Sandia National Laboratories

Environmental Program

# Magnetometer Towed Array

## Technology Need

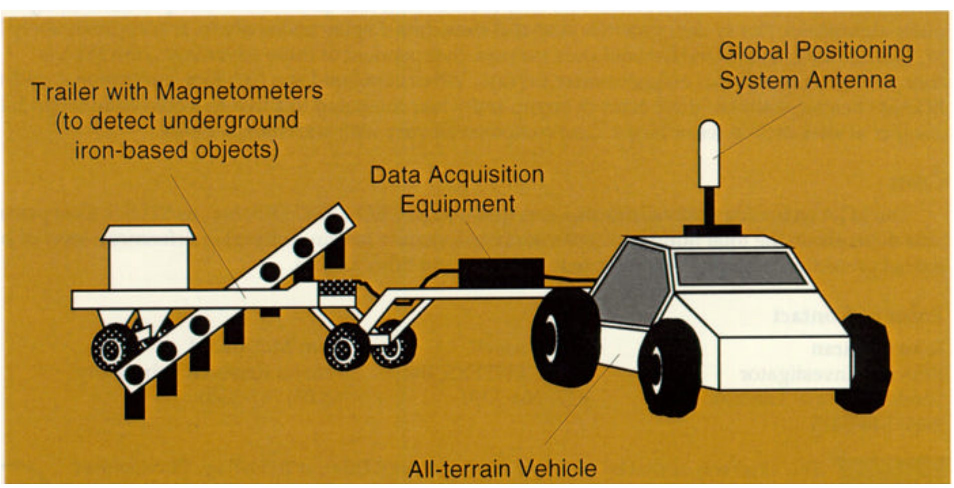
Abandoned hazardous waste sites typically involve buried wastes. The assessment of these sites traditionally includes geophysical investigations in which measurements are collected on a coarse grid. Conventional technology requires a person to walk a grid and take measurements by hand using non-intrusive geophysical tools. A typical survey grid is 5 feet by 5 feet or greater, with survey rates of an acre or two per day. Results from such conventional geophysical surveys provide data that are interpreted to provide qualitative and semi-quantitative (i.e., screening) information. Large areas are not surveyed (i.e., outlying burials are missed) because of the time consuming nature of conventional surveys. Further, the course conventional grid does not allow the boundaries of burials to be adequately determined and may miss small, isolated targets.

## Objective

The Magnetometer Towed Array (MTA) was designed to provide rapid, high-resolution, non-intrusive characterization of buried hazardous waste based on total-field magnetometers.

## Project Description

The MTA or Multi-Sensor Towed Array Detection System (MTADS) is a vehicle-based system which deploys a non-intrusive sensor platform containing seven total-field magnetometers with precise satellite positioning for locating buried ferrous objects such as drums and tanks. The system provides automated, rapid (10 acres per day and up) geophysical surveys of very high data density (70,000 to 100,000 measurements per acre).



Magnetometer Towed Array

The system consists of an array of seven cesium-vapor magnetometers mounted on a 3 m-wide trailer and towed by a low magnetic signature all-terrain vehicle. On-board computers sample magnetic field measurements from each Geometrics 822 magnetometer 20 times per second. An eighth, stationary magnetometer at a clean location continuously records diurnal variations in the background field. The on-board computers also log the pitch, roll, direction (fluxgate compass) and position information from a satellite-based global positioning system (GPS). With a static unit and a roving unit, the Trimble 4000 SSE GPS provides real-time location accuracy of $^{2}$1 m at 1 Hz almost 100% of the time and $^{3}$ 0.5 m accuracy 50% of the time. Post processing can improve these accuracies. The Naval Research Laboratory continues to advance this technology that they originally developed.

The distance between sampling nodes is fixed at 0.5 m perpendicular to the line of travel while it varies with vehicle speed parallel to the line of travel. At 11 kilometers/hour (7 miles/hour) the effective grid is 0.5 m by 0.16 m. This rate provides about 60,000 measurements per acre, assuming no overlap. The system surveyed Kirtland Air Force Base's RB-11 landfill at a rate of about one acre per half-hour. On a good day, the system can collect over 1,000,000 spatially correlated measurements of the magnetic field.

Magnetometer data are typically analyzed qualitatively. In performing qualitative analysis, the geophysicist mentally merges prior geophysical experience with site specific information. Such interpretations are usually provided in relative terms such as large or small. Quantitative analysis of magnetometer data has typically been limited to the two-dimensional matching of profiles. Computers allow three-dimensional model matching, where the spatial distribution of magnetometer values from a field survey are compared to the spatial distribution of values from an assumed target. The best match between the field data and the assumed or modeled target provides the quantitative interpretation of the object.

Targets can be analyzed using a three-dimensional model matching code. The MTA simulation code uses an iterative least-squares procedure for matching field data to individually modeled dipoles in the far field. This point dipole model assumes that all targets are single points at varying depths and masses. These simulated point dipoles are placed at various subsurface locations and given various sizes; surface responses are simulated based on these target characteristics. This process is repeated until the best match is found between the simulated response and the actual field data. Targets are quantified in terms of location (x, y, z) and mass.

## Advantages

MTA represents a characterization technology which enhances the speed and thoroughness of environmental clean-up. It provides an order of magnitude greater resolution than conventional technology which allows better horizontal resolution, data redundancy, and quantitative interpretation using computer algorithms. The system provides near real-time data display and analysis. It is approximately 10 to 30 times faster than standard walkover surveys. Independent of these advantages, the MTA is cheaper than conventional magnetometer surveys. When compared to a two-foot conventional grid, the MTA is cheaper at sites of three acres or larger, and when compared to a five-foot conventional grid, it is cheaper at sites of 50 acres or larger. Cost comparisons vary with site characteristics.

## Costs

The MTA technology is available as a service through GEO-CENTERS, Inc., as STOLS. Cost per unit area depends on the total number of acres surveyed, surface terrain, cultural interferences, level of personnel protection required, reporting requirements, and other factors.

## Contacts

Tom Burford
(505) 845-9893 phone
tdburfo@sandia.gov

Dick Russell
GEO-CENTERS, Inc.
(617) 964-7070 phone

Jim McDonald
Naval Research Laboratory
(202) 767-3340 phone

*This effort is funded by the U.S. Department of Energy, Office of Science and Technology, through the Landfill Stabilization Focus Area, Low Level and Other Contaminants in Arid Environments Product Line.*