INNOVATIVE TECHNOLOGY

Summary Report

DOE/EM-0407

# Indoor Radiation Mapping Using the Laser Assisted Ranging and Data System (LARADS)

**Deactivation and Decommissioning Focus Area**

*Prepared for*

**U.S. Department of Energy**

Office of Environmental Management

Office of Science and Technology

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INNOVATIVE TECHNOLOGY
Summary Report

# Indoor Radiation Mapping Using the Laser Assisted Ranging and Data System (LARADS)

OST Reference #1946

**Deactivation and Decommissioning Focus Area**

*Demonstrated at*
Hanford Site
Richland, Washington

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 on the OST Web site at http://OST.em.doe.gov under "Publications."

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# SECTION 1- EXECUTIVE SUMMARY

The Laser Assisted Ranging and Data System (LARADS) is a characterization technology that provides real-time data on the location and concentration levels of radiological contamination. The system can be utilized with a number of available detection instruments and can be integrated with existing data analysis and mapping software technologies to generate superior quality survey data reports. This innovative technology is competitive with baseline technologies in terms of cost and survey times, but is much more flexible and provides more useful reports. The system also has the capability of electronically logging survey data, making it easy to store and retrieve. Such data are scientifically derived and not subject to interpretation. The LARADS is an extremely attractive alternative to manually generated survey data reports.

## ■ Technology Summary

This section summarizes the demonstration of an innovative characterization technology, Laser Assisted Ranging and Data System (LARADS), developed by Thermo NUtech and its subsidiary, Thermo Hanford, Inc. (THI). The LARADS provides real-time data on the location and concentration levels of radiological contamination during surveys. The LARADS, which also produces automated survey reports, was demonstrated for the U. S. Department of Energy's (DOE) C Reactor Interim Safe Storage (ISS) Project Large Scale Technology Demonstration (LSTD) at the DOE's Hanford Site in Richland, Washington. 1394 $m^2$ (15,000 $ft^2$) of wall and floor surfaces were surveyed.

***Problem Addressed***

DOE's nuclear facilities require characterization and documentation of the results as part of planning and decision-making for decontamination and decommissioning (D&D) projects and to release areas that have been cleaned up. Conducting radiation surveys of indoor and outdoor surfaces and generating accurate survey reports is an important component of the D&D program. Historically, at the Hanford Site radiation survey reports have been generated by observing and recording readings from the survey instrument and preparing handwritten reports, usually containing crudely-drawn sketches of the areas being surveyed. This method is not always reliable, as handwritten reports are often unclear or illegible, and source term quantification and location are uncertain. The volume and quality of data that can be included in these manually generated reports is minimal.

The LARADS provides an attractive alternative to traditional methods of generating radiological survey data reports. The LARADS is based on integration of an auto-tracking civil surveyor's "total station" with a radiological detection system, along with electronic data generation and storage, and is characterized by the following features, capabilities, and configuration:

***Features and Configuration***

- Compatible with readily available portable or hand-held radiological survey detectors for both beta/gamma and alpha surface contamination
- Applicable to a variety of surfaces including floors, buildings, and structures (either interior or exterior)
- Capable of providing well-documented, usable release surveys or providing characterization surveys involving high levels of contamination
- Adaptable to mobile platform configurations for large-area surveys

- Electronic storage of survey and radiation detection data that are scientifically derived and not subject to interpretation or recorded manually
- Flexible report generation capabilities that are easily integrated with existing software technologies (such as a Geographic Information System [GIS] or computer-aided design [CAD]), providing three-dimensional graphic and photographic presentations.

The LARADS consists of the following components:

- Tracking system
- Radio or wired data communication devices
- Customized software and a portable computer that can be set up either at the survey area or remotely

A hand-held radiological detector with a count rate meter was employed in this demonstration.

***Potential Markets***

The technology is suitable for DOE nuclear facility D&D sites or similar sites that must be surveyed to facilitate property transfer or release.

***Advantages of the Innovative Technology***

The following table summarizes the innovative technology against the traditional (baseline), hand-written survey reports, in key areas:

| Category | Comments |
|---|---|
| Cost | The cost of operating the LARADS technology ($5.00/m$^2$)* is similar to the baseline ($5.27/m$^2$) , and less costly for highly-contaminated areas |
| Performance | The LARADS produces reports that are more accurate, complete, and clear than the current baseline |
| Implementation | No special site services are required to implement the LARADS or the baseline |
| Secondary Waste Generation | The LARADS (and the baseline) do not generate any significant secondary waste |
| ALARA | Use of the LARADS enhances as low as reasonably achievable (ALARA) practice compared to the baseline tested by reducing the time that technicians spend noting detector readings and locations while in proximity to contamination sources |
| | * Cost for LARADS shown applies if one RCT is used, as discussed in the Cost Conclusions in Section 5 |

***Shortfalls/Operator Concerns***

As the total station is the comparatively high-cost item of the LARADS, proper radiological work practices and engineering controls should be taken to prevent it from becoming contaminated. While contamination will not weaken its ability to perform surveys, it will affect the locations where it can be used without radiological controls. (As presently configured, the tripod can be wrapped in plastic, but the head cannot be completely wrapped. A cover that would protect over 90% of the head surface could be added.) As with any radiological detection device, the same care should be taken to prevent the radiological detector from becoming contaminated, as this will probably affect survey results. The operator must check that tracking and electric power supply are maintained.

***Skills/Training***

Training of field technicians is minimal (less than one day), provided that the trainees are proficient in standard radiological survey practices. The set up and use of the total station requires technician training on this system. In addition, personal computer (PC)-based knowledge, along with the use of GIS software, are necessary to produce enhanced-quality Auto-CAD overlay reports.

## ■ Demonstration Summary

This report covers the period February through December 1997, during which time 1394 $m^2$ (15,000 $ft^2$) of floors and walls were surveyed at the C Reactor.

***Demonstration Site Description***

At its former weapons production sites, the U. S. Department of Energy (DOE) is conducting an evaluation of innovative technologies that might prove valuable for facility decontamination and decommissioning (D&D). As part of the Hanford Site LSTD at the C Reactor ISS Project, at least twenty technologies will be tested and assessed against baseline technologies currently in use. DOE's Office of Science & Technology/Deactivation and Decommissioning Focus Area, in collaboration with the Environmental Restoration Program, is undertaking a major effort of demonstrating improved and innovative technologies at its sites nationwide, and if successfully demonstrated at the Hanford Site, these innovative technologies could be implemented at other DOE sites and similar government or commercial facilities.

***Applicability***

- This system is useful for site characterization in support of D&D engineering design and during and subsequent to D&D activities.
- By using various radiation probes, the LARADS has the ability to capture both alpha and beta/gamma information.
- Clear, concise, comprehensible maps can be automatically generated representing the location and extent of contamination. These maps are useful for job planning and decontamination activities. Additionally, data can be used as input to dose assessment software with more accuracy, completeness, speed, and reproducibility than with the baseline technology.

***Key Demonstration Results***

It was successfully demonstrated that the LARADS system has the following capabilities:

- Accurate correlation of contamination level to the contamination location (+/- 2.5 cm [1 in.]).
- Continuous radiological data acquired and stored in database format.
- Clear, concise, easily understood graphics of survey data.
- Provides a tracking record that can be used to check for full coverage of the surface that was surveyed.
- Flexibility with the existing software allows the system to be adapted to most radiation survey probes such as scintillator detectors (gamma or alpha probes), gas-filled detectors, and Geiger Mueller (GM) probes.
- Costs using the innovative technology are similar to baseline costs; however, report information is more complete and comprehensible, resulting in indirect cost savings to a project.

- Production rates using the innovative technology are better than with the baseline for areas larger than several hundred square meters. Based on production rates demonstrated, an example area of 520 $m^2$ (5600 $ft^2$) would take 7 work days with LARADS and 10 days with the baseline technology.

### *Regulator Issues*

The LARADS is a mapping tool for characterization of contaminated surfaces; therefore, there are no special regulatory permits required for its operation and use. The detection level of the radiological instrumentation meets the requirements of 10 *Code of Federal Regulations* (CFR) Parts 20 and 835, and proposed Part 834.

### *Technology Availability*

This technology is commercially available through THI or Thermo NUtech (parent Co. of THI), on a service contract basis, for beta/gamma and alpha surveys of floors and walls.

### *Technology Limitations/Needs for Future Development*

Due to physical size and geometry of the total station, this system is not appropriate for small, congested areas. However, other than adding metric conversions to the mapping feature, at the present time there is no need to modify the system demonstrated at the Hanford Site C Reactor.

## ■ Contacts

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All published Innovative Technology Summary Reports are available at http://em-50.doe.gov. The Technology Management System, also available through the EM-50 Web site, provides information about OST programs, technologies, and problems. The OST Reference # for Indoor Radiation Mapping Using the Laser Assisted Ranging and Data System (LARADS) is 1946.

