

G.O.CART: Geophysical Operations CART **An Integrated Multi-method Geophysical Mapping System**

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ABSTRACT

Successful geophysical mapping depends entirely on physical property contrasts within the subsurface. No physical property contrast means no detectable parameter. Geophysical surveys are most commonly performed using a single survey method which generally provides information about a unique physical property such as conductivity, radioactivity, or magnetic susceptibility. The complexity of environmental site characterization frequently demands information about multiple physical properties that when combined may be used to enhance remediation efforts. Recent technological advances in mobile computing and geophysical instrumentation have greatly improved the ability to provide simultaneous multi-method surveying. Faster data acquisition rates, GPS navigation, and portable pocket size computers are the leading factors driving this development.

hydroGEOPHYSICS, Inc. (HGI) and GEM Systems Advanced Magnetometers (GEM) have successfully integrated this mapping technology on a towed geophysical trailer. The platform is almost entirely non-metallic making it suitable for acquisition of high quality magnetic, radiometric, and electromagnetic data. Geophysical instruments are coupled with a GPS navigation system and controlled by a Pocket PC (PDA). The Geophysical Operations CART or "G.O.CART" is towed by an all terrain vehicle (ATV) which is operated by a single person. These technologies provide a multi-parameter geophysical surveying capability for identification and characterization of TRU-contaminated radiological and hazardous materials.

The G.O.CART system will be most effective for site clearance and characterization that may include:

- Pre-remediation surveying for background baseline measurements
- Pre-remediation characterization of waste and soil variability
- Potential magnetic mapping of areas affected by burning
- High precision location of trenches, caissons and drums for excavation
- Post-remediation surveying for regulatory compliance and documentation

G.O.CART Platform

The G.O.CART platform is almost entirely non-metallic, constructed of high-density fiberglass which provides the maximum rigidity for the lowest weight. Large diameter composite plastic wheels were selected for their superior all terrain handling and are mounted individually. The wheel mounting structure eliminates the

need for a through-axle and increases the ground clearance to nearly 3-feet. The area between the wheels can also be used to mount ground coupling sensors such as ground penetrating radar. The CART can be adjusted to hold a variety of geophysical instruments and has a retractable telescoping boom that can extend up to 20-feet. This separation distance is important for towing

by an ATV which typically adds unwanted interference due to its large metallic mass.

GPS Navigation

The G.O.CART includes a GPS guidance and tracking system that eliminates the time consuming effort of pre-survey manual grid layout. Station accuracy is greatly improved since geophysical data points are localized to real-world coordinates during the acquisition phase. Random walk site clearance surveys can be accomplished as easily as predefined grid surveying. The real-time GPS location is presented to the operator via a "heads-up" data display (Pocket PC) which is mounted on the ATV. In this manner, the operator can monitor the position relative to predefined survey boundaries and even control the rate of travel, an important aspect for certain surveying methods.

Data Display

Custom software allows a Pocket PC to integrate with a variety of geophysical instruments that can include: magnetics, electromagnetics, and radiometrics. The Pocket PC (5"x3"- 400Mhz CPU, 64MB RAM) is mounted on the ATV steering column and presents the operator with a display of the geophysical data. Real-time data display allows one to first perform a random-walk reconnaissance survey to identify general target areas and quickly eliminates large unneeded portions. This process helps in reducing the survey area, increases the survey resolution, and generally lowers the surveying cost.

Geophysical Sensors

Magnetics

Magnetic and gradiometric surveys provide the ability to define soils that have been

disturbed (e.g. through trenching), and provide direct detection of ferrous pipes and caissons containing fissile materials. Characterization of disturbed soils is routine in archeological-type investigations – a common application for the GSM-19 Overhauser unit. The new GSMP-40 Potassium unit has even higher sensitivity and will enhance characterization of subtle soil disturbances by an order of magnitude (i.e. identification of soils disturbed through trenching). Another application for magnetics / gradiometrics is geologic mapping; a procedure that may be effective for constraining depth of burial (through basement mapping) and location of geologic structures that may represent potential fluid migration pathways for contaminants. Magnetics / gradiometrics provide an effective means of directly detecting ferrous targets that serve as containers for contaminants. Ferrous targets may also include utilities, wells, drums, rebar, re-mesh, caissons, and tanks.

