



TECHNICAL PAPER

# STANDARDIZED UXO DEMONSTRATION SITES

## GEOPHEX, LTD. – GEM-3/HANDHELD

*MOGULS SCORING RECORD NO. 451*



The GEM-3 in the handheld platform is shown being demonstrated by Geophex Ltd.

Technologies under development for the detection and discrimination of unexploded ordnance (UXO) require testing so that their performance can be characterized. To that end, Standardized Test Sites have been developed at Aberdeen Proving Ground (APG), Maryland and Yuma Proving Ground (YPG), Arizona. These test sites provide a diversity of geology, climate, terrain, and weather as well as diversity in ordnance and clutter. Testing at these sites is independently administered and analyzed by the government for the purposes of characterizing technologies, tracking performance with system development, comparing performance of different systems, and comparing performance in different environments.

The Standardized UXO Technology Demonstration Site Program is a multi-agency program spearheaded by the U.S. Army Environmental Center (USAEC). The U.S. Army Aberdeen Test Center (ATC) and the U.S. Army Corps of Engineers Engineering Research and Development Center (ERDC) provide programmatic support. The program is being funded and supported by the Environmental Security Technology Certification Program (ESTCP), the Strategic Environmental Research and Development Program (SERDP) and the Army Environmental Quality Technology Program (EQT).

## DEMONSTRATOR'S SYSTEM AND DATA PROCESSING DESCRIPTION

GEM-3 Electromagnetic Induction (EMI) sensors are multi-frequency (up to 10 frequencies logarithmically spaced in the 30 Hz to 47930 Hz range) sensors consisting of three concentric coils and digital electronics. The outer coil is the primary transmitter, the inner coil the receiver, and the annular coil is a secondary (bucking) transmitter that creates a primary field cavity around the transmitter. The electronics includes a digitally controlled switching H-bridge transmitter current-source, a 24 bit analog to digital (A/D), and a Digital Signal Processor (DSP) with random access memory (RAM) and flash memory and serial data ports (RS-232). A user interface consists of a palm pack computer with Geophex software; commercial digital Global Positioning System (DGPS) is fully integrated.

The system is a continuous wave frequency domain system in which data are recorded while the transmitter is on; the transmitter waveform consists of a continuous mix of superposed sine waves at the specified frequencies. The measured raw time-series data are voltages (pre-amplified) measured by the receiver coil and by a small reference coil located in the transmitter primary/bucking coil annular space (proportional to primary field and phase referenced to primary field), and sampled by the A/D. Data are pre-processed in units of 30-Hz intervals (base periods) and averaged over a selectable number of base periods, typically two for cart-survey operation (net output rate of 15 Hz).

### The GEM-3

in the handheld platform was demonstrated by Geophex Ltd. at the Aberdeen Proving Ground Standardized Demonstration Site's Moguls Area.

This technical paper contains the results of that demonstration.

This is a reference document only and does not serve as an endorsement of the demonstrator's product by the US Army or the Standardized UXO Technology Sites Program.

### For more information

US Army Environmental Center  
Public Affairs Office  
410-436-2556, fax 410-436-1693  
e-mail: [usaecpao@aec.apgea.army.mil](mailto:usaecpao@aec.apgea.army.mil)  
<http://aec.army.mil>  
<http://www.uxotestsites.org>

The cart-mounted configuration, with a 96-cm diameter coil disk mounted on either a manually pushed composite material wheeled cart or an all terrain vehicle (ATV) towed wooden wheeled cart, is used in environments where a large sensor on a wheeled cart is practical and wide-area coverage required, such as flat, open terrain. The ATV towed system is augmented with a navigation system that provides the driver with steering indicators in order to maintain preplanned survey lines, but it requires greater room for turning than the hand pushed cart. The actual sensors are identical and can be interchanged. A DGPS system is integrated with the GEM console, and the antenna mounted directly above the sensor, provides geo-referenced data, which are recorded in the GEM console flash memory and/or the system (laptop PC) computer. Data are post-processed for target detection/classification.

## PERFORMANCE SUMMARY

Results for the Moguls test broken out by size, depth and nonstandard ordnance are presented in table below. Results by size and depth include both standard and nonstandard ordnance. The results by size show how well the demonstrator did at detecting/discriminating ordnance of a certain caliber range. The results are relative to the number of ordnance items emplaced. Depth is measured from the geometric center of anomalies.

The Response Stage results are derived from the list of anomalies above the demonstrator-provided noise level. The results for the Discrimination Stage are derived from the demonstrator's recommended threshold for optimizing UXO field cleanup by minimizing false digs and maximizing ordnance recovery. The lower 90 percent confidence limit on probability of detection and P<sub>fd</sub> was calculated assuming that the number of detections and false positives are binomially distributed random variables. All results have been rounded to protect the ground truth. However, lower confidence limits were calculated using actual results.

## SUMMARY OF MOGUL RESULTS FOR GEM-3

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
<b>RESPONSE STAGE</b>									
P <sub>d</sub>	0.15	0.15	0.10	0.10	0.15	0.10	0.15	0.15	0.15
P <sub>d</sub> Low 90% Conf	0.10	0.09	0.08	0.05	0.11	0.04	0.09	0.08	0.05
P <sub>d</sub> Upper 90% Conf	0.17	0.19	0.19	0.16	0.24	0.24	0.19	0.20	0.27
P <sub>fa</sub>	0.15	-	-	-	-	-	0.15	0.10	0.20
P <sub>fa</sub> Low 90% Conf	0.11	-	-	-	-	-	0.13	0.08	0.05
P <sub>fa</sub> Upper 90% Conf	0.16	-	-	-	-	-	0.19	0.14	0.49
BAR	1.65	-	-	-	-	-	-	-	-
<b>DISCRIMINATION STAGE</b>									
P <sub>d</sub>	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.05
P <sub>d</sub> Low 90% Conf	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P <sub>d</sub> Upper 90% Conf	0.02	0.04	0.03	0.03	0.03	0.14	0.02	0.04	0.16
P <sub>fa</sub>	0.00	-	-	-	-	-	0.05	0.00	0.00
P <sub>fa</sub> Low 90% Conf	0.01	-	-	-	-	-	0.01	0.00	0.00
P <sub>fa</sub> Upper 90% Conf	0.03	-	-	-	-	-	0.04	0.03	0.23
BAR	0.25	-	-	-	-	-	-	-	-

Response Stage Noise Level: 0.00

Recommended Discrimination Stage Threshold: 5.00

*Note: The recommended discrimination stage threshold values are provided by the demonstrator.*

To view the full Scoring Record for this demonstration and for all other demonstrations conducted at the Aberdeen and Yuma Proving Grounds in support of the Standardized UXO Technology Demonstration Sites Program please visit our Web site at: [www.uxotestsites.org](http://www.uxotestsites.org).