# SECTION 2

# TECHNOLOGY DESCRIPTION

## ■ Overall Process Definition

The DOE nuclear facilities D&D program requires accurate documentation of radiological survey results obtained for inside and outside surfaces. Traditionally, this has been accomplished with the preparation of handwritten survey reports, that are often difficult to read. The LARADS technology offers a viable alternative to this conventional approach by providing comprehensive, high-quality, useable reports. The system (Figure 1) consists of these distinct components:

**Figure 1a. The LARADS system in action.**

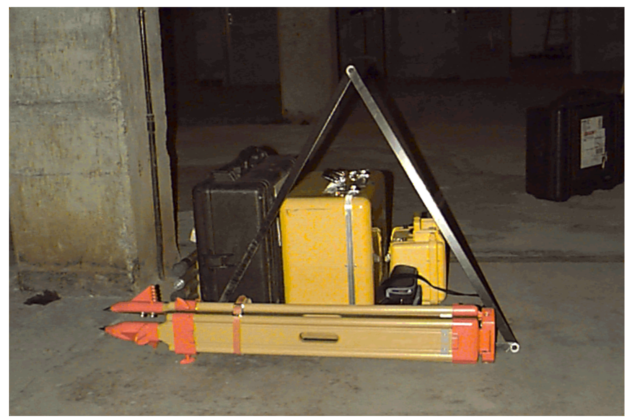


**Figure 1b. The LARADS equipment as packaged.**

### *Components*

1. A tracking system. This consists of a modified civil surveyor's "total station." A total station is capable of determining range (distance from the measurement probe to the total station setup), azimuth, and elevation to a target. A target prism mounted on or in close proximity to the radiological detector reflects a low-intensity laser beam back to the total station.

2. Radio data communication devices (as was used in the C Reactor demonstration). (Note that wired communication is an option.) The measured contamination level is transmitted to a receiver that is connected to a computer.

3. A portable notebook PC and customized software. The system produces files that can be imported into a number of commercially available GIS software packages.

Also, an off-the-shelf portable radiological count rate meter (e.g., Eberline E-600 with suitable detector[s]) with automatic data transmission capabilities is used with the system.

### *Overview*

- The LARADS is capable of determining the position of a radiological detector as it moves across the subject of interest (wall, floor) and storing the positional coordinates of the detector, as well as the radiological reading, in electronic files. The system accurately transcribes the readings to various types of mapping displays.

- The system has customized software that allows it to display in real-time on the PC monitor the survey trace, a background view of a surface (i.e., digital photo or CAD drawing) and the current radiological reading(s). The survey trace can be used to check that full coverage of the surface has been attained. Radiological data points that exceed a user-defined set point are highlighted as the survey progresses.
- The system provides a projected plan view of walls, top view of floors, and bottom view of ceilings, with X/Y origin user-selectable (usually left-hand corner of the room), area under survey, or a component being surveyed. The system is also capable of generating results in geodetic (i.e., State Plane, UTM, etc.) coordinates.
- Depending on the type of detector used, this technology accommodates up to two channels of radiological information storage per position, i.e., alpha, beta, gamma, or multiple region of influence gamma.
- The LARADS accommodates collection of radiological data in a buffer when it has lost lock with the detector, such as when the surveyor passes behind obstructions. Once lock-in is re-established, data are linearly interpolated between the two “good” positions. These interpolated values are flagged in the stored file for later interpretation and quality assurance.
- The electronic files collected are downloaded and processed in CAD, GIS, and/or other software packages to overlay on digital photos or CAD drawings to produce a graphical representation of contamination levels across the surface. These files can be loaded into a number of available database/spreadsheet packages for statistical analysis.
- The system is battery-operated and capable of ~8 hours of operation between charges. The only expendable items that would be generated by implementing this technology are the optional plastic wrappings that can be used to prevent contamination of equipment.
- The LARADS can accommodate a variety of radiation detection probes (e.g., alpha scintillator counter, beta/gamma counter such as a gas proportional counter or an ion chamber, sodium iodide detector, etc.)

## ■ System Operation

***Setup***

It takes about 20 minutes to set up the system under normal operation conditions (noncongested and open areas, ~3 m x 4 m [9 ft x 12 ft]). Prior to initiating the survey, the setup involves the following steps:

- Source check the radiological detection subsystem
- Mount and level the total station on a tripod
- Connect the total station to a power source and a computer
- Measure the height of the laser window from the floor and input the height into the computer
- Connect a radio modem with a battery attachment to the computer and to the survey instrument
- Perform a system check to verify that all of the components are operating
- Establish a predetermined alarm set point for the rate meter and set the alarm using the computer menu
- Establish a lock from the laser to the prism that is attached to the detector.

Under ideal conditions, the total station would be set up at least 3.7 m (12 ft) from the survey area. A larger distance from the survey surface translates to a wider area that can be surveyed without moving the total station and performing additional setup sequences. The computer can be at any convenient location, either in the same building or at a remote office.

***Operation***

The survey can be performed by one or two people. In a one-person operation, the surveyor will watch the face of the Eberline E380-AB/E-600 probe/meter and/or listen to the audio function for signs of increasing activity during the survey. With two people, one surveyor will monitor the survey on the computer screen while the second performs the scan and maintains proper detector scan rate and distance from the survey surface. While two people are not required, the time to set up and complete a survey can be slightly shortened and two persons make it convenient if the total station is placed at a far distance or if hand scanning a large area results in operator fatigue. Personnel using the LARADS need basic computer skills and an understanding of x - y coordinate systems. During each survey, the operator must ensure that electric power and tracking are maintained. Where non-fixed contamination is involved, the equipment should be protected from contamination. There are no secondary waste streams or any substantial safety or environmental concerns with the LARADS technology.

# SECTION 3

## PERFORMANCE

## ■ Demonstration Plan

***Site Description***

The demonstration was conducted at the C Reactor building at DOE's Hanford Site. The purpose of the LSTD program is to demonstrate and document performance data and costs for improved and innovative technologies that can aid in placing the C Reactor into an interim storage mode for up to 75 years, or until the final disposal of the reactor's core is completed. The C Reactor ISS objectives include placing the reactor in a condition that will not preclude or increase future decommissioning costs, minimizing the potential for releases to the environment, and reducing the frequency of inspections thereby reducing potential risk to workers.

The DOE nuclear facility D&D program requires accurate characterization of buildings and structures in order to plan D&D activities or to certify facilities for unrestricted release. The demonstrations of the LARADS and the baseline technology were conducted in the Laundry Sorting Room of the C Reactor facility. Approximately 53 $m^2$ (570 $ft^2$) of floors and walls up to about 2.5 m (8 ft) was surveyed with the LARADS for both beta/gamma and alpha radiation. Similarly, 49 $m^2$ (525 $ft^2$) were surveyed using the baseline technology. THI, a subsidiary of the developer and one of Bechtel Hanford Inc.'s (BHI) subcontractors, provided radiological control technicians (RCTs) for the demonstration. THI developed and submitted a specific procedure for the completion of this demonstration. The procedure was carried out as a demonstration on February 14 and 19, 1997. Over 1341$m^2$ (14,430 $ft^2$) at the C Reactor were subsequently surveyed using the LARADS and released, making the total area surveyed equal to 1394 $m^2$ (15,000 $ft^2$).

***Demonstration Objectives***

Objectives of the demonstration included the following desired performance features for the equipment:

- Capability of measuring survey points with xyz coordinates along with radiological readings (i.e., perform a release survey with locating and quantifying of hot spots).
- The product must be a real-time, three-dimensional, radiation map.
- Mapping accuracy within 2.5 centimeters (1 in.).
- Easy to decontaminate with conventional practices.
- Ability to operate at temperatures between 3$^o$C and 40$^o$ C.
- Have background subtraction capability.
- Ability to operate in a radiologically contaminated zone and able to perform the demonstration in such a way as to avoid contamination.
- Ability to store and interpret a building grid (coordinates), a floor grid, and a wall grid. Output must result in a map of contamination related to the physical structures (room, wall, door, window, column, etc.).
- The composite electronic file must be down-loadable to a commercially available PC system. The computer, software, and software license must be supplied with the unit.

***Demonstration Chronology***

To briefly summarize, the demonstration operations and main steps included the following:

- The LARADS was checked for operation by THI personnel prior to and after the demonstration at the Hanford Site.
- The total station and ranging system was calibrated by THI prior to the start of the demonstration and was rechecked after the demonstration.
- The radiological probes used by this system were calibrated by Pacific Northwest National Laboratory (PNNL) prior to the demonstration and source checked by THI personnel prior to and after the demonstration.
- Approximately 100% of the reachable areas (approximately 53 $m^2$ [570 $ft^2$]) of the Reactor Laundry Sorting Room was mapped using the LARADS for beta/gamma radiation. For any area that exceeded the predetermined beta/gamma level set point, an alpha measurement was also conducted to determine the alpha contamination level. Since the demonstration, The LARADS has been deployed at C Reactor, and over 1394$m^2$ (15,000 $ft^2$) of surfaces have been surveyed for beta/gamma and released. Costs are based on surveying 520 $m^2$ (5,600 $ft^2$).
- Radiological information was obtained using a commercially-available 100 $cm^2$ active area zinc sulphide-coated thin plastic scintillation detector (Eberline E-380-A/B) interfaced with a commercially-available count/dose rate meter (CRM [Eberline E-600]). Data were collected and stored on the LARADS onboard notebook computer in units of counts per minute (cpm). Later these data were analyzed and converted to radiological activity and reported in units of disintegrations per minute (dpm), normalized for $Cs^{137}$.