Very Low Frequency Electromagnetics (VLF)

VLF surveys work on the principle of detection of electromagnetic responses due primarily to steeply dipping mineralized or conductive structures (e.g. faults) or massive metallic objects. VLF can provide a "fast-pass" technology for direct detection of containers and geologic structures that may represent potential fluid migration pathways. Within the Hanford area, VLF should have a substantial depth of investigation (compared to shorter focus EM methods).

Multi-frequency Electromagnetics (EM)

The Geophex GEM-2 frequency domain electromagnetic system provides the ability to discriminate subsurface features with depths of burial up to 30 feet. It can be used for mapping contrasts in soil conductivities

that may result from varying soil moisture or migration of contaminant plumes.

Electromagnetic surveying is particularly suited to detection of buried objects and infrastructure that may include foundations, trenches, utilities, drums, wells, and caissons. This instrumentation represents a significant enhancement to VLF both in terms of its range of frequencies and also in terms of the interpretation methods available for frequency domain EM. These include comparison of In-phase and Quadrature responses for characterization and discrimination of specific types of metallic / ferromagnetic containers, and conductivity mapping of variations in soil.

Radiometrics

Radiometrics is the primary method used in detecting surface contamination due to radio-nuclides as well as naturally occurring

radioactive minerals. Typical site investigations use hand-held instruments with small sensor volumes. Hand-held surveys also typically provide data at discrete point locations. The G.O.CART allows large volume sensor capacity which offers increased sensitivity, continuous coverage, and greater depth of investigation for optimal site characterization.

Continuous profiling can provide a detailed contour map of radionuclide site contamination. Pre-defined windows can be set to detect gamma ray emissions at unique spectral windows corresponding to Co, Cs, and Eu – the typical gamma by-products of man-made transuranic wastes.

Summary

The integration of multi-parameter geophysical methods on a mobile acquisition platform offers the opportunity to characterize transuranic radionuclides, their location in trenches/drums; and corresponding geologic structures that may represent migration pathways. The improvements in geophysical mapping will greatly enhance our understanding of pre-remediation site complexities and offer a means of monitoring the success of cleanup operations. Combining saturation coverage geophysical data with discrete point soil and water sampling can provide the environmental engineer with a wealth of information that was previously cost prohibitive. These advancements will be equally useful in providing a cost effective and non-invasive confirmation of site restoration for regulatory compliance.

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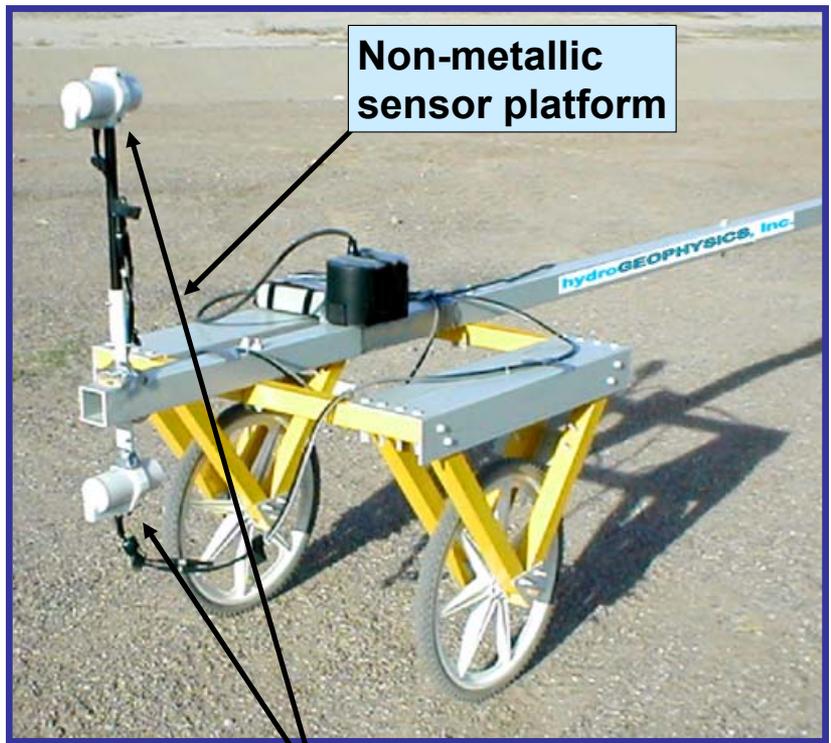
Technology Overview:

