TECHNICAL PAPER

STANDARDIZED UXO DEMONSTRATION SITES

GEOPHEX, LTD. – GEM-3 EM REAL TIME DISC/HANDHELD

MOGULS SCORING RECORD NO. 665

The GEM-3 EM Realtime Disc in the handheld platform is shown as being demonstrated by Geophex, Ltd.

The GEM-3 EM Realtime Disc 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.

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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

The hand-held GEM-3 sensor consists of a concentric sensing coil set having two transmitting coils (Tx) wired such that current flows in opposite directions, a central receiver coil (Rx), an electronic console, and an iPAC® user interface with software for real-time data processing. The GEM-3 coils create a central magnetic cavity region using two concentric, circular loops that are electrically connected in an opposing polarity. The inner coil typically has half as many turns as the outer (6 and 12 for our current 40 cm diameter version used here).

The GEM-3 electronics includes a digital signal processor (DSP) that performs the transmitter waveform generation and processes samples from the receiver analog-to-digital converter (ADC), including discrete Fourier transform (DFT) math to produce inphase and quadrature measurements (parts per million (ppm) relative to primary field at Rx) at each frequency and data time-stamping with a real-time clock for synchronization to a Differential Global Positioning System (DGPS).

The iPAC® performs the detection and discrimination algorithms using the electronic console inphase and quadrature outputs and provides real-time enunciation to the operator in the form of audio and graphical detection queues, graphical identification, and discrimination results.

Major features of the GEM-3 sensor include: ADC sampling at 96 kHz at 24 bits, sampling (ppm) at up to 30 times a second regardless of how many frequencies are used, with automatic averaging down to operator selectable rate (typical 5 Hz), integration with an iPAC® hand-held computer for user interface, iPAC® software with graphical/audio functions and real-time detection and discrimination algorithms.

Performance Summary

Results for the Moguls test, broken out by size, depth and nonstandard ordnance, are presented 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 ordnances 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 probability of false positive 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.

The overall ground truth is composed of ferrous and non-ferrous anomalies. Due to limitations of the magnetometer, the non-ferrous items cannot be detected. Therefore, the summary presented in the Ferrous Only table exhibits results based on the subset of the ground truth that is solely the ferrous anomalies. The second table exhibits results based on the full ground truth. The response stage noise level and recommended discrimination stage threshold values are provided by the demonstrator.

Summary of Mogul Results for GEM-3 Real Time Disc/Hand Held

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to < 1	>= 1
RESPONSE STAGE									
P_d	0.70	0.75	0.60	0.75	0.85	0.55	0.90	0.50	0.15
P_d Low 90% Conf	0.63	0.68	0.51	0.68	0.55	0.40	0.85	0.43	0.08
P_d Upper 90% Conf	0.72	0.80	0.67	0.81	0.72	0.68	0.94	0.61	0.32
P_fa	0.65	-	-	-	-	-	0.75	0.50	0.35
P_fa Low 90% Conf	0.62	-	-	-	-	-	0.73	0.48	0.13
P_fa Upper 90% Conf	0.68	-	-	-	-	-	0.81	0.58	0.60
BAR	3.00	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.50	0.50	0.50	0.60	0.50	0.30	0.70	0.40	0.10
P_d Low 90% Conf	0.46	0.44	0.44	0.50	0.43	0.19	0.62	0.32	0.02
P_d Upper 90% Conf	0.56	0.58	0.60	0.65	0.60	0.45	0.75	0.50	0.22
P_fa	0.40	-	-	-	-	-	0.50	0.25	0.20
P_fa Low 90% Conf	0.36	-	-	-	-	-	0.45	0.23	0.06
P_fa Upper 90% Conf	0.42	-	-	-	-	-	0.54	0.32	0.49
BAR	1.45	-	-	-	-	-	-	-	-

Response Stage Noise Level: -1,000.00
Recommended Discrimination Stage Threshold: 4.97

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.