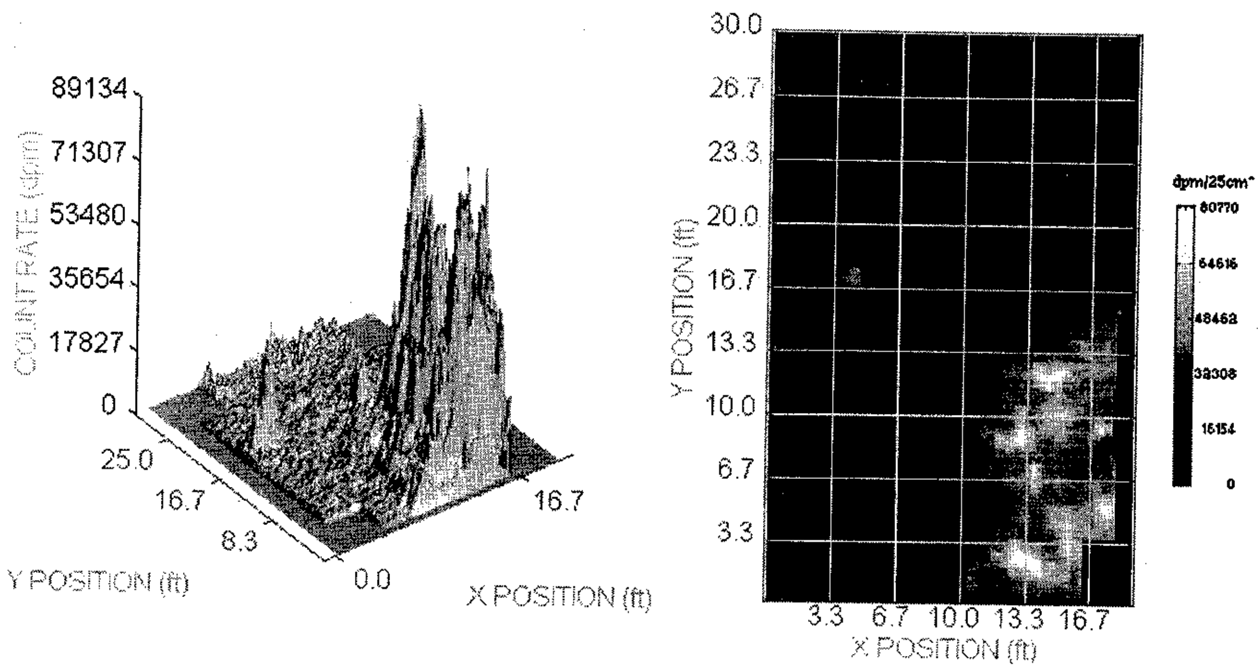

Figure 5. Two data-display options of the truck dock survey data.

SECTION 3

PERFORMANCE

Demonstration Plan

The purpose of the CP-5 demonstration was to measure the performance of SRA-SCM/SIMS in a facility with relatively small and irregularly shaped rooms in comparison with standard manual survey techniques. The performance of the SRA system for large facilities involving several thousand square meters has been previously reported (Shonka et al., June 1996).

In general, three types of radiation surveys are needed to support D&D activities. The first consists of surveys of hallways and floors as part of standard HP surveillance procedures within a facility. The second uses surveys to measure the amount and location of contamination for use by cleanup crews or by personnel planning decontamination efforts. This type of survey typically requires specific measurements of the contamination level and the location of these measurements on a layout of the area for use by personnel not involved in the original measurements. The third involves surveys and documentation that will be used for free-release certification of a specific area.

In this report, a direct comparison between the SRA survey system and manual surveys was done for only the first two types of surveys. Since no manual surveys were done for the free release case, only an estimate of the relative performance was possible.

Table 1 shows the areas surveyed by the SRA system within the CP-5 facility. The survey time corresponds to the time to layout the survey strips and to collect the data. The analysis time corresponds to the amount of time required to process the data once it was transferred into the analysis computer.

Table 1. Description of areas surveyed

Area	Floor	Location	Survey Area (ft^2)	Number of Survey Strips	Survey Time (min)	Analysis Time (min)
Test	Service	D-055	400	4	20	5-10
Truck Dock	Main	B-112/E-101	400	9	16	5-10
Rod Storage	Main	C-117	350	4	12	5-10
Heat Exchange Pit	Service	D-018/D-022	300	11	20	20
Milled Area	Service	C-010/C-005	450	12	20	5-10
Service Room	Service	C-010/C-005	900	14	45	20

A baseline manual survey was performed only on the test area and included radiation surveys involving surveillance and routine documentation. No attempt was made to obtain the times required to do a manual free-release survey. The times for the baseline manual system and SRA-SCM/SIMS are shown in Table 2. The checkout and calibration times were roughly equivalent. The same smear surveys would have been done in either case if loose contamination had been found and are not part of the comparison between the two systems. The gamma exposure measurement was not available on the SRA device although it could be added to the device in future upgrades. These results show that for the test area the SRA system was approximately 5 times faster than the manual survey (20 versus 105 min) in performing a general surveillance survey. The SRA system is approximately 5-6 times faster than the manual survey (25-30 versus 155 min) in performing surveys that require a routine level of documentation.

Table 2. Comparison of baseline and SRA survey times for test area

Description	SRA Time (min)	Manual (Baseline) Time (min)
Checkout and Calibration	20-35	35
Gamma Exposure	Not Applicable	10
Floor Survey	20	105
Smear Survey	Not Applicable	70
Data Analysis	5-10	50

Since no manual survey for free release was done, only a qualitative comparison can be made between the performance of the SRA system and the manual survey. The data from the SRA system report is consistent with the regulatory requirements for free release (see Table 3 for a sample output table); thus, no additional time would be required by the SRA system to produce the appropriate free-release documentation. Due to increased regulatory and documentation requirements, it is estimated that the manual free-release survey would take 3 times as long to perform. The SRA system could be expected to be approximately 16 - 18 times faster for floor survey and data analysis when performing free release surveys.

