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Road Transportable Analytical Laboratory (RTAL) System

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DISCLAIMER

4.5 Road Transportable Analytical Laboratory (RTAL) System

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ABSTRACT

U.S. Department of Energy (DOE) facilities around the country have, over the years, become contaminated with radionuclides and a range of organic and inorganic wastes. Many of the DOE sites encompass large land areas and were originally sited in relatively unpopulated regions of the country to minimize risk to surrounding populations. In addition, wastes were sometimes stored underground at the sites in 55-gallon drums, wood boxes or other containers until final disposal methods could be determined. Over the years, these containers have deteriorated, releasing contaminants into the surrounding environment. This contamination has spread, in some cases polluting extensive areas.

Remediation of these sites requires extensive sampling to determine the extent of the contamination, to monitor clean-up and remediation progress, and for post-closure monitoring of facilities. The DOE would benefit greatly if it had reliable, road transportable, fully independent laboratory systems that could perform on-site the full range of analyses required. Such systems would accelerate and thereby reduce the cost of clean-up and remediation efforts by (1) providing critical analytical data more rapidly, and (2) eliminating the handling, shipping and manpower associated with sample shipments.

The goal of the Road Transportable Analytical Laboratory (RTAL) Project is the development and demonstration of a system to meet the unique needs of the DOE for rapid, accurate analysis of a wide variety of hazardous and radioactive contaminants in soil, groundwater, and surface waters. This laboratory system has been designed to provide the field and laboratory analytical equipment necessary to detect and quantify radionuclides, organics, heavy metals and other inorganic compounds. The laboratory system consists of a set of individual laboratory modules deployable independently or as an interconnected group to meet each DOE site's specific needs.

After evaluating the needs of the DOE field activities and investigating alternative system designs, the modules included in the RTAL system are:

- Radioanalytical Laboratory
- Organic Chemical Analysis Laboratory
- Inorganic Chemical Analysis Laboratory
- Aquatic Biomonitoring Laboratory
- Field Analytical Laboratory
- Robotics Base Station
- Decontamination/Sample Screening Module
- Operations Control Center

Each module provides full protection for operators and equipment against radioactive particulates and conventional environmental

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contaminants. This is especially important in areas where radioactive particulates from environmental matrices, e.g. soils, aerosolized by wind or volatile chemicals are present. These contaminants can adversely affect sensitive chemical and radiochemical analyses as well as potentially being harmful to personnel.

The goal of the integrated laboratory system is a sample throughput of 20 samples per day, providing a full range of analyses on each sample within 16 hours (after sample preparation) with high accuracy and high quality assurance. This is much shorter than the standard 45 day turnaround time typical of commercial laboratories. In addition, shipping samples off-site is a time-consuming, paperwork-intensive process, leading to additional delays in sample analyses. The focused project support provided by the RTAL is designed to significantly accelerate characterization and remediation efforts of critical restoration projects.

A prototype RTAL system was constructed for demonstration at the DOE's Fernald Environmental Management Project (FEMP). It is being deployed at FEMP's OU-1 Waste Pits. Its performance will be evaluated with samples from these pits and with other environmental samples from the FEMP site. The prototype RTAL system will consist of 5 modules - Radioanalytical Laboratory, Organic Chemical Analysis Laboratory, Inorganic Chemical Analysis Laboratory, Aquatic Biomonitoring Laboratory, and Operations Control Center. The U.S. Army Biomedical R&D Laboratory has volunteered to provide the Inorganic Chemical Analysis Laboratory and Aquatic Biomonitoring Laboratory as part of its concurrent demonstration of Integrated Biological Assessment (IBA) technology. The demonstration of the prototype RTAL is scheduled to start late in the 1st Quarter of FY96.

The RTAL will provide the DOE with significant time and cost savings, accelerating and improving the efficiency of clean-up and remediation operations throughout the DOE complex. At the same time, the system will provide full protection for operating personnel and sensitive analytical equipment against the environmental extremes and hazards encountered at DOE sites.