## ■ Treatment Performance

***LARADS***

The LARADS collects data points at a rate of one per second. These data points represent the radiological information from the CRM and their associated physical coordinates. The LARADS records these data points in electronic files with the onboard computer system. This allows downloading of these files into a GIS for generating maps of the surveyed area and creation of a database relevant to the positions and radiological readings.

Each surface survey effort entailed initializing the tracking sub-system, powering up the radiation detection sub-system and computer, and performing the survey. The initialization sequence allowed the tracking sub-system to establish a local coordinate system for each surface. (This coordinate system is currently in English Standards units [feet]. There are plans to modify the LARADS to report in metric units, but this modification was not in place for this specific demonstration project.)

Every attempt was made to traverse the survey area on parallel passes ensuring 100% coverage of the area; however, this was not always possible. The survey speed was approximately 2 in./sec. to 3 in./sec. A spacing jig was attached to the detector to maintain its distance, as near as practical, to 1/4 in. from the surface. In this manner, detector geometry remained relatively constant throughout the wall survey portion of the project. However, using a handle extension ("walking stick") to allow floor surveys to be conducted with less discomfort to the surveyor, caused the detector geometry to suffer when conducting the floor survey. (This was corrected in other work with the LARADS.)

The LARADS surveyed approximately 53 $m^2$ (570 $ft^2$) during initial demonstration activities. Since the demonstration, the LARADS has been successfully deployed at C Reactor and a total of over 1394 $m^2$ (15,000 $ft^2$) of surfaces have been surveyed and released. The information collected during the deployment, along with information collected during the demonstration were used for performance and cost evaluations presented in this report. During the initial demonstration phase, the LARADS system collected a total of 7,163 data points within the surveyed areas. Each of these data points represents the radiological information from the specific radiological detector along with the physical coordinates of the readings.

Forty-three of the initial data points collected contained readings above the minimum detectible activity (MDA). When the LARADS CRM detector passes over a contaminated area, the cpm logged will rise, peak, and tail off again to background levels. Due to their spurious nature, 10 of these readings were determined to be "false positive," which accounted for less than 0.14% of the data collected and that were identified as false in data processing. These false positives are kept in the data files, but are filtered out for the graphics or tables included within the survey report.

Two locations on the floor were found to be contaminated above the detection systems MDA. One of these was found to exceed 5k dpm/100 $cm^2$ (the 10 CFR 835 Appendix D value). This was found in a construction joint located in the southeast corner of the floor. The other elevated reading location was below the 5k dpm/100 $cm^2$ level (4371 dpm/100 $cm^2$). This elevated location was found in a slab penetration or insert located in the southeast quadrant of the floor area. (These two locations were also noted in the baseline survey.)

Figure 2 is a survey track map of the floor with the area surveyed overlaid on vector-based room feature schematics. This figure is presented as a comparison to the current baseline method of hand drawing sketches (Figure 3). Figure 4 is a survey track maps overlaid upon digital photos of a wall area. Figures 2 and 4 show the LARADS data mapping and presentation capabilities.

***Baseline***

- THI RCTs performed a survey of all the floor and reachable wall areas of the Laundry Sorting Room (same area as the initial LARADS survey), using the same radiation detection probe and meter as the LARADS, and the same survey protocol for beta/gamma and alpha radiation filed measurements. All detectors were calibrated by PNNL and source checked by THI RCTs.

- Areas that indicated elevated beta readings were static checked for beta/gamma activity and also static checked using a zinc sulphide scintillation detector system (an E-380AB probe with an E-600 meter) for alpha radiation. Hot spot areas are normally marked with paint to identify the contaminated areas for future references, but they were not marked for this demonstration.

- The interior walls of the room were surveyed to a height of approximately 8 ft from the floor surface, and the floor surface was surveyed in its entirety.

- A handwritten radiological survey report was generated containing information regarding the conduct of the survey such as date, time, instruments used, location, etc., as well as the survey results. This report included a hand drawn sketch of the surveyed area with associated radiological contamination levels (see Figure 3).

# LARADS Radiological Survey

## 105-C Technology Demonstration Project

### Floor - Laundry Sorting Room
### Survey Track Map

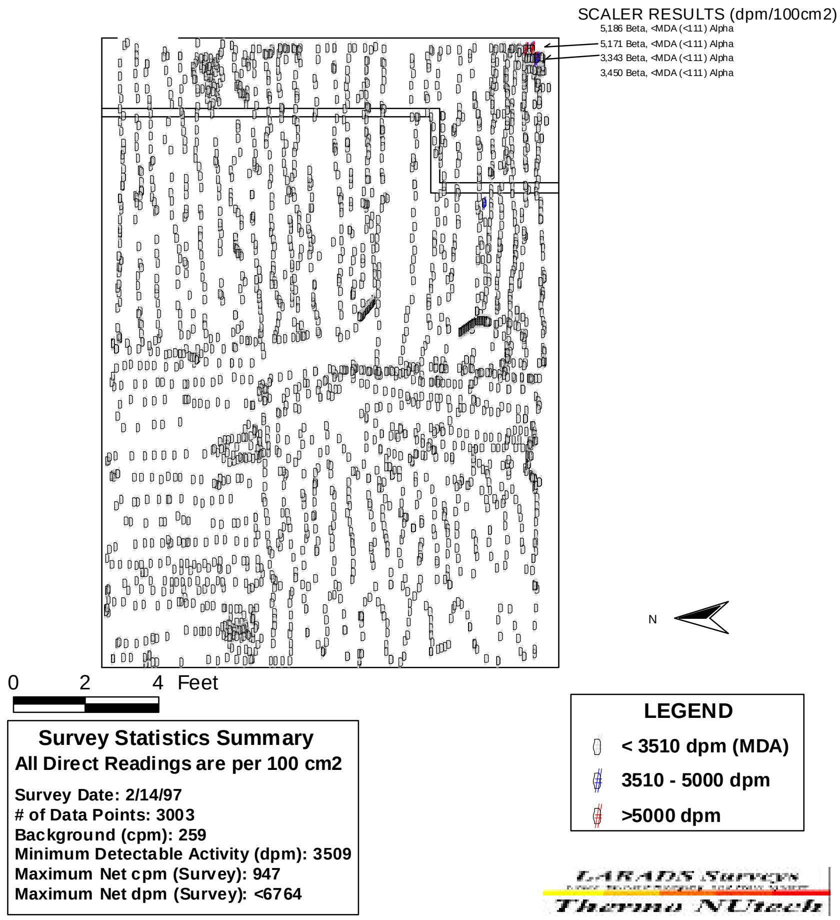



**Figure 2. The LARADS survey track map of the Laundry Sorting Room floor.**

**Note: Spaces between data points are not survey gaps, because the detector face is much larger in area. All areas were scanned with overlap.**