SRA-SCM/SIMS performed without any significant mechanical or computer problems during the 4-day testing period. There was in general good agreement between the manual and SRA system surveys except for one or two high count-rate regions in which the SRA device undercounted the data due to failure to incorporate dead-time corrections. These corrections have subsequently been implemented and should not be a problem in future tests.

Table 3. Summary of the count rate data (DPM/100 cm^2) averaged over 1-m^2 areas for the truck dock

Unit: (1,9) Mean: 0 Max: 0 Min: 0 Std: .0000	Unit: (2,9) Mean: 3,998 Max: 18,597 Min: 0 Std: .0110	Unit: (3,9) Mean: 2,685 Max: 9,118 Min: 0 Std: .0074	Unit: (4,9) **Mean: 5,314** Max: 17,213 Min: 0 Std: .0154	Unit: (5,9) Mean: 4,714 Max: 18,735 Min: 0 Std: .0131	Unit: (6,9) Mean: 0 Max: 0 Min: 0 Std: .0000
Unit: (1,8) Mean: 3,214 Max: 4,974 Min: 0 Std: .0042	Unit: (2,8) Mean: 3,249 Max: 6,906 Min: 0 Std: .0063	Unit: (3,8) Mean: 3,648 Max: 8,786 Min: 410 Std: .0066	Unit: (4,8) Mean: 4,397 Max: 41,452 Min: 0 Std: .0152	Unit: (5,8) Mean: 3,044 Max: 8,963 Min: 0 Std: .0068	Unit: (6,8) Mean: 3,860 Max: 6,286 Min: 0 Std: .0063
Unit: (1,7) **Mean: 5,113** Max: 8,927 Min: 0 Std: .0082	Unit: (2,7) **Mean: 6,022** Max: 15,097 Min: 1,770 Std: .0075	Unit: (3,7) **Mean: 7,354** Max: 18,190 Min: 233 Std: .0098	Unit: (4,7) **Mean: 8,533** Max: 16,957 Min: 2,648 Std: .0080	Unit: (5,7) **Mean: 8,177** Max: 14,767 Min: 2,580 Std: .0077	Unit:(6,7) **Mean: 6,627** Max: 11,926 Min: 0 Std: .0087
Unit: (1,6) **Mean: 14,661** Max: 45,901 Min: 0 Std: .0301	Unit: (2,6) **Mean: 18,056** Max: 104,711 Min: 701 Std: .0644	Unit: (3,6) **Mean: 9,747** Max: 19,770 Min: 1,581 Std: .0097	Unit: (4,6) **Mean: 18,331** Max: 60,516 Min: 3,432 Std: .0321	Unit: (5,6) **Mean: 21,351** Max: 41,569 Min: 3,936 Std: .0241	Unit: (6,6) **Mean: 23,423** Max: 61,552 Min: 0 Std: .0427
Unit: (1,5) **Mean: 6,257** Max: 12,464 Min: 0 Std: .0100	Unit: (2,5) **Mean: 7,615** Max: 13,703 Min: 1,782 Std: .0073	Unit: (3,5) **Mean: 10,545** Max: 33,527 Min: 1,652 Std: .0169	Unit: (4,5) **Mean: 32,876** Max: 131,606 Min: 8,567 Std: .0809	Unit: (5,5) **Mean: 107,648** Max: 298,734 Min: 26,767 Std: .1813	Unit: (6,5) **Mean: 107,219** Max: 167,509 Min: 0 Std: .1610
Unit: (1,4) Mean: 4,933 Max: 7,591 Min: 0 Std: .0076	Unit: (2,4) **Mean: 7,418** Max: 12,811 Min: 1,916 Std: .0069	Unit: (3,4) **Mean: 10,907** Max: 30,752 Min: 2,644 Std: .0177	Unit: (4,4) **Mean: 68,700** Max: 235,981 Min: 9,237 Std: .1432	Unit: (5,4) **Mean: 152,395** Max: 317,483 Min: 27,099 Std: .1309	Unit: (6,4) **Mean: 110,579** Max: 253,767 Min: 0 Std: .1782

Table 3. (continued)

Unit: (1,3) Mean: 4,841 Max: 8,361 Min: 0 Std: .0076	Unit: (2,3) **Mean: 7,443** Max: 13,122 Min: 1,316 Std: .0078	Unit: (3,3) **Mean: 15,368** Max: 38,022 Min: 2,991 Std: .0252	Unit: (4,3) **Mean: 90,467** Max: 263,980 Min: 13,685 Std: .1582	Unit: (5,3) **Mean: 108,637** Max: 229,280 Min: 28,342 Std: .0977	Unit: (6,3) **Mean: 104,562** Max: 241,643 Min: 0 Std: .1543
Unit: (1,2) **Mean: 5,309** Max: 9,556 Min: 0 Std: .0074	Unit: (2,2) **Mean: 6,620** Max: 13,474 Min: 0 Std: .0096	Unit: (3,2) **Mean: 20,367** Max: 37,652 Min: 5,132 Std: .0210	Unit: (4,2) **Mean: 104,689** Max: 311,000 Min: 22,012 Std: .2001	Unit: (5,2) **Mean: 171,294** Max: 279,966 Min: 0 Std: .1624	Unit: (6,2) **Mean: 162,235** Max: 220,247 Min: 0 Std: .1297
Unit: (1,1) Mean: 0 Max: 0 Min: 0 Std: .0000	Unit: (2,1) Mean: 4,538 Max: 9,185 Min: 0 Std: .0074	Unit: (3,1) **Mean: 24,401** Max: 90,053 Min: 0 Std: .0511	Unit: (4,1) **Mean: 63,979** Max: 220,534 Min: 0 Std: .1409	Unit: (5,1) **Mean: 102,322** Max: 263,462 Min: 0 Std: .1904	Unit: (6,1) Mean: 0 Max: 0 Min: 0 Std: .0000

SECTION 4

TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Technology Applicability

SRA-SCM/SIMS is a complete system for surveying floors or surfaces for alpha and beta contamination and can be applied to routine operational surveys, characterization surveys, and free release and site closure surveys. The SRA system has maximum utility in facilities that have large areas to survey; however, even in small facilities with relatively irregularly shaped rooms, the use of the SRA system should reduce costs and increase survey accuracy.