- 1. Technological improvements facilitate high resolution and lower cost geophysical mapping of large areas for environmental uses.**
- 2. New non-metallic geophysical trailer towed by an All Terrain Vehicle (ATV) increases acquisition speed and data reliability.**
- 3. Pocket PC (PDA) manages multiple geophysical methods and allows the user to simultaneously satisfy complex site objectives.**
- 4. Global Positioning System (GPS) navigation provides a greater degree of control with accuracy needed to perform:**
 - 1. Time-based evaluation of survey progress / completion**
 - 2. Precise positioning of survey measurement stations**
- 5. Data processing advances deliver near real-time results.**



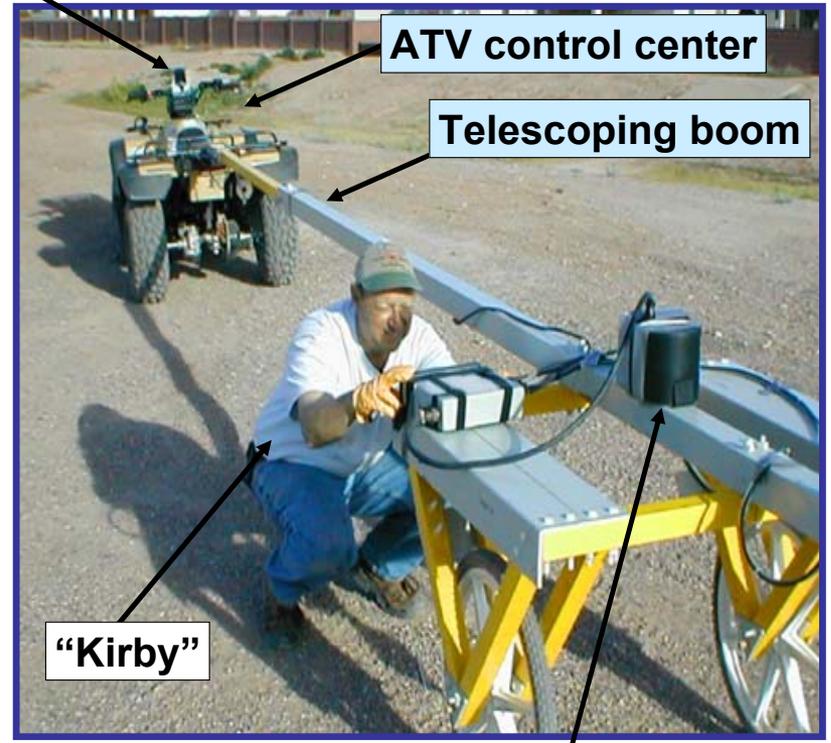
GO-CART – Geophysical Operations CART

GPS position & data display unit



Non-metallic sensor platform

Gradient magnetic sensors



ATV control center

Telescoping boom

“Kirby”