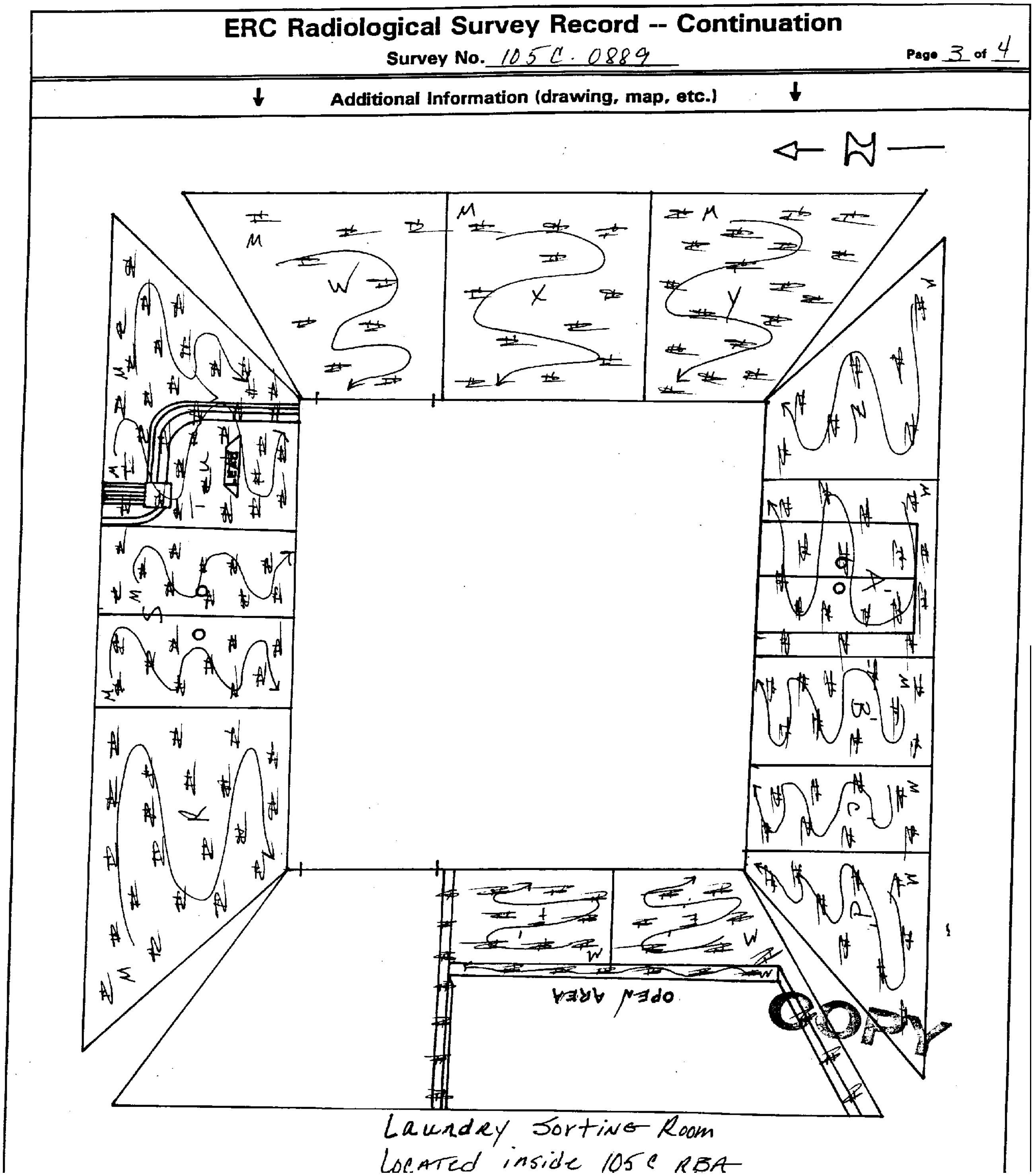



**Figure 3. Baseline survey report of the Laundry Sorting Room walls.**

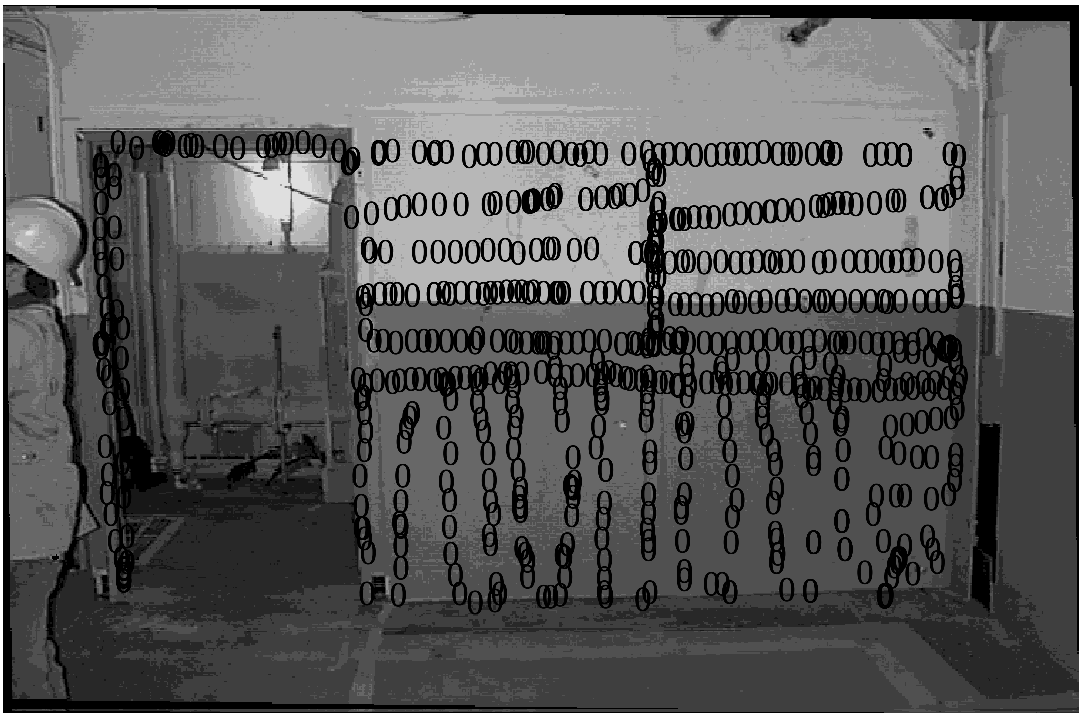
**Notes:**

- **All areas were scanned with overlap.**

# LARADS Radiological Survey

## 105-C Technology Demonstration Project

### East Wall - Laundry Sorting Room
### Survey Track Map



1 0 1 2 Feet

0 **< 3509 dpm (MDA)**

**Survey Statistics Summary**
**All Direct Readings are per 100 cm2**

Survey Date: 2/14/97
# of Data Points: 700
Background (cpm): 259
Minimum Detectable Activity (dpm): 3509
Maximum Net cpm (Survey): 79
Maximum Net dpm (Survey): <3509 (<MDA)

LARADS Surveys
Thermo NUtech

**Figure 4. The LARADS overlay of survey results on the east wall of the Laundry Sorting Room.**

**Note: All areas were scanned with overlap.**

***Meeting Performance Objectives***

The objectives listed in the Demonstration Overview section were met. The main purpose of this demonstration was to evaluate the data collection and survey result mapping capability of this system; evaluation of the radiological detector employed is not within the scope. In addition, the LARADS identified and mapped the same hotspots that the baseline survey system located and identified.

***Comparison of Innovative Technology to Baseline***

Table 3-1 summarizes performance and operation of the innovative technology compared to the baseline technology.

Because of the variety of functions and facilities, the DOE complex presents a wide range of D&D working conditions. The working conditions for an individual job directly affect the manner in which D&D work is performed. Evaluations of the innovative and baseline technology presented in this report are based upon a specific set of conditions or work practices found at the Hanford Site, and are presented in Table 3-2. This table is intended to help the technology user identify work item differences between baseline and innovative technologies.

***Skills/Training***

Training of field technicians is minimal, provided that the trainees are proficient in standard radiological survey practices. The set up and use of the total station requires technician training on this system. It was observed during the deployment of the LARADS that the experienced RCTs can learn to operate the system in less than a day. In addition, PC-based computer knowledge, along with the use of GIS software, are necessary to produce enhanced quality Auto-CAD overlay reports. This can easily be achieved provided that the operator has the basic knowledge of operation of PC-based computer software. Training of onsite personnel is not involved if the LARADS is deployed as a vendor service.

***Operational Concerns***

As the total station is the comparatively high-cost item of the LARADS, proper radiological work practices and engineering controls should be taken to prevent it from becoming contaminated. While contamination will not weaken its ability to perform surveys, it will affect the locations where it can be used without radiological controls. (As presently configured, the tripod can be wrapped in plastic, but the head cannot be completely wrapped. A cover that would protect over 90% of the head surface could be added.)

As with any radiological detection device, the same care should be taken to prevent the radiological detector from becoming contaminated, as this will probably affect survey results.

The LARADS operator must be vigilant to ensure that tracking and electric power supply are maintained.

**TABLE 3-1. Summary of Performance and Operation - Baseline Versus Innovative Technology Demonstration.**

| Activity or Feature | Baseline Tech | Innovative Tech Demo |
|---|---|---|
| Field time (Survey)[1] | Same | Same |
| Coverage of Area[1] | ~100% | ~100% |
| Setup[2] | 0.33 hrs | 1 hr |
| Calibration[3] | Same | Same |
| Report Preparation | 2 hrs | 0.5 hr (and with better quality than baseline) |
| Report Archiving | Hard copy, microfilming[4] | Electronic format |
| Report Clarity | Acceptable | Better than baseline |
| Survey Report Generation | 30 min. | 30 min. |
| Flexibility | Adequate | More flexible than baseline |
| Precision, accuracy, representativeness, completeness | Adequate | Better than baseline |
| Safety | Same | Same |
| Data interpretation | Adequate | Better than baseline |
| Ease of operation | Easy | Need some training[5] |
| Waste generation | Minimal | Plastic wrap to protect equipment |
| Utility requirements | Same | Same |
| Reproducibility[6] | Subjective | Better than baseline |
| Ease of Use[5] | Skill of craft | More involved than baseline[5] |

(Hours shown are person-hours)

**NOTES:**

1. Two persons were used for 3 hours each for the improve/innovative technology demonstration. However, the system can be operated with one person for improved labor efficiency.
2. Setup, as used to describe baseline, includes time to layout grid lines prior to survey and is highly dependent upon size of surface area to be surveyed. The LARADS setup is time to level tripod and connect system cabling and is <20 min per room regardless of size.
3. The radiological detection sub-system used for the LARADS demonstration is easier to calibrate than the baseline rad detection meter. The contamination rate meter used with the LARADS can be calibrated to an alpha/beta detector in <45 min.
4. Costs to prepare and maintain records unknown.
5. Training and ease of use are not involved if the LARADS is deployed as a vendor service.
6. Reproducibility is defined as the ability to return to the same precise location after passage of time to compare readings.