INTRODUCTION

The U.S. Department of Energy (DOE) facilities around the country have, over the years, become contaminated with radionuclides and a range of organic and inorganic wastes. Many of the DOE sites encompass large land areas and were originally sited in relatively unpopulated regions of the country to minimize risk to surrounding populations. In addition, many times wastes were stored underground at the sites in 55-gallon drums, wood boxes or other containers until final disposal methods could be determined. Over the years, these containers have deteriorated, releasing contaminants into the surrounding environment. This contamination has spread, in some cases polluting extensive areas.

Remediation of these sites requires extensive sampling to determine the range of the contamination, to monitor clean-up and remediation progress, and for post-closure monitoring of facilities. Transporting these samples to a central laboratory, especially to one off-site, requires wipe tests for surface contamination before shipment and after receipt, specialized transportation containers and procedures (depending on the level of radioactivity present in the sample), and a substantial amount of additional paperwork. It can be very difficult and time-consuming to ship samples off-site from DOE facilities because of requirements established to ensure against inadvertent release of radioactive materials. The occasional improper shipment of radioactive materials from DOE facilities has led to periodic curtailment of all shipments to ensure that

proper shipping procedures are followed. Such curtailments can cause havoc to projects where accurate and timely sample analytical data is critical to decision-making and also because environmental samples degrade over time.

The DOE would benefit greatly from the use of reliable, road transportable, fully independent laboratory systems that could perform the full range of analyses required on-site. By focusing on high priority problems, such systems would accelerate clean-up and remediation efforts. They would provide critical analytical data more rapidly, and save money by eliminating handling, shipping and manpower costs associated with sample shipments.

The RTAL developed for the DOE is based on the earlier laboratories and operations control centers developed by Engineering Computer Optecnomics (ECO), Inc. for the U.S. Environmental Protection Agency, and the U.S. Departments of Defense and State. These include counter-terrorist systems for use in areas contaminated with chemical or biological warfare agents. The advances achieved in the development of these earlier systems have been incorporated into the development of the RTAL.

OBJECTIVE

The Road Transportable Analytical Laboratory (RTAL) Project covers the development and demonstration of a system to meet unique DOE needs for rapid, accurate analysis of a wide variety of hazardous and radioactive contaminants in soil, groundwater, and surface waters. This laboratory system is designed to provide the analytical equipment necessary to detect and quantify radionuclides, organics, heavy metals and other inorganics. The laboratory system consists of a set of individual laboratory modules deployable independently or as an interconnected group to meet each DOE site's specific needs.

The goal of the integrated laboratory system is a sample throughput of 20 samples per day, providing a full range of analyses on each sample within 16 hours (after sample preparation) with high accuracy and high quality assurance. This is much shorter than the standard 45 day turnaround time typical of commercial laboratories. In addition, shipping of samples off-site is a time-consuming, paperwork-intensive process, leading to additional delays in sample analyses. This focused attention on high priority needs can accelerate and improve the efficiency of clean-up and remediation operations. The RTAL will be synergistic with existing analytical laboratory capabilities by reducing the occurrence of unplanned "rush" samples which are disruptive to efficient laboratory operations.

PROJECT DESCRIPTION AND RESULTS

To meet the wide range of environmental analytical requirements at the DOE's facilities while retaining the flexibility for rapid, cost-efficient response, the RTAL was conceived as a series of individual modules that could be deployed individually or as an integrated group. After evaluating the needs of the DOE field activities and investigating alternative system designs, the modules to be included in the full RTAL are:

- Radioanalytical Laboratory
- Organic Chemical Analysis Laboratory
- Inorganic Chemical Analysis Laboratory
- Aquatic Biomonitoring Laboratory
- Field Analytical Laboratory
- Robotics Base Station
- Decontamination/Sample Screening Module
- Operations Control Center

Each module provides full protection for operators and equipment against radioactive particulates and conventional environmental contaminants. This is especially important in areas where radioactive particulates from

environmental matrices, e.g. soils, are aerosolized by wind or volatile chemicals are present. These contaminants can adversely affect sensitive chemical and radiochemical analyses as well as being potentially harmful to personnel.