Some of the key advantages of the SRA system follow.

- SCM in conjunction with the LCD display screen is an extremely useful tool for routine surveillance surveys.
- SIMS provides a unique tool for analyzing the data from SCM and for generating data reports that can meet regulatory requirements. In addition, the system is easy to use and to learn.
- The system generates automatic data reports with minimal operator intervention.
- The proportional counter on SCM can be easily changed so that the dimensions can be optimized for the area being scanned.
- Because all of the data are recorded by the computer, the reliability of the measured data are significantly increased. In addition, the system relieves the operator of much of the routine data recording and transcribing, which reduces operator fatigue and improves performance.

The major limitation of the system is in surveying small rooms with a large number of obstacles. It is possible that combining manual survey instrumentation with SIMS could reduce this problem.

Competing Technologies

The baseline methodology to SCM is a manual survey by trained Health Physics Technicians (HPTs). Manual surveys are time consuming and tedious. This can lead to high labor costs, unreliable data, and potentially unnecessary exposure. See Appendix B, Baseline Technology—Manual Characterization, for details related to procedures and equipment used in manual baseline surveys.

A competing technology also demonstrated as part of the CP-5 LSDP is the Mobile Automated Characterization System (MACS). MACS is a mobile robotic system which performs floor characterization surveys using radiation sensors to generate alpha and beta contaminant information.

Another competing technology for surface characterization is the Three-Dimensional, Integrated Characterization and Archiving System (3D-ICAS), funded through DOE's Federal Energy Technology Center. Coleman Research Corporation is the prime contractor.

Data comparing the performance of SRA-SCM/SIMS to the competing technologies listed above is not available. A comparative analysis of the technologies demonstrated for surface characterization at CP-5 will be performed and included in the LSDP final report.

Patents/Commercialization/Sponsor

SCM has been patented (U.S. Patents 5,440,135 and 5,541,415) as an outcome of Small Business Innovative Research (SBIR) funding. Two commercial systems based on the SCM technology have been sold by SRA and are in use. SIMS is copyrighted. SRA, developer of SCM and SIMS, has held discussions about paths to commercialization, including licensing the technology, with a number of radiation instrumentation companies commonly associated with the commercial nuclear power industry.

SECTION 5

COST

Introduction

This cost analysis summarizes and evaluates SRA-SCM/SIMS and estimates the potential for savings relative to manual surveying. The objective is to assist decision makers in determining if this technology is applicable to their survey needs and offers a cost benefit in its deployment. This analysis strives to develop realistic estimates that represent actual D&D work within the DOE complex. However, this is a limited representation of actual cost because the analysis uses only data observed during the demonstration. Some of the observed costs are eliminated or adjusted to make the estimates more realistic. These adjustments are allowed only when they do not distort the fundamental elements of the observed data (i.e., does not change the productivity rate, quantities, work elements, etc.) and eliminates only those activities which are atypical of normal D&D work. Descriptions contained in Appendix B detail the changes to the observed data.

The cost to perform and document a floor radiation survey with conventional radiation monitoring equipment is considerable and depends on the complexity and size of the room or area to be surveyed, the level and type of contamination in the room or area, and the analysis requirements imposed on the survey end results such as whether the survey is being conducted for characterization or for closure.

At the high end of the cost spectrum, manual surveys for surface contamination can sweep out as little as 50 cm^2 to 100 cm^2 per second, with more time required for stopping to interpret meter readings. Recording survey data and transcribing it to a useable format can take time equivalent to the original survey time. Further, surveys for closure require a minimum of five measurements per square meter and a much greater level of data assimilation and documentation. Thus, to survey a room or area for closure would take significantly more time.

Methodology

This cost analysis compares the innovative SRA-SCM/SIMS technology to the conventional manual survey technology currently used for radiological surveying at the ANL facility. The SRA-SCM/SIMS technology has been demonstrated at the CP-5 Reactor facility at ANL under controlled conditions with a vendor providing personnel and equipment for which timed, measured, and quantified activities were recorded to determine achievable production rates.

Data collected during the demonstration included the following:

- activity duration,
- work crew composition,
- equipment used to perform the activity,
- training courses required and taken (excluded from analysis),
- quantification of activities, and
- information from discussions with the ANL Test Engineer and CP-5 Facility Personnel.

The following baseline documents were used as references:

- *Decommissioning Cost Estimate for Full Decommissioning of the CP-5 Reactor Facility*, prepared for Argonne National Laboratory by NES, Inc., June 1992.
- Activity Cost Estimate (ACE) backup sheets, dated 5/15/96, for CP-5 decommissioning.
- Floor Radiological Characterization (a survey using conventional instrumentation to characterize floor contamination on Area D-055 of Building 330 at ANL).

Efforts have been applied in setting up the baseline cost analysis to assure unbiased and appropriate production rates and costs. Specifically, a team consisting of members from the Strategic Alliance (ICF Kaiser, an ANL D&D technical specialist, and a test engineer for the demonstration) and USACE have reviewed the estimate assumptions to ensure a fair comparison.

The selected basic activities being analyzed come from the *Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary* (HTRW RA WBS), USACE, 1996. The HTRW RA WBS was developed by an interagency group and its use in this analysis provides consistency to established national standards.