**Table 3-2. Summary of Variable Conditions**.

| Variable | The LARADS Technology | Baseline Technology |
|---|---|---|
| Scope of Work | | |
| Quantity and type of material surveyed in test areas * | 502 $m^2$ (5600 $ft^2$) of floor and wall surfaces surveyed in one room; results of the survey are mapped and a report is generated. | 49 $m^2$ (525 $ft^2$) of floor and wall surfaces surveyed in one room; results of the survey are mapped and a report is generated. |
| Location of test area | Reactor Building C, Laundry Sorting Room. | Reactor Building C, Laundry Sorting Room. |
| Nature of work | Surfaces were characterized and mapped for beta/gamma and alpha contamination. | Surfaces were characterized and mapped for beta/gamma and alpha contamination. |
| Work Environment | | |
| Level of contamination in the test areas | The demonstration area is not a radiation area. Any contamination that might be present is non-removable and, therefore, fixed. | The demonstration area is not a radiation area. Any contamination that might be present is non-removable and, therefore, fixed. |
| Level of floor obstructions in test areas | Unobstructed. | Unobstructed. |
| Work Performance | | |
| Technology acquisition means | Survey and mapping are a vendor provided service. | Survey and mapping are performed by Hanford Site RCTs. |
| Compliance requirements | Compliance is that necessary to meet the requirements for a typical survey. | Compliance is that necessary to meet the requirements for a typical survey. |
| Work Process Steps | | |
| Survey tracking rate<br><br>**(This is provided for information only and is not a factor in the cost comparison)** | Actual:<br>**6.3 cm/sec. (2.5 in./sec.)** | Actual:<br>**6.3 cm/sec. (2.5 in. /sec.)** |
| Data recording duration | Size of room being surveyed and level of contamination in the room will not impact the speed of data collection. | Larger and more heavily contaminated rooms will see a decrease in the speed of data collection due to the requirement for increased hand-logging of verification readings. (See the cost conclusions in section 5) |

* Areas surveyed shown in this table represent: walls surveyed using the innovative LARADS technology during June-August 1997; and walls and floor surveyed using the baseline technology. As mentioned in Section 5 on Cost, the cost analysis includes extrapolating the data for the 49 $m^2$ baseline survey to 520 $m^2$, in order to compare the technologies on an equal basis.

# SECTION 4

# TECHNOLOGY APPLICABILITY AND ALTERNATIVE TECHNOLOGIES

## ■ Competing Technologies

Alternative methods to the LARADS technology are the conventional hand-drawn maps, or the indoor Ultrasonic Ranging and Data (USRAD) system marketed by Chemrad Tennessee (Oak Ridge, Tennessee) that automatically does mapping comparable to the LARADS. The demonstrated system provides more complete survey reports that are generated faster and with less effort than the baseline method.

## ■ Technology Applicability

- This technology can be used to provide thorough, well-documented release or characterization surveys of contaminated or potentially contaminated floors, buildings, and structures prior to and after decommissioning and demolition/dismantlement.

- The system may be used both on interior and exterior surfaces.

- The precision and quality of the survey documents (maps generated by the system) supports regulatory review and fulfills the intent of free release survey requirements.

- For larger areas (>100 $ft^2$), the system can be configured with large-area detectors on a mobile platform for surveying walls, ceilings, and floors.

- The LARADS is very flexible. Compatibility with the existing software allows the use of the majority of available portable or hand-held radiological survey detectors (e.g., sodium iodide for Cs-137 and Co-60 gammas, GM probe, alpha scintillator probe, etc.). The automatic tracking, ranging, and mapping capabilities are adaptable to surveying any surface. As the system collects three-dimensional coordinates, it may be used on surfaces (to the extent that probe size allows; probe is 4 in. wide and 6 in. long) as well as general area (i.e., middle of the room, a distance above the floor or wall). Three-dimensional presentation software exists and data presentation is dependent on the user's needs and requirements.

- The system can also be configured with high-level radiation detectors and can be used for investigating and documenting more extreme radiological conditions.

## ■ Patents/Commercialization/Sponsor

This technology is commercially available through THI or Thermo NUtech (parent Co. of THI), on a service contract basis, for beta/gamma and alpha surveys of floors and walls.

The demonstration at C Reactor was sponsored by DOE's Office of Science & Technology/Deactivation and Decommissioning Focus Area, in collaboration with the Environmental Restoration Program.

## ■ Marketplace Opportunities

- Radiologically contaminated sites with surface contamination or suspect surface contamination slated for remediation or D&D activities and release (DOE, U. S. Environmental Protection Agency or U. S. Nuclear Regulatory Commission [NRC] sites).

- Operational and maintenance radiation surveys at DOE or NRC sites.

# SECTION 5

## COST

The purpose of this section is to summarize cost elements for the innovative technology and analyze the potential for savings relative to equivalent cost elements for the baseline technology. The objective is to assist a decision maker who is considering further investigation of the innovative technology or those who may desire to deploy such a system.

## ■ Methodology

This cost analysis compares the innovative LARADS technology, interfaced with standard portable radiological CRMs, to a baseline technology consisting of surveying with standard count/dose rate meters and hand-mapping and recording the results. The latter has been the standard procedure for radiological surveying of wall surfaces at the Hanford Site. Costs for the innovative technology are taken from actual costs experienced during its deployment at the C Reactor, where it was used to survey walls in several rooms of the building. Costs for the baseline technology are taken from a demonstration conducted in the Laundry Sorting Room of the C Reactor. A total 1394 $m^2$ of surfaces have been surveyed using the LARADS technology, of which 520 $m^2$ were completed at the time this cost comparison was developed, compared to a total of only 49 $m^2$ of wall and floor surveyed during the initial demonstration of the baseline technology. Thus, for comparison purposes, costs for the baseline are extrapolated out to the 520 $m^2$ (5,600 $ft^2$). Final results from running both surveys are contained in reports that include maps of the surveyed surfaces detailing location, type, and level of contamination.

Activities included for cost comparison are as follows:

**Innovative Technology**

- Transport equipment from the storage area to the work area
- Set up the LARADS equipment and establish starting coordinates; run background check for CRM readings
- Survey utilizing a CRM interfaced with the LARADS
- Reposition the LARADS at new locations and reset coordinates
- Exit-frisk equipment
- Assemble report from the survey results

**Baseline Technology**

- Transport equipment from the storage area to the work area
- Set up equipment; run background check for CRM readings
- Survey with CRM and hand-record the data
- Exit-frisk equipment
- Assemble report from the survey results

Based on the conditions established for the comparison, costs for the LARADS vary from being essentially equivalent to the baseline technology to nearly twice the cost of the baseline technology. These differences are directly related to the number of RCTs utilized when surveying with the LARADS and are discussed in more detail herein.

## Cost Analysis

The LARADS technology is available from the vendor at the rates indicated in Table 5-1:

**Table 5-1. Innovative Technology Acquisition Costs.**

| ACQUISITION OPTION | ITEM | COST |
|---|---|---|
| Vendor provided service (based on 1997 rate per eight -hour day from Thermo Hanford, Inc.) | • Two vendor technicians<br>• The LARADS equipment, + rate meter and probe | \$800.00<br>\$60.00<br>**Total Daily Rate: \$860.00**<br>(with two technicians) |
| | • Alternative with one vendor technician<br>• The LARADS equipment, + rate meter and probe | \$400.00<br>\$60.00<br>**Total Daily Rate: \$460.00**<br>(with one technician) |

Observed unit costs and production rates for principal components of the demonstrations for both the innovative and baseline technologies are presented in Table 5-2.

**Table 5-2. Summary of Unit Costs & Production Rates Observed.**

| INNOVATIVE TECHNOLOGY | | | BASELINE TECHNOLOGY | | |
|---|---|---|---|---|---|
| **Cost Element** | **Unit Cost** | **Production Rate** | **Cost Element** | **Unit Cost** | **Production Rate** * |
| Set up the LARADS | \$188.00/each | N/A | Surveying with conventional instrumentation (assumes 1 RCT surveying) | \$3.21m$^2$/hr ($.29/ft$^2$) | 17.4 m$^2$/hr (187 ft$^2$/hr) * |
| Survey utilizing the LARADS<br>• with 1 RCT surveying<br>• with 1 RCT scanning + 1 RCT at the station | \$3.21/m$^2$ (\$.29/ft$^2$)<br>\$5.81/m$^2$ (\$.54/ft$^2$) | 18.6 m$^2$/hr (200 ft$^2$/hr)<br>18.6 m$^2$/hr (200 ft$^2$/hr) | Data analysis & report assembly (assumes 1 RCT compiling the report) | \$100.00/day** | N/A |
| Report generation (assumes 1 RCT compiling the report) | \$29.00/each | N/A | | | |

* The production rate for baseline will be adversely impacted if activity above background is encountered. With the LARADS, productivity can be constant. With baseline, the technician must stop and assess elevated response, either to quantify hot spots or to verify that activity is below criteria of concern.

** Baseline reports are done at the end of each workday.

Unit costs and rates indicated are only for the activities shown and do not consider mobilization, setup, productivity losses, or demobilization. Costs included in Table 5-2 for the innovative technology are for labor and for equipment rental; for the baseline costs are for labor and for equipment amortization. The total cost for using this technology is sensitive to several site-specific conditions. The survey production rate will vary with the working conditions, e.g., percent of job performed in rooms with irregular wall geometry, numerous openings in the walls, or permanent obstructions in front of the walls, all of which will force moving the LARADS more often and thereby decrease productivity.

For additional discussion of cost variable conditions that may occur when using the innovative technology and the potential effect these conditions may have on unit costs and production rates, refer to Section 3 of this report.