Electromagnetic sensor



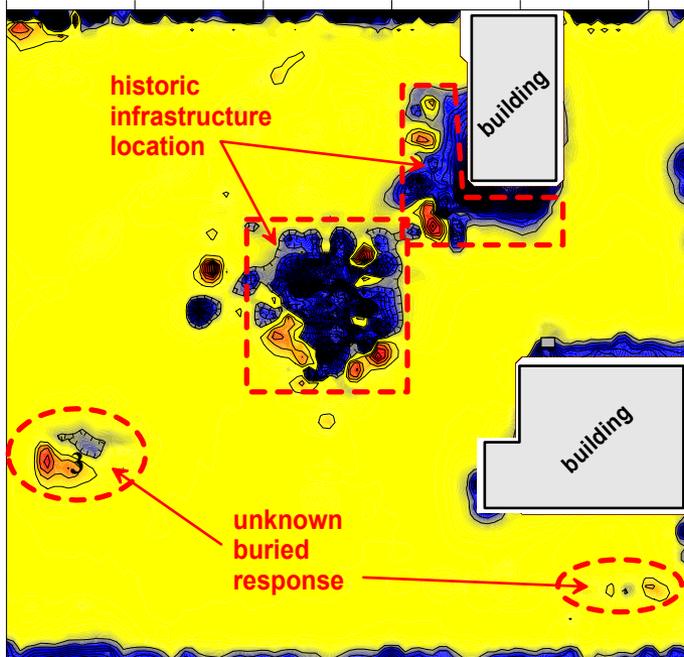
GO-CART – Geophysical Operations **CART**

- **Non-metallic extruded fiberglass construction provides a rigid platform for use over rugged terrain.**
- **Separate wheel mounts provide over 2.5 feet of ground clearance. Area between wheels can be used to for mounting ground-coupling sensors.**
- **Telescoping boom allows up to 30 feet of separation between ATV and sensors (eliminates metallic and electrical noise).**
- **ATV houses large capacity 12V power source and provides operator with a real-time, heads-up display showing location, speed and acquired data.**

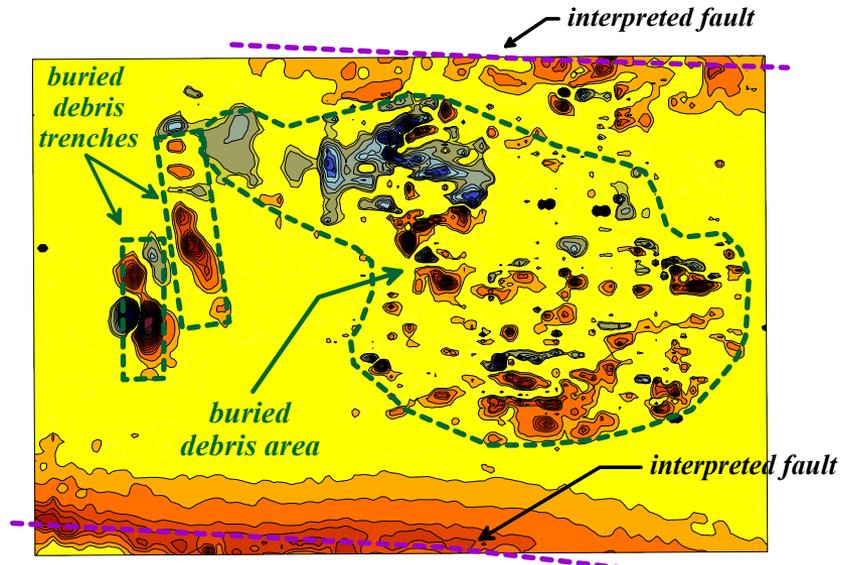




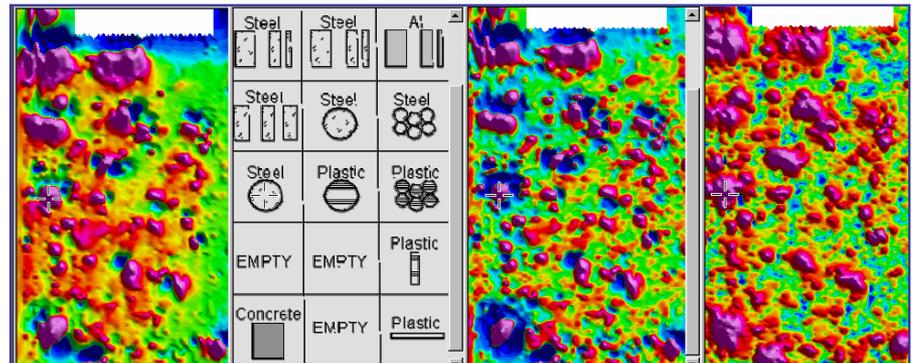
Magnetic Surveying



Buried infrastructure detection



Geologic characterization & landfill mapping



Buried object detection