Each module has the following features to ensure reliable, independent operation:

- Shock and vibration protected for road transport
- No Department of Transportation restrictions
- Filtration of incoming and exhaust air through HEPA filters
- Integral electrical generation system providing filtered power
- Uninterruptible power supply
- Heating, ventilation and air conditioning (HVAC) system capable of handling wide range of outside temperatures and humidities
- Controlled air flow from "clean" to "dirty" areas
- Insulation in walls, floor and roof
- Integral fuel tanks
- Rugged, redundant design for maximum availability
- Hardened equipment for maximum reliability
- Designed for long life
- Designed for minimum acquisition and maintenance costs
- Designed for ease of repair and maintenance
- Designed for ease of exterior decontamination
- Innocuous appearance to minimize public apprehension during transport and deployment

The continuous supply of electricity is critical to the reliability of the tests being performed. The loss of power would shut down the analytical equipment and support and control systems, critical for maintaining controlled experimental conditions. For this reason, an automatic switching circuit is provided for use when operating from an external power source. If the external power source fails, this circuit automatically starts the laboratory's electrical generator and switches all systems to this independent source of power, thus ensuring maintenance of experimental conditions.

Each module is housed in a standard 48 foot long by 8½ foot wide trailer to facilitate transport to the test sites. These units have no Department of Transportation restrictions on road transport. Wider trailers are considered "wide loads" which must have vehicular escorts, can not travel all roads, and must pay road use fees in most states. These restrictions limit the adaptability of extra-wide systems to meet the changing requirements across the DOE complex and adds significantly to their operating costs.

The use of a truck, with a dedicated engine, instead of a trailer for the laboratories was also considered. The use of a separate vehicle to move trailer-mounted modules results in higher system reliability and lower cost compared to the use of truck-mounted laboratories with a dedicated prime mover. Experience has shown that truck engines which are operated sporadically have much higher than normal breakdown frequencies. For example, the state of Maryland's truck-mounted air pollution laboratory underwent three engine overhauls within 8,000 miles of driving due to the fact that it was moved so infrequently. In addition, use of a separate prime mover saves the acquisition cost of the truck. Vehicles to move the trailers can be rented readily anywhere in the country. Since deployed modules will normally be at a single site for extended periods, the economics strongly favor setting up the modules on separate trailers rather than using a dedicated prime mover.

The chosen arrangement of RTAL modules closely follows the steps the samples and operating personnel will take, as shown in

Figure 1. The module closest to the contaminated area is the Decontamination/Sample Screening Module. This module is divided into two halves. The decontamination side is used to decontaminate personnel in protective gear who have been collecting samples or performing other duties in contaminated areas. The other side of the module is for screening of collected samples. Personnel, in appropriate protective gear, bring the samples to the sample pass-through (located on the side of the module closest to the contaminated area). The samples are passed directly into the hot cell inside the Sample Screening side of the module. The samples are screened for radiation level to determine handling requirements during subsequent testing. They are also subdivided for the analyses to follow.

The next modules behind the Decontamination/Sample Screening Module are the Robotics Base Station and the Field Analytical Laboratory. These modules provide robotically operated and hand-carried instrumentation for field determination of radioactive and chemical contamination levels. These modules are needed for initial mapping of large areas. The robotic systems, in particular, would include automated geographic positioning equipment to fix the location of each measurement. All data is transmitted to the computer in the Robotic Base Station for computerized mapping. The data provided by the robotic and field analytical systems would not meet the same high quality assurance and quality control standards as the samples analyzed in the RTAL modules. However, the data are very useful in determining the location of "hot spots," i.e. areas where personnel require protective ensembles.