## ■ Costs

Figure 5 is a chart displaying a comparison of costs between the innovative and baseline technologies for surveying a total area of 520 $m^2$ ( 5,600 $ft^2$). As previously noted, this represents the actual wall areas surveyed during deployment of the LARADS technology at the C Reactor, but is an extrapolated wall area for the baseline technology. Both methodologies utilize the same hand-held instrumentation to obtain similar survey results. The comparison is based on total observed costs for each technology. This comparison is valid for release surveys where few spots are encountered that have activity higher than background.

A second scenario for utilizing the innovative technology is also included in the chart for comparison purposes. This scenario involves the use of one RCT to set up and do the surveying with the LARADS as opposed to the two RCTs that were actually used. See Appendix C for a description of activities included in each cost category and the detailed cost analysis for the innovative technology (both cases) and the baseline technology.

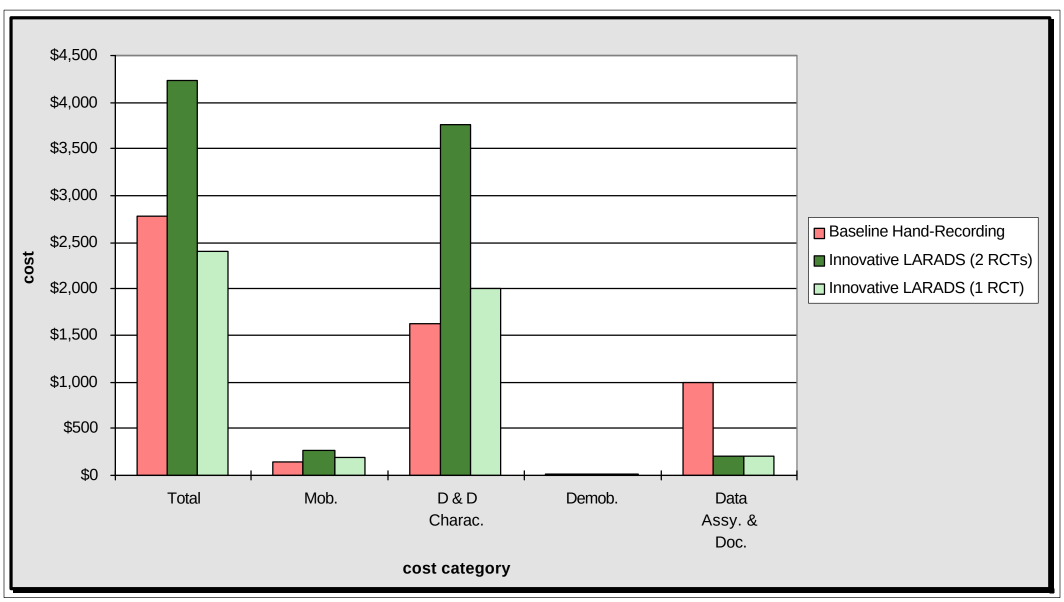



**Figure 5. Costs**.

## ■ Cost Conclusions:

When two RCTs use the LARADS for surveying, one manning the computer and the other running the survey instrument, the technology has higher costs than the baseline technology in all categories except for report generation. The total unit cost for the LARADS when utilizing two RCTs is $8.83/m$^2$ ($0.82/ft$^2$). The total unit cost for the baseline technology is $5.06/m$^2$ ($.47/ft$^2$ ). Total unit costs are based upon the conditions and assumptions established for the demonstration and are derived by dividing the total cost for each of the innovative and baseline technologies by 520 m$^2$ (5,600 ft$^2$) . See Appendix C, Tables C-1 an C-2 for calculations of total costs for the innovative and baseline technologies, respectively.

Although the LARADS takes more time to set up and move, it has a unique advantage over the baseline equivalent in its ability to store collected survey data for later assimilation into reports. This saves time in report generation. Also note that data listed in Table 5-2 show that the LARADS has a slight productivity advantage over the baseline technology. This is due to a lower confidence level in the data collected using the baseline method; i.e., hand-recording the data involves rechecking (or verification) of readings to ensure accuracy. The LARADS eliminates shortcomings inherent in the baseline methodology by automatically and precisely locating and recording survey instrument readings in the first pass.

A cost scenario using one RCT to run a LARADS survey on the demonstration wall area was generated and is presented in Table C-1.1 of Appendix C. Under this scenario, the total unit cost for the LARADS is $5.27/m$^2$ ($.49/ft$^2$) , making it nearly identical in cost to the baseline technology. It should be noted, however, that the standard procedure at the Hanford Site for surveying large wall areas or wall areas of any size that have a high level of contamination is to use two RCTs in order to allow alternating the RCT using the hand-held instrument. This reduces operator fatigue and the possibility of operator error.

For large and heavily contaminated wall areas, it is possible that using the LARADS with two RCTs may actually cost less than the baseline methodology. Taking redundant readings to pinpoint hotspots is characteristic with the baseline technology and, for heavily contaminated wall surfaces, can lead to a reduction in productivity over using the baseline methodology on lightly contaminated wall surfaces or wall surfaces being surveyed for free release. If a baseline scenario is run using an assumed 35% reduction in productivity (and all other conditions and assumptions for the demonstration are applied), then using the LARADS with two RCTs becomes less expensive than the baseline technology for wall surface areas over 715 m$^2$ (7700 ft$^2$).

In conclusion, a potential user of the innovative technology must weigh factors such as job size, duration and level and concentration of contamination in order to properly assess costs. If the job is complex, but under approximately 715 m$^2$ (7700 ft$^2$) in size, then the user may want to determine if the trade-off between the increased labor costs to run the LARADS with two RCTs is offset by its guaranteed increase in productivity, accuracy, and completeness over the conventional baseline methodology. For example, if the regulated requirements for a characterization or closure survey require an increased amount of documentation or an increase in precision, then it may be wise to utilize the LARADS technology. Those desiring a detailed description of assumptions used to formulate the cost comparison should refer to Appendix C of this report.

## SECTION 6

# REGULATORY/POLICY ISSUES

## ■ Regulatory Considerations

- The LARADS is a mapping tool for characterization of contaminated surfaces; therefore, there are no special regulatory permits required for its operation and use.

- The system can be used for free release surveys, depending on the detection level requirements. For this demonstration, the detection level of the radiological instrumentation meets the requirements of 10 CFR Parts 20 and 835, and proposed Part 834.

- Although the demonstration took place at a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site, no CERCLA requirements apply to the surveys conducted.

## ■ Safety, Risk, Benefits, and Community Reaction

***Worker Safety***

- Normal radiation protection worker safety procedures used at the facility would apply.
- Technology users should implement contamination control practices.
- Normal electrical grounding requirements should be met if the option to use 115-VAC power is selected.
- Normal precautions with lead-acid battery storage apply.

***Community Safety, Environmental and Socioeconomic Impacts, and Community Perception***

- It is not anticipated that implementation of the LARADS innovative technology would present any adverse impacts to community safety or the environment.

- Similarly, no socioeconomic impacts are expected in association with use of this technology.

- This technology should be well perceived by the public since it enhances the information that is available, such as maps and records, upon which cleanup and no-action decisions are based.

# SECTION 7

# LESSONS LEARNED

## ■ Implementation Considerations

- The tracking system component of the LARADS has the capacity to reestablish the tracking signal after being interrupted when maneuvering around obstacles. The data can be interpolated between areas where an interruption has occurred; however, for achieving the most effective surveys, obstacles and movable objects should be cleared from the survey area as much as possible.

- The system loses sensitivity when totally covered with plastic sheeting. Therefore, extra care is required when operating the system in contaminated areas.

- The LARADS is well suited for large, open indoor areas and is weatherproof for outdoor use.

## ■ Technology Limitations/Needs for Future Development

- Due to physical size and geometry of the total station, this system is not appropriate for small, congested areas.

- At the present time, there is no need to modify the mapping features of the system demonstrated at the Hanford Site C Reactor other than adding metric conversions.

## ■ Technology Selection Considerations

- The technology is suitable for DOE nuclear facility D&D sites or similar sites that must be surveyed to facilitate property transfer or release.

- This system is useful for site characterization in support of D&D engineering design and during and subsequent to D&D activities.

- By using various radiation probes, the LARADS has the ability to capture both alpha and beta/gamma information.

- Clear, concise, comprehensible maps can be automatically generated, representing the location and extent of contamination. These maps are useful for job planning and decontamination activities. Additionally, data can be used as input to dose assessment software with more accuracy, completeness, speed, and reproducibility than the baseline technology.

- Data acquired through use of the LARADS are scientifically derived, and are not subject to subjective observations. The data are electronically logged, and are not recorded or presented manually.

# APPENDIX A

## REFERENCES

ANSI, 1989, *Performance Specifications for Health Physics Instrumentation for Use in Normal Environmental Conditions,* ANSI N42.17A-1989, American National Standards Institute, New York, New York.

10 CFR 835, "Occupational Radiation Protection," *Code of Federal Regulations*, as amended.

NRC, 1992, *Termination of Operating Licenses for Nuclear Reactors,* Regulatory Guide 1.86, U.S. Nuclear Regulatory Commission, Washington, D.C.

THI, 1997, *Final Survey Report for C Reactor Technology Demonstration,* Thermo Hanford, Inc., Richland, Washington, 1997.