Some costs are omitted from this analysis to aid understanding and to facilitate comparison with costs for individual sites. The ANL indirect expense rates for common support and materials are omitted from this analysis. Overhead rates for each DOE site vary in magnitude and in the way they are applied. Decision makers seeking site-specific costs can apply their site's rates to this analysis without having to replace ANL's rates. This omission does not sacrifice the relative percentage of cost-savings accuracy because overhead is applied to both the innovative and baseline technology costs. Engineering, quality assurance, administrative costs, and taxes on services and materials are also omitted from this analysis for the same reasons indicated for the overhead rates.

The standard labor rates established by ANL for estimating D&D work are used in this analysis for the portions of the work performed by local crafts. Additionally, the analysis uses an 8-h work day with a 5-day week.

Summary of Cost Variable Conditions

The innovative and baseline technology estimates presented in this analysis are based upon a specific set of conditions or work practices found at CP-5 and are presented in Table 4. This table is intended to help the technology user identify work items which can result in cost differences.

Table 4. Summary of cost variable conditions

Cost Variable	SRA-SCM/SIMS Technology	Baseline (Manual) Technology
	Scope of Work	
Quantity and type of material surveyed in test areas	2,800 ft^2 of concrete floor with a paint coating tested.	400 ft^2 of concrete floor with a paint coating actually tested; 2,400 ft^2 of concrete floor with a paint coating extrapolated based on the production rate established for the area actually tested.
Location of test area	• Test Area D-055, Bldg. 330 • Truck Dock • Rod Storage Room • Heat Exchange Pit • Milled Area • Service Room	• Test Area D-055, Bldg. 330
Nature of survey work	Floors were surveyed for background radiation and characterized for alpha and beta contamination using one pass of the Shonka Research Associates, Inc. (SRA) monitor.	Floor was surveyed for background (gamma) contamination and alpha and beta contamination by using three separate tests, all conducted in one pass each.

Table 4. (continued)

Cost Variable	SRA-SCM/SIMS Technology	Baseline (Manual) Technology
Work Environment		
Level of floor contamination in the test areas	The demonstration area is not a radiation area. Any contamination that might be present is fixed.	The demonstration area is not a radiation area. Any contamination that might be present is fixed.
Level of floor obstructions in test areas	The level of floor obstructions in the tested areas varied from unobstructed in test area D-055 to very obstructed in the Heat Exchange Pit. The Heat Exchange Pit is also a small floor area and as such, required many stops, starts, and changes of direction with the SRA monitor.	Since only test area D-055 of Building 330 was surveyed with the manual methods, the floor area is considered unobstructed.
Work Performance		
Technology acquisition means	Equipment is assumed to be purchased by Argonne National Laboratory (ANL) for use by site health physics technicians (HPTs).	Equipment is assumed owned by ANL and used by site HPTs.
Compliance requirements	Compliance is assumed to be that necessary to meet the requirements for a typical characterization survey.	Compliance is assumed to be that necessary to meet the requirements for a typical characterization survey.
Work process steps	Floors surveyed in one pass of the SRA device.	Floors surveyed with three separate devices run in one pass each.
Survey productivity rate	• Unobstructed Floor Area: 30 ft^2/min • Obstructed Floor Area: 15 ft^2/min • Average: 23 ft^2/min	• Unobstructed Floor Area: 3.8 ft^2/min (Productivity rate for an obstructed floor area not observed, but assumed to be the same as an unobstructed floor area.)
Data recording and analysis productivity rate	• Average: 39 ft^2/min (Average includes some anomalies from the demonstration and would probably be higher under full-production conditions.)	• Average: 8 ft^2/min
Scale of production	Scale of the characterization job or the size of area to be surveyed is assumed to be of little consequence except when using the device in small, heavily obstructed rooms or areas. Where such conditions were encountered during the demonstration, a reduced rate of productivity usually resulted. It should be noted that a 52-in-wide detector was used during the demonstration for all rooms and areas tested. A range of narrower detectors are now available that should increase survey speed in small, heavily obstructed rooms or areas.	Scale of the characterization job or the size of area to be surveyed is assumed to be of little consequence. Although most of the instrumentation used is hand-held and relatively maneuverable, it is unknown whether a small, heavily obstructed floor area will affect the survey speed since it was not actually demonstrated.

Potential Savings and Cost Conclusions

For the conditions and assumptions established for this cost comparison, the innovative technology was approximately 30 percent of the cost of the baseline alternative. Specifics related to potential equipment purchase prices and tables used to derive approximate unit costs can be found in Appendix B. Figure 6 summarizes the cost comparison between the SRA-SCM/SIMS technology and the baseline technology.