The next set of modules are the four laboratories which are the heart of the RTAL system. These are the Radioanalytical, the Organic Chemical Analysis, the Inorganic Chemical Analysis, and the Aquatic Biomonitoring Laboratories. The subdivided samples from the Decontamination/Sample Screening Module are analyzed for specific analytes in the first three laboratories. The Aquatic Biomonitoring Laboratory is used for broad screening of hazardous contamination (radiological or chemical) using fish and amphibians as test organisms. Aquatic biomonitoring tests are used to detect the presence of ultra-low trace levels of contamination, i.e. below standard detection levels for specific analytes, and analytes for which there is no test. It can also be used to determine the absence of contaminants, providing a means for determining whether an environmental matrix is "clean."

The next module is the Operations Control Center, which serves as the coordinating "brain" for all RTAL operations. The entrance to the Operations Control Center provides a portal monitor for all personnel leaving the laboratory area. Even though great care will be taken to ensure that all personnel handling samples remain uncontaminated, a final check is important to ensure that there is no inadvertent contamination as a result of operations conducted within the RTAL area. If contamination is detected, a decontamination shower is located in this module adjacent to the frisking station.

This RTAL system configuration divides the overall area into three contamination zones. The first zone is the contaminated area where radioactive and chemical contaminants are expected. The second zone is the laboratory modules where contaminated samples are handled in hoods, on bench tops, and in the analytical equipment. Although these areas are designed to contain contaminants, there is always a small risk of inadvertent release. The third zone is the contaminant-free zone beyond the portal monitor in the Operations Control Center.