# APPENDIX B

## ACRONYMS AND ABBREVIATION

| Acronym/ Abbreviation | Description |
|---|---|
| ALARA | As Low As Reasonably Achievable |
| ANSI | American National Standards Institute |
| BHI | Bechtel Hanford, Inc. |
| CAD | computer-aided design |
| CERCLA | *Comprehensive Environmental Response, Compensation and* |
| CFR | *Code of Federal Regulations* |
| CRM | count rate meter |
| cpm | counts per minute |
| D&D | decontamination and decommissioning |
| DOE | U.S. Department Of Energy |
| DOE-RL | DOE- Richland Operations Office (WA) |
| dpm | disintegrations per minute |
| FETC | Federal Energy Technology Center |
| G&A | general and administrative (costs) |
| GIS | geographical information system |
| GM | Geiger Mueller |
| ICT | Integrated Contractor Team |
| ISS | Interim Safe Storage |
| LARADS | Laser Assisted Ranging and Data System |
| LSTD | Large Scale Technology Demonstration |
| MDA | minimum detectible activity |
| NRC | U. S. Nuclear Regulatory Commission |
| PC | personal computer |
| PNNL | Pacific Northwest National Laboratory |
| RCT | radiological control technician |
| THI | Thermo Hanford, Inc. |
| USACE | U.S. Army Corps Of Engineers |
| UTM | Universal Transverse Mercator (coordinates) |
| VAC | volts, alternating current |
| WBS | work breakdown structure |

## APPENDIX C

## 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. The definitions are based on a work breakdown structure (WBS) for mobilization, characterization, demobilization, data assembly, and documentation.

### Innovative Technology - LARADS

**MOBILIZATION (WBS 331.01)**

**Transport Equipment from Storage to Work Area:** This cost element provides for transporting equipment from a location on the Hanford Site to the C Reactor. Activity cost is measured as one each daily activity.

**Daily Equipment Setup:** This cost element includes setting up the LARADS tripod and leveling it, connecting the total station to a power source and computer, measuring the height of the laser window, connecting the radio modem to the survey instrument and the computer, establishing a predetermined alarm set point for the survey instrument, and source checking the radiological subsystem. The activity cost is measured as a daily activity.

**Safety Meeting:** This cost element is a weekly safety meeting for the entire D&D work crew at the C Reactor. For purposes of fitting the format of the cost summary, the meeting time has been divided by 5 and distributed out as a daily activity.

**D&D CHARACTERIZATION (WBS 331.17)**

**Use LARADS in Conjunction with an Eberline E-600 to Survey for Beta-Gamma:** This cost element includes one RCT performing the scan with an Eberline E-600 and one RCT monitoring the computer screen on the LARADS. The activity cost is measured on a per square foot basis.

**Reposition LARADS & Reset Coordinates:** This cost element includes moving the LARADS tripod and computer to new locations after tracking limits of the device have been reached. The number of times required to move the device in a typical work day varied during the deployment and depended upon RCT experience in operating the device (a "learning curve" was encountered), square foot area and height of walls within the rooms surveyed, level of obstruction in front of the surveyed walls, and the number of openings present in surveyed walls. For purposes of simplification, the number of moves used in the cost calculation is based on an average. During the deployment, four moves per day were typically required and form the basis of this cost activity.

**DEMOBILIZATION (WBS 331.21)**

**Exit-Frisking LARADS:** This cost activity includes running an instrument sweep of the LARADS equipment to check for radiological contamination. It is measured as a daily activity.

**D&D DATA ASSEMBLY & DOCUMENTATION (WBS 331.17)**

**Assemble Report from the Mapping Results:** This cost activity includes downloading data collection files from the field system computer into an office-based GIS system for analysis and report generation. It is measured as a daily activity.

**COST ANALYSIS**

The LARADS was deployed at the C Reactor on the Hanford Site. The technology was used to collect survey data generated by readings from a portable Eberline E-600 CRM equipped with an Eberline E-380 AB zinc sulfite scintillator probe with a face area of 100 $cm^2$. The probe was used to detect both alpha and beta radiation simultaneously on wall surfaces of several rooms in the facility at a scan speed of up to 4 in. per second. The LARADS tracked location of the survey rate meter by means of a tripod-mounted laser and reflection prism mounted to the rate meter. Survey readings were transferred to the LARADS computer by means of a radio modem also attached to the rate meter.

The LARADS technology was acquired as a vendor service from THI, who supplied both the LARADS equipment and two RCTs to operate it. Actual surveying used as the basis of this cost analysis with the LARADS took place over 25 roughly consecutive work days starting the last week of June 1997 and ending the first week of August 1997. In that time period, 520 $m^2$ (5,600 $ft^2$) of wall area was surveyed.

It is important to note that the LARADS did not achieve ideal production every day it was used during the deployment. Several factors were responsible for this and include:

- the necessity to remove debris from ongoing D&D activities at the C Reactor that were piled up in front of walls and obstructed a clear tracking path for the LARADS laser
- other interferences and delays caused by ongoing D&D work
- battery problems that affected the LARADS computer
- short circuits in the power cords attached to the LARADS equipment and other problems associated with equipment cabling
- occasional aberrant survey instrument readings caused by improper settings (forcing resurveying)
- daily demands on RCT time outside the LARADS survey work (a key reason for delays in finishing surveying work)

Surveying with the LARADS proceeded at the pace of 18.6 $m^2$ (200 $ft^2$) per hour for roughly 4 hours of productive surveying per day when little or no interference occurred. Under unencumbered production conditions, the rest of the work day was occupied with normal daily lunch and work breaks; time to make an average of four location moves with the LARADS equipment; and time to pack up equipment, leave the job-site, and return to an office to compile the survey results. Calculated costs for the LARADS are based on these productivity assumptions in order to reasonably and fairly judge it against a comparable baseline technology (that must be extrapolated to match the 520 $m^2$ (5,600 $ft^2$) surveyed with the LARADS) and to establish a basis by which other DOE sites can judge the technology. Thus, the following cost table distills the deployment from an activity that took roughly 1 month activity to an activity that takes 7 fully-productive days.

**Table C-1. Cost Summary - LARADS (Utilizing Two RCT's)**

| Work Breakdown (WBS) | Unit Cost (UC) | | | | | | Total (TQ) | Unit Measure | Total Cost (see 1) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| | Hours | Rate | Hours | Rate | | Unit Cost | | | | |
| **MOBILIZATION (WBS 331.01)** | | | | | | | | **Subtotal:** | **$283.54** | |
| Transport Equipment from Storage to Work Area | 0.08 | $99.90 (see 3) | 0.08 | $7.50 (see 4) | | $8.59 | 8 | day (see 5) | $68.74 | Based on 5 minutes per day of surveying to take equipment from a storage area to the work locationin the C Reactor |
| Daily Equipment Setup (Including Source-Check) | 0.25 | $49.95 (see 2) | 0.25 | $7.50 | | $14.36 | 8 | day (see 5) | $114.90 | Based on 15 minutes per day of surveying to set up equipment at the work location |
| Safety Meeting | 0.50 | $99.90 | | | | $49.95 | 2 | each | $99.90 | Based on the Hanford Site requirement to have one safety meeting per week |
| **D&D CHARACTERIZATION (WBS 331.17)** | | | | | | | | **Subtotal:** | **$3,866.40** | |
| Use LARADS in conjunction with Eberline E-600 to survey for beta-gamma | 0.0050 | $99.90 | 0.0050 | $7.50 | | $0.54 | 5,600 | square foot | $3,007.20 | Based on 2 RCTs averaging 4 hours of actual surveying per day |
| Reposition the LARADS & Reset Coordinates (Registration) | 0.25 | $99.90 | 0.25 | $7.50 | | $26.85 | 32 | each | $859.20 | Based on an average of 4 moves per day of surveying utilizing the LARADS equipment |
| **DEMOBILIZATION (WBS 331.21)** | | | | | | | | **Subtotal:** | **$229.80** | |
| Exit-Frisking LARADS | 0.17 | $49.95 | 0.17 | $7.50 | | $9.77 | 8 | day (see 5) | $78.13 | Equipment standby and time for an RCT to survey the equipment |
| Breaking Down LARADS Equipment | 0.33 | $49.95 | 0.33 | $7.50 | | $18.96 | 8 | day (see 5) | $151.67 | Includes removing the LARADS system PC, CRM, and data links |
| **D&D DATA ASSEMBLY & DOCUMENTATION (WBS 331.17)** | | | | | | | | **Subtotal:** | **$229.80** | |
| Generate Report from the Survey Results | 0.50 | $49.95 | 0.50 | $7.50 | | $28.73 | 8 | day (see 5) | $229.80 | Based on an average report generation time of 30 minutes per day of surveying |

**TOTAL: $4,609.54** (for 5,600 sf of wall)

Notes:

1) UC=UC X TQ

2) The labor rate of $49.95/hr is based on the rate for a RCT and includes base wage, fringes, and area overhead, but excludes BHI G&A and overhead.
3) The labor rate of $99.90 is based on a crew rate for two vendor-supplied RCTs and incudes base wage, fringes, and area overhead, but excludes BHI G&A and overhead.
4) The equipment rate of $7.50/hour is based on a rate of $300.00/week established by Thermo Hanford, Inc. The hourly rate assumes an average 40-hour work week.