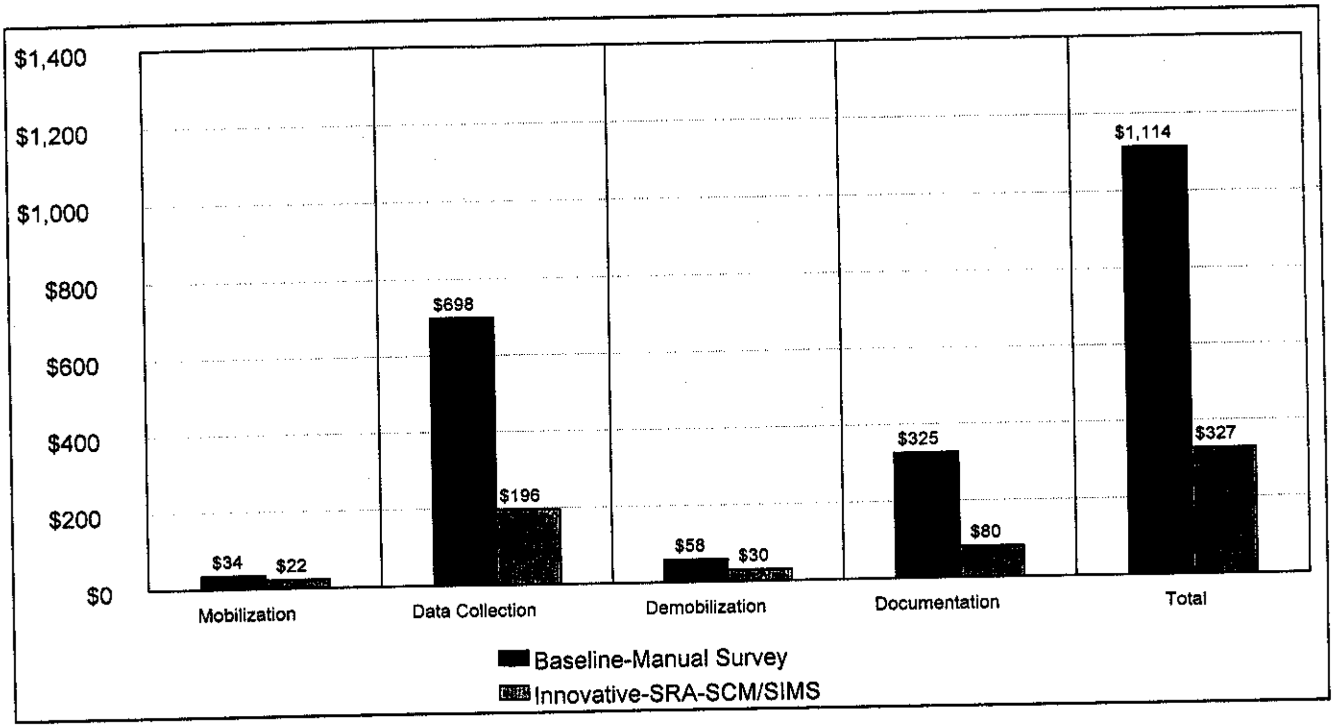

Figure 6. Cost comparison summary.

It must be recognized that the cost comparison between the SRA-SCM/SIMS technology and the baseline technology has the following limitations:

- Only one common region was surveyed using both methods.
- SRA-SCM/SIMS built-in software automatically generates reports of significantly greater level than could be realized with the baseline methodology without incurring significant additional cost.
- Using the SRA-SCM/SIMS device may not eliminate the need to verify or supplement measurements with conventional (existing) survey equipment.

The first limitation tends to skew the cost estimate to favor the baseline methodology since production rates for the baseline had to be extrapolated for most of the rooms. Survey production rates for the SRA-SCM/SIMS technology varied from 15 ft^2/min in the Heat Exchange Pit to 30 ft^2/min in the Rod Storage Room. Actual baseline production rates were established in the test area which is unobstructed and has a relatively small number of contaminated regions. It is unknown whether more complicated or obstructed floor areas would have an impact on the baseline production rates, but since most of the instrumentation is hand-held, it is assumed that such impacts would be negligible. On the other hand, it is known by experience that a large number of relatively small area contamination regions tends to slow down a manual survey due to meticulous verification requirements with the hand instrumentation. Documentation of survey results with SRA-SCM/SIMS technology are independent of the number, size, or complexity of the contaminated regions.

The second limitation also skews the cost estimate to favor the baseline methodology. This is particularly true where large amounts of regulatory documentation are required at the conclusion of a survey, such as in a free release or closure scenario. Since all of the data measured and collected by SRA-SCM/SIMS is logged into the onboard computer, it is simply a matter of manipulating the data with the SIMS software to quickly generate a variety of data displays and data analyses which can then be converted into report format and printed using a conventional PC. Depending on the circumstances of the closure survey, the SRA-SCM/SIMS technology may reduce HPT reporting time by a factor of nine over a comparable baseline.

The last limitation tends to skew the cost estimate to favor the SRA-SCM/SIMS technology. Since the device only records and analyzes alpha and beta-gamma emissions, other tests, such as for detection of low-energy gamma and x-ray emissions, would still need to be conducted. Presently, this requires returning to the currently available hand-held devices designed to take these measurements. Smear tests for determining contamination levels of loose material would also still need to be taken, especially for characterization and closure scenarios. Moreover, it will probably be necessary to substitute hand-held instrumentation on floors where confined space limits access for the SRA device, which was actually experienced during the demonstration in the Heat Exchanger Pit. The use of hand-held instruments to supplement or complete a function performed by the SRA-SCM/SIMS technology detracts from its cost advantage.

Despite the limitations of the cost analysis, it is felt that the SRA-SCM/SIMS technology still saves significant time and money over using manual surveys to measure, record, and analyze radiological contamination of floor surfaces.

SECTION 6

REGULATORY AND POLICY ISSUES

Regulatory Considerations

The regulatory and permitting issues related to the use of the SRA technology at the ANL CP-5 Test Reactor are governed by the following safety and health regulations. These same regulations apply to baseline manual surveys.

- Occupational Safety and Health Administration (OSHA) 29 *Code of Federal Regulations* (CFR) 1926

- 1926.300 to 1926.307	Tools–Hand and Power
- 1926.400 to 1926.449	Electrical–Definitions
- 1926.28	Personal Protective Equipment
- 1926.52	Occupational Noise Exposure
- 1926.102	Eye and Face Protection
- 1926.103	Respiratory Protection

- OSHA 29 CFR 1910

- 1910.211 to 1910.219	Machinery and Machine Guarding
- 1910.241 to 1910.244	Hand and Portable Powered Tools and Other Hand-Held Equipment
- 1910.301 to 1910.399	Electrical–Definitions
- 1910.95	Occupational Noise Exposure
- 1910.132	General Requirements (Personnel Protective Equipment)
- 1910.133	Eye and Face Protection
- 1910.134	Respiratory Protection
- 1910.147	The Control of Hazardous Energy (Lockout/Tagout)

Since SRA-SCM/SIMS is designed for use when decontaminating structures, there is no regulatory requirement to apply CERCLA's nine evaluation criteria. However, some evaluation criteria required by CERCLA, such as protection of human health and community acceptance, are briefly discussed below. Other criteria, such as cost and effectiveness, were discussed earlier in this document.