Personnel and samples exiting the contaminated zone must go through the

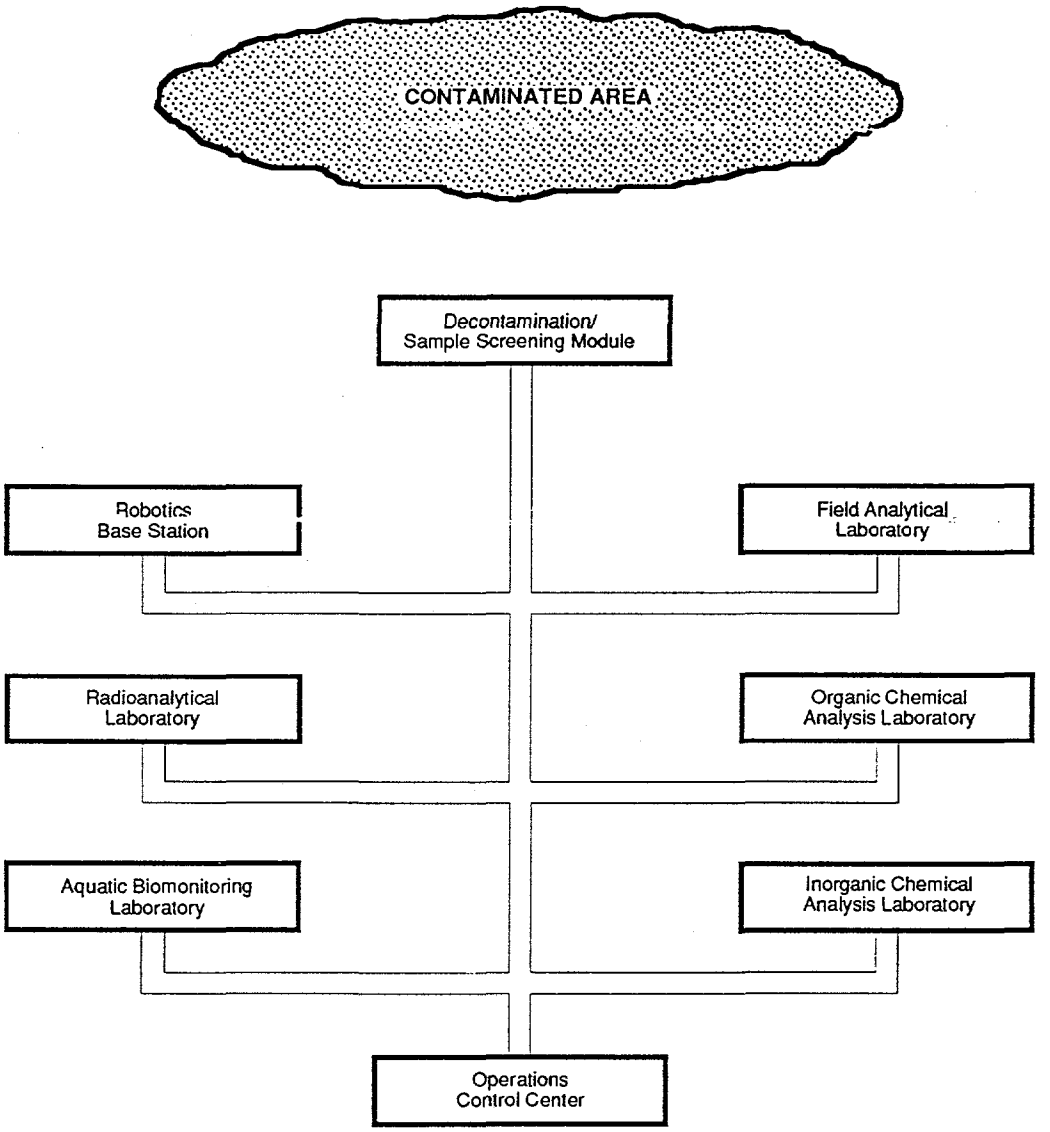

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Figure 1. Road Transportable Analytical Laboratory Integrated Complex

Decontamination/Sample Screening Module. This ensures that the only contamination entering the second zone is contained within the samples. All personnel exiting the second zone must go through the Operations Control Center frisking station to ensure they are contaminant-free. This arrangement minimizes contaminant risks for all personnel, both within and outside the RTAL area.

The DOE's Office of Environmental Restoration and Waste Management is conducting a study of projected analytical needs across the DOE Complex. The study defines four levels of handling requirements based on sample radioactivity:

R1 - bench-top	<10 mR/h and <10 nCi/g alpha
R2 - hood	10-200 mR/h or <10 nCi/g alpha
R3 - hot cell	>200 mR
R4 - glove box	<200 mR/h and >10 nCi/g alpha

Preliminary results show that the vast majority (84%) of the samples projected to be collected fall in the R1 category, suitable for bench-top handling. Samples falling in the R2 category (handling in a hood) represent 14% of the total. Samples in the R3 and R4 categories (handling in a glove box or hot cell) represent a combined total of only 2% of the samples to be collected. These results clearly indicate that the RTAL system design should emphasize handling of samples on benches and in hoods. Providing the hot cells, glove boxes, and associated handling equipment necessary to perform the complete range of analyses on the 2% of the samples in the R3 and R4 categories greatly increases the cost of the RTAL modules. The RTAL's mission is to provide rapid response with high quality assurance and control for a limited number of samples. The remaining samples, not requiring rapid analysis, would be processed through central laboratories. For this reason, it was determined that the sample screening area of the Decontamination/Sample Screening Module would be designed to safely screen for all sample categories, R1 through R4, but the other laboratory modules would be designed for R1 and R2 samples only.

An additional module that can be included in the RTAL is the Protected Living Quarters. This module would be located beyond the Operations Control Center and used when personnel are needed on-site for around-the-clock operations. The need for such demanding efforts are expected to occur infrequently. However, in critical situations, the Protected Living Quarters would be very effective in supporting needed personnel in a safe environment very near the area of operations.

The RTAL incorporates cellular communications and, if desired, satellite communications. STU-III encryption devices for secure communications can also be added, if needed.