The Hanford Site 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 back out the Hanford Site's rates first. This omission does not sacrifice the 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 reason indicated for the overhead rates. The standard labor rates established by the Hanford Site 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-hour work day with a 5-day week.

**Table C-1.1. Cost Summary - LARADS (Utilizing One RCT)**

| Work Breakdown Structure (WBS) | Unit Cost (UC) Labor Hours | Labor Rate | Equipment Hours | Equipment Rate | Other | Total Unit Cost | Total Quantity (TQ) | Unit of Measure | Total Cost (TC) (see 1) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| **MOBILIZATION (WBS 331.01)** | | | | | | | | | **$201.62** | |
| Transport Equipment from Storage to Work Area | 0.08 | $49.95 (see 2) | 0.08 | $7.50 (see 3) | | $4.60 | 8 | day (see 4) | $36.77 | Based on 5 minutes per day of surveying to take equipment from a storage area to the work location in the C Reactor |
| Daily Equipment Setup (Including Source-Check) | 0.25 | $49.95 | 0.25 | $7.50 | | $14.36 | 8 | day | $114.90 | Based on 15 minutes per day of surveying to Storage to Work Area |
| Safety Meeting | 0.50 | $49.95 | | | | $24.98 | 2 | each | $49.95 | Based on the Hanford Site requirement to have one safety meeting per week |
| **D&D CHARACTERIZATION (WBS 331.17)** | | | | | | | | | **$2,068.20** | |
| Use LARADS in conjunction with an Eberline E-600 to survey for beta-gamma | 0.0050 | $49.95 | 0.0050 | $7.50 | | $0.29 | 5,600 | square foot | $1,608.60 | Based on 1 RCT averaging 4 hours of actual surveying time per day |
| Reposition the LARADS & Reset Coordinates (Registration) | 0.25 | $49.95 | 0.25 | $7.50 | | $14.36 | 32 | each | $459.60 | Based on an average of 4 moves per day of surveying utilizing the LARADS equipment |
| **DEMOBILIZATION (WBS 331.21)** | | | | | | | | | **$228.60** | |
| Exit-Frisking LARADS | 0.17 | $49.95 | 0.15 | $7.50 | | $9.62 | 8 | day (see 4) | $76.93 | Equipment standby and time for an RCT to |
| Breaking Down LARADS Equipment | 0.33 | $49.95 | 0.33 | $7.50 | | $18.96 | 8 | day (see 4) | $151.67 | Includes removing the LARADS system PC, CRM, and data links |
| **D&D DATA ASSEMBLY & DOCUMENTATION (WBS 331.17)** | | | | | | | | | **$229.80** | |
| Generate Report from the Survey Results | 0.50 | $49.95 | 0.50 | $7.50 | | $28.73 | 8 | day (see 4) | $229.80 | Based on an average report generation time of 30 minutes per day of surveying |

**TOTAL: $2,728.22** (for 5,600 sf of wall)

## Baseline Technology

**MOBILIZATION (WBS 331.01)**

**Transport Equipment from Storage to Work Area**: This cost element provides for transporting equipment from a location on the Hanford Site to the C Reactor. The activity is measured as a one each per day.

**Source-Check Equipment**: This cost element includes routine background checks with the hand-held survey instrumentation before beginning surveying. The activity is measured as a one each per day.

**Safety Meeting**: This cost element is a weekly safety meeting for the entire D&D work crew at the C Reactor. For purposes of fitting the format of the cost summary, the meeting time has been divided by five and distributed as a daily activity.

**D&D CHARACTERIZATION (WBS 331.17)**

**Survey Walls with an Eberline E-600 and Hand-Record the Results:** This cost element includes routine sweeps for beta-gamma and alpha contamination using the Eberline hand-held instrumentation. It also includes stopping the instrument sweep to record readings. This is particularly essential at hot spots where hand-recording must occur simultaneously with, or immediately after, receiving detector readings to accurately establish the location and size of hot spots. For the baseline demonstration, the activity is measured as a one each activity since the contamination level of the test area was low and relatively few hot spots were found. (In heavily contaminated regions, it is anticipated that this would be an ongoing activity occurring simultaneously with the instrument sweep and, thus, would probably need to be measured on a unit basis such as square foot per minute). The activity cost is measured on a per-square-foot basis.

**DEMOBILIZATION (WBS 331.21)**

**Exit Frisk Equipment:** This cost element includes time to sweep miscellaneous equipment, such as clipboards, pencils, etc. for contamination. It does not include time to check the actual detectors for contamination.

**D&D DATA ASSEMBLY & DOCUMENTATION (WBS 331.17)**

**Assemble a Report from the Survey Results:** This cost activity includes logging all of the hand-recorded data into an office-based GIS for analysis and report generation.

**COST ANALYSIS**

The baseline technology consists of using conventional detectors to sweep for radiological contamination. It was demonstrated at the Hanford Site on 49 $m^2$ (525 $ft^2$) of floor and wall areas in the Laundry Sorting Room of the C Reactor. Measurement equipment used during the baseline demonstration was the same as the LARADS measurement equipment (an Eberline E-380AB probe/E-600 that has the capability of detecting both beta/gamma and alpha contamination. The survey was conducted at an average scan speed of 6.35 centimeters (2.5 in.) per second.

For the demonstration, survey work was conducted by one RCT employed by THI. Hourly RCT labor rates are the result of discussions between the U. S. Army Corps of Engineers (USACE) and BHI and are detailed in

Table C-2. A separate hourly rate was calculated for the survey equipment used and is based on an amortized cost that factors in initial procurement costs, average service life, and annual repair costs.

In order to create an equitable comparison between the baseline and the innovative technologies, costs for the baseline demonstration are extrapolated out to the 520 $m^2$ (5,600 $ft^2$) of wall areas that were surveyed during deployment of the LARADS. A total comparable cost is then calculated using labor and equipment costs and survey productivity established during demonstration of the baseline technology. Based on these assumptions, to survey an equivalent wall area with the baseline methodology will take 10 fully productive days.

The Hanford Site 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 with out having to back out the Hanford Site's rates first. This omission does not sacrifice the 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 reason indicated for the overhead rates. The standard labor rates established by the Hanford Site 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-hour work day with a 5-day week.

**Table C-2. Cost Summary - Baseline.**

| Work Breakdown Structure (WBS) | Unit Cost (UC) Labor Hours | Labor Rate | Equipment Hours | Equipment Rate | Other | Total Unit Cost | Total Quantity (TQ) | Unit of Measure | Total Cost (TC) (see 1) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| **MOBILIZATION (WBS 331.01)** | | | | | | | | **Subtota:** | **$123.87** | |
| Transport Equipment from Storage to Work Area | 0.08 | $49.95 (see 2) | 0.08 | $1.38 (see 3) | | $4.11 | 9 | day (see 4) | $36.96 | Based on 5 minutes per day of surveying to take equipment from a storage area to a work location in the C Reactor |
| Source-Check Equipment | 0.08 | $49.95 | 0.08 | $1.38 | | $4.11 | 9 | day (see 4) | $36.96 | Based on 5 minutes per day of surveying to check background radiation levels |
| Safety Meeting | 0.50 | $49.95 | | | | $24.98 | 2 | each | $49.95 | Based on the Hanford Site requirement to have one safety meeting per week |
| **D&D CHARACTERIZATION (WBS 331.17)** | | | | | | | | **Subtotal** | **$1,524.25** | |
| Survey Walls with an Eberline E-600 and Hand Record the Results | 0.0053 | $49.95 | 0.0054 | $1.38 | | $0.27 | 5,600 | square foot | $1,524.25 | Based on 1 RCT averaging 3 hours of actual surveying time per day |
| **DEMOBILIZATION (WBS 331.21)** | | | | | | | | **Subtotal** | **$78.53** | |
| Exit Frisk Equipment | 0.17 | $49.95 | 0.17 | $1.38 | | $8.73 | 9 | day (see 4) | $78.53 | Equipment standby plus time for a RCT to survey the equipment |
| **D&D DATA ASSEMBLY & DOCUMENTATION (WBS 331.17)** | | | | | | | | **Subtotal** | **$899.10** | |
| Assemble a Report from the Survey Results | 2.00 | $49.95 | | | | $99.90 | 9 | day | $899.10 (see 4) | |
| | | | | | | | | **TOTAL:** | **$2,625.75** | (for 5,600 sf of wall) |

1) UC=UC X TQ
2) The labor rate of $49.95/hr is based on the rate for an RCT and includes base wage, fringes, and area overhead, but excludes BHI G&A and overhead.
3) The equipment rate of $1.38/hr is based on an amortized hourly cost for an Eberline E-600 digital rate meter equipped with an Eberline SHP-380-AB large area probe.
4) The total number of days is based upon 3.67 productive hours of surveying per day at a survey productivity rate of 187 sf/hour.
5) The Hanford Site indirect expense rates for common support and materials are also 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 first back out the Hanford Site's rate. Engineering, quality assurance, administrative costs and taxes on services and materials are also omitted from this analysis for the same reasons. The analysis assumes an 8-hour work day and a 40-hour work week.