Safety, Risks, Benefits, and Community Reaction

With respect to safety issues, the SRA system involves the same considerations as those involved in standard gas proportional counter systems regularly used by health physicists. Most of these involve the high-voltage of the system and the gas cylinder and are typical of what is routinely encountered in an industrial environment.

A major benefit is that the improved accuracy and reliability of the system can provide the public with increased confidence that the various radiation surveys are being conducted in a professional manner. In addition, the rich display capabilities of SIMS allow various visual presentations of the survey results, which can increase the public acceptance of the data. Reduction in exposure should also be realized by reducing the amount of time personnel are required to be in a radiological area collecting data.

SECTION 7

LESSONS LEARNED

Implementation Considerations

The SRA system demonstrated at CP-5 is a well developed and commercially available technology. As configured, the system requires the availability of 120-V AC power, which could be a problem in remote areas or in facilities in which much of the power has been disconnected. Some consideration of the width of the gas proportional counter needs to be made so that it is optimized for the facility.

Technology Limitations and Needs for Future Development

The SRA system technology would benefit from the following design improvements:

- Elimination of the requirement that survey strips be perpendicular to each other.
- Low cost method of determining the orientation of a survey strip relative to the walls of the room being surveyed. This would increase the ease of orientating survey data with standard facility drawings.

Technology Selection Considerations

Any large nuclear site can make use of this technology. The technology is applicable for documenting the conditions of large surface areas, primarily for alpha or beta surface contamination. SRA-SCM/SIMS technology can be applied to routine operational surveys, characterization surveys, and free release and site closure surveys.

Although primarily oriented toward handling the large data sets generated by SCM, SIMS can be applied to the integration of survey information from a wide variety of measuring devices. In fact, the more survey data a site generates, the more need there is for a system to manage it. SIMS is used for analysis and report generation and to assist in providing useful presentations of the data to other applications, such as electronic-based drawings and mapping systems.

While SCM and SIMS could in principle be used for minor surveys, use of the system is not recommended for areas of less than a few square meters or surveys with less than a hundred measurement points, since the visualization of the data becomes less useful for small data sets.

APPENDIX A

REFERENCES

Shonka, J. J. et al. *Development of Position Sensitive Proportional Counters for Hot Particle Detection in Laundry and Portal Monitors,* NUREG/CR-5868. September 1992.

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Strategic Alliance for Environmental Restoration . *CP-5 Large Scale Demonstration Project, Test Plan for the Demonstration of SRA Surface Contamination Monitor at CP-5*, Argonne National Laboratory. November 1996.

Strategic Alliance for Environmental Restoration. *CP-5 Large Scale Demonstration Project, Data Report for the SRA Surface Contamination Monitor and Survey Information Management System, at CP-5*, Argonne National Laboratory. February 1997.

APPENDIX B

TECHNOLOGY COST COMPARISON

This appendix contains definitions of cost elements, descriptions of assumptions, and computations of unit costs that are used in the cost analysis.

Innovative Technology—SRA Surface Contamination Monitor

Mobilization (WBS 331.01)

Set Up Equipment: This cost element provides for cabling equipment together (if required), plugging in and turning on the equipment, and running self diagnostics and calibrations on the equipment before use. The activity cost is measured as a lump sum for one activity.

Decontamination and Decommissioning Characterization (WBS 331.17)

Conduct SRA - SCM Survey: This cost element includes running the device to conduct the survey, automatically logging data (measurements), and adjusting the path the device follows to follow room configurations, miss obstructions, and ensure that the device's encoder wheel stays on the "mapped-out" strips for data logging purposes. The activity is measured as a per square foot of area surveyed cost.

Lay Out Room at Each Move: This cost element includes roughly measuring rooms to be surveyed by hand and then laying out a series of gridded "strips" the device will follow for surveying. The activity is measured as one cost per area or room laid out.

Demobilization (WBS 331.21)

Survey-Out Equipment and Decontaminate: This cost element provides for radiological survey of the equipment by a site HPT to ensure that contaminated equipment does not leave the site. The element includes costs for decontamination. Costs include equipment stand-by time plus HPT labor. The activity cost is measured as a lump sum for one activity.

Decontamination and Decommissioning Data Assembly and Documentation (WBS 331.17)

Create Analysis for Data: This cost element includes taking data logged during the survey and utilizing the STITCHER© graphical interface program to create computer files which are then manipulated in Windows®. Data is then converted to graphical reports within Windows® via a software called VISUSPECT©. The activity is measured as a per square foot of area surveyed cost.

Cost Analysis

Costs for demonstration of the SRA-SCM innovative technology are based on operating the device within the limits for free release established by ANL. Productivity losses due to anomalies exceeding the operating limitations of the device are not considered in the cost estimate. Areas and rooms identified for the demonstration and the times required to survey them form the basis of the cost estimate and are listed in Table B-1.

Most sites across the DOE complex conduct radiological surveys with their own personnel and equipment. For this reason, it will be assumed that the SRA-SIMS equipment will be purchased for use by site HPTs. (This same assumption will apply where a D&D contractor has been retained for site cleanup).