The RTAL computers are interconnected in a wireless Local Area Network (LAN). Appropriate software is included so that the computer systems within the RTAL complex can be monitored and controlled from the Operations Control Center or any of the other modules. This greatly enhances the efficiency of the operation and minimizes personnel requirements for operating the complex and performing the analyses.

The RTAL will provide the DOE with significant savings in terms of time and cost. Samples will be analyzed within about a day as opposed to the 45 day turnaround typical of commercial laboratories. In addition, off-site sample shipments will be eliminated, saving additional time and manpower. Preliminary estimates indicate that the focused, integrated approach provided by the RTAL can provide significant savings to the DOE compared to commercial laboratories. More importantly, the RTAL's rapid, high quality data response will accelerate and improve the efficiency of clean-

up and remediation operations throughout the DOE complex, resulting in major reductions in program costs.

A prototype RTAL system was constructed and delivered to the DOE's Fernald Environmental Management Project (FEMP) for demonstration. It will be deployed at FEMP's OU-1 Waste Pits. Its performance will be evaluated with samples from these pits and with other environmental samples from the FEMP site. The prototype RTAL system will consist of 5 modules - Radioanalytical Laboratory, Organic Chemical Analysis Laboratory, Inorganic Chemical Analysis Laboratory, Aquatic Biomonitoring Laboratory, and Operations Control Center. The Radioanalytical Laboratory houses two Germanium Detectors (weighing 5,000 lb. each), 24 Alpha Spectrometers, a Liquid Scintillation Counter, and a Gross Alpha/Beta Counter. The Organic Chemical Analysis Laboratory houses a Gas Chromatograph (GC)/Mass Spectrometer (MS), Purge and Trap GC/MS, GC with Flame Ionization Detector, automated Liquid/Liquid Extractor, automated Solid/Liquid Extractor, Size Exclusion Chromatograph, and Toxicity Characteristic Leachate Procedure (TCLP) Apparatus. Each laboratory also houses a sample preparation area (with hoods) in a separate room. The U.S. Army Biomedical R&D Laboratory has volunteered to provide the Inorganic Chemical Analysis Laboratory and Aquatic Biomonitoring Laboratory as part of its concurrent demonstration of Integrated Biological Assessment (IBA) technology.

FUTURE ACTIVITIES

The demonstration of the prototype RTAL is scheduled to start late in the 1st Quarter of FY96. This demonstration has several objectives:

1. Demonstrate the ability to conduct radiological, organic and inorganic chemical analyses in these field facilities with high quality assurance and control.
2. Quantify the analytical throughput of the analyses using the prototype RTAL system.
3. Quantify the turnaround time (starting from the completion of sample collection through data reporting) associated with performing analyses in the RTAL.
4. Quantify the costs (starting from the completion of sample collection through data reporting) associated with performing analyses in the RTAL.
5. Demonstrate the use of Integrated Biological Assessment to quantify hazard levels of groundwater, soils, and surface waters at DOE sites.

The demonstration tests will consist of (a) analysis of actual or surrogate samples within the RTAL radiological and chemical analytical laboratories, and (b) performance of abbreviated Integrated Biological Assessment tests using the Aquatic Biomonitoring Laboratory.

The radioanalyses will focus on total and isotopic quantification of uranium in water and soil samples since that is the radiological contaminant of concern in FEMP's environmental samples. The inorganic analyses will focus on quantification of heavy metals, and the performance of the Toxicity Characteristic Leachate Procedure (TCLP) on soils. The organic analyses will focus on volatile organic compounds (VOC) and semi-volatile organics. These tests are typical analytical requirements at DOE sites. The samples will be actual field samples, with some prepared surrogate added.

The demonstration of Integrated Biological Assessment techniques in the Aquatic Biomonitoring Laboratory will utilize ground and process discharge water. The test water will flow past aquatic organisms in a series of test tanks. The effects on the test organisms, e.g. movement and breathing frequency, will be monitored to assess the hazard level of the test water.

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