It is important to note that SRA-SIMS technology demonstrated features for improved processing, analysis, and reporting of survey data that had no equivalent in the baseline technology. Thus, the end report from the new technology, while recording the essential measurements, provided much more data and much more comprehensive analysis than was provided for the baseline technology. The assumptions for projecting the SRA-SIMS technology demonstration costs to reflect a commercial cost are summarized as follows:

- SRA-SIMS is purchased by ANL and used by one site HPT for a floor characterization survey.
- Costs for personal protection equipment (PPE) and pre-job safety meetings are omitted due to a low level of contamination in the test areas.
- Radiological characterization is for alpha and beta-gamma contamination only.
- Productivity loss factors (PLFs) are not considered.
- Initial setup of the device is conducted once before beginning the survey work and the activity is not repeated when transferring the device from one test area or room to another.
- Hourly equipment rates are calculated in accordance with USACE EP-1110-1-B, 1995, and are based on the following data provided by the manufacturer and the ANL site:
  - Purchase price of $35,000 to $45,000 for SCM (1997 pricing).
  - Purchase price of $2,500 to $10,000 for the computer workstation (1997 pricing).
  - Purchase price of $5,000 (single user) to $10,000 (site) for the SRA-SIMS computer software (1997 pricing).
  - An anticipated 10-yr life for SRA-SCM and an anticipated life of 5 yr each for the computer and SIMS software.
  - A yearly use rate of 1,000 h and a discount rate of 5.8 percent for all components per Office of Management and Budget (OMB) circular A-94.
  - An equipment acquisition cost of 9.3 percent of the purchase price of the equipment (included in the equipment hourly rate).
- Each area or room surveyed is roughly measured by hand, sketched, and then gridded with a test strip pattern that the device will follow when running. The gridded strip pattern is logged into the device's onboard computer. The activity is repeated at each new area or room to be surveyed.
- Time to move the device from area to area or room to room is omitted since a comparable exercise would be necessary for the baseline survey method.
- Dead time for software corrections and any other time-consuming artifacts of the demonstration are omitted. (An example of this is where the SRA device encountered localized areas of gross contamination and the software failed to fully correct for it).
- Demobilization consists of surveying-out the device and is done only once at the completion of all surveying work.

- Data collection utilizes the full capability of the SRA-SIMS device. Reporting is done upon completion of the surveys by utilizing components of the SIMS software to generate graphical displays of the survey results.

- Oversight expenses incurred by engineering, quality assurance, and administrative activities are omitted.

Based on these assumptions, the activities, quantities, production rates, and costs observed during the demonstration are shown in Table B-1, Cost summary - SRA Surface Contamination Monitor.

Table B-1. Cost summary - SRA Surface Contamination Monitor

Work Breakdown Structure (WBS)	Unit Cost (UC) Labor Hours	Labor Rate	Equipment Hours	Equipment Rate	Other	Total Unit Cost	Total Quantit (TQ)	Unit of Measure	Total Cost (TC)[1]	Comments
Mobilization (WBS 331.01)								**Subtotal:**	**$21.81**	
Set Up Equipment for Use	0.33	$56.00	0.33	$10.08		$21.81	1	Lump Sum (LS)	$21.81	20 min for one Health Physics Technician (HPT) for the total activity
Decontamination and Decommissioning Characterization (WBS 331.17)								**Subtotal:**	**$195.62**	
Conduct Survey with Shonka Research Associates, Inc. (SRA)	0.0008	$56.00	0.0008	$10.08		$0.05	2,800	Square Foot (ft^2)	$148.02	calculation based on survey productivity rate established for surveying six rooms
Lay Out Room at Each Move and Enter the Survey Pattern into the Monitor	0.17	$56.00				$9.52	5	Each	$47.60	
Demobilization (WBS 331.21)								**Subtotal:**	**$29.74**	
Survey-Out Device	0.45	$56.00	0.45	$10.08		$29.74	1	LS	$29.74	equipment standby time plus time for one HPT to survey the equipment
Decontamination and Decommissioning Data Assembly and Documentation (WBS 331.17)								**Subtotal:**	**$79.56**	
Create Analysis for Data	0.0004	$56.00	0.0004	$10.08		$0.03	2800	ft^2	$79.56	calculation based on the total analysis time recorded for six rooms tested
								TOTAL:	**$326.72**	

[1] TC = UC * TQ

Mobilization (WBS 331.01)

Set Up Equipment: This cost element provides for running self diagnostics and calibrations on all equipment before using and establishing a work plan for the areas or rooms to be surveyed. The activity cost is measured as a lump sum for one activity.

Decontamination and Decommissioning Characterization (WBS 331.17)

Gamma Scan: Cost activity includes surveying for background ambient low energy gamma and x-ray levels using the Eberline PRM 5-3 hand-held pulse rate meter with the Eberline PG-2 large area scintillation detector. The activity is measured as a per square foot of area surveyed cost.

Alpha and Beta Scan: Cost activity is for establishing general areas of alpha and beta particle contamination and includes using the Eberline FM-4G floor monitor equipped with the Eberline PAC-4G-3 portable alpha meter. The activity is measured as a per square foot of area surveyed cost.

Alpha and Beta Direct Scan: Cost activity includes using the Bicron Electra Ratemeter for taking detailed counts for alpha and beta particle emissions from areas of contamination identified with the alpha and beta scan. The activity is measured as a per square foot of area surveyed cost.

Demobilization (WBS 331.21)

Survey-Out Equipment and Decontaminate: This cost element provides for radiological survey of the equipment by a site HPT to ensure that contaminated equipment does not leave the site. This element includes costs for decontamination. Costs include equipment stand-by time plus HPT labor. The activity cost is measured as a lump sum for one activity.

Decontamination and Decommissioning Data Assembly and Documentation (WBS 331.17)

Record and Analyze Data: Cost activity includes collection, analysis, and interpretation of data from surveys conducted. The activity is measured as a per square foot of area surveyed cost.

Document Results: Cost activity includes placing measured levels of contamination on computer-aided drafting and design (CADD) drawings of the floor area surveyed. The activity is measured as a per square foot of area surveyed cost.

Cost Analysis

The baseline technology is assumed to be characterization using conventional equipment and methodologies, otherwise known as a manual survey. The baseline technology cost estimate takes data from a manual survey conducted on the D-055 test floor area of Building 330. To generate a comparable estimate between the baseline and the innovative technology, only those baseline activities considered equivalent to the capabilities of the innovative technology are included in the estimate. Tests such as conducting sampling of loose material using smears are excluded. Additionally, since the manual survey was conducted only on the test area of Building 330, production rates for the baseline tests are extrapolated to the other rooms and areas where the SRA device was demonstrated to produce a comparable estimate.

Manual tests considered equivalent to the demonstrated capabilities of the SRA device include measurements for background (gamma) radiation, measurements to assess the general level and location of alpha and beta contamination (qualifying), and measurements to assess the precise (or direct) level of alpha and beta contamination (quantifying).

Cost data on the instrumentation used for equivalent tests was gathered in order to establish equipment hourly rates. These include current purchase price, calibration expenses, and consumables and were amortized over an anticipated equipment life span of 15 yr based on current experience and use of existing HPT equipment at ANL.

Production rates are measured in square feet per minute. Extrapolated times do not factor room configuration or the presence of floor obstructions since it is assumed that utilizing the hand-held instruments affords enough flexibility to minimize those effects. Assumptions for formulating the baseline cost estimate are summarized as follows:

- All survey equipment is owned by ANL.
- Surveying work is performed by one site HPT.
- PLFs for potential use of PPE and respiratory protection are not considered.
- Radiological characterization is for alpha and beta-gamma contamination only.
- Costs for smear sampling for loose contamination and gamma exposure rate measurements are not included in the baseline cost estimate.
- Hourly equipment rates are established based on a 15-yr useful life, a yearly use rate of 1,000 h, and a discount rate of 5.8 percent for all components.
- An acquisition cost of 9.3 percent of the purchase price of the equipment is added to the cost of the equipment.
- Equipment calibration is checked only once before beginning all work.
- Extrapolated times for surveying other rooms are based on production rates established for the test area of Building 330.
- Times to move equipment from one room or area to another are omitted.
- Demobilization consists of surveying-out equipment used and is done only once at the completion of all surveying work.
- Drawings or sketches of the rooms and areas surveyed are already available for documenting the survey results.

Based on these assumptions, the activities, quantities, production rates, and other costs associated with the baseline (or manual) method for surveying are shown in Table B-2, Cost summary - baseline technology.

Table B-2. Cost summary - baseline technology

Work Breakdown Structure (WBS)	Unit Cost (UC)						Total Quantity (TQ)	Unit of Measure	Total Cost (TC)[1]	Comments
	Labor		Equipment		Other	Total Unit Cost				
	Hours	Rate	Hours	Rate						
Mobilization (WBS 331.01)								**Subtotal:**	**$33.67**	
Set Up Equipment for Use	0.58	$56.00	0.58	$2.05		$33.67	1	Lump Sum (LS)	$33.67	
Deactivation and Decommissioning Characterization (WBS 331.17)								**Subtotal:**	**$698.02**	
Gamma Scan (Background Measurement)	0.0017	$56.00	0.0017	$0.52		$0.10	2,800	Square Foot (f^2)	$269.04	based on productivity rate established for surveying six rooms - see baseline assumptions
Scan for Alpha and Beta (Qualifying Measurements)	0.0008	$56.00	0.0008	$0.82		$0.05	2,800	ft^2	$130.46	based on productivity rate established for surveying six rooms - see baseline assumptions
Take Direct Readings for Alpha and Beta (Quantifying Measurements)	0.0019	$56.00	0.0019	$0.71		$0.11	2,800	ft^2	$298.52	based on productivity rate established for surveying six rooms - see baseline assumptions
Demobilization (WBS 331.21)								**Subtotal:**	**$58.05**	
Survey-Out Equipment	1.00	$56.00	1.00	$2.05		$58.05	1	LS	$58.05	equipment standby plus time for a Health Physics Technician (HPT) to survey the equipment
Decontamination and Decommissioning Data Assembly and Documentation (WBS 331.17)								**Subtotal:**	**$324.58**	
Record and Analyze Data	0.0013	$56.00				$0.07	2,800	ft^2	$196.00	total for six rooms
Document Results	0.0008	$56.00				$0.05	2,800	ft^2	$128.58	total for six rooms
								TOTAL:	**$1,114.32**	

[1] TC = UC*TQ

APPENDIX C

ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	**Description**
ACE	Activity Cost Estimate (Sheets)
ANL	Argonne National Laboratory
CADD	Computer-Aided Drafting and Design
CFR	*Code of Federal Regulations*
CP-5	Chicago Pile 5 Research Reactor Facility
3D-ICAS	Three-Dimensional, Integrated Characterization and Archiving System
D&D	Decontamination and Decommissioning
DDFA	Deactivation and Decommissioning Focus Area
DOE	Department Of Energy
ESH	Environment, Safety and Health
ft	Foot (Feet)
h	Hour(s)
HP	Health Physics
HPT	Health Physics Technician
HTRW RA WBS	*Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary*
lb	Pound(s)
LCD	Liquid Crystal Display
LS	Lump Sum
LSDP	Large Scale Demonstration Project
MACS	Mobile Automated Characterization System
min	Minute(s)
OMB	Office of Management and Budget
OSHA	Occupational Safety and Health Administration
OST	Office of Science and Technology
PC	Personal Computer
PLF	Productivity Loss Factor
PPE	Personnel Protective Equipment
SBIR	Small Business Innovative Research
SCM	Surface Contamination Monitor
SIMS	Survey Information Management System
SRA	Shonka Research Associates, Inc.
USACE	U.S. Army Corps Of Engineers
yr	Year(s)