



TECHNICAL PAPER

STANDARDIZED UXO DEMONSTRATION SITES

GEOPHEX, LTD. – EM GEM-5/TOWED

OPEN FIELD SCORING RECORD NO. 740

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 GEM-5 array sensor consists of a single large rectangular transmitting coil (Tx) and seven receiver coil (Rx) coaxial pairs wired in a differential (gradient) mode, an electronic console incorporating seven analog-to-digital converters (ADCs) and digital signal processors (DSPs) and a digitally controlled Tx current driver, and a laptop personal computer data logger. Data time stamping is performed with a real-time clock for synchronization to a Differential Global Positioning System (DGPS), and two DGPS units provide positioning for the seven receivers and the operator navigation computer. The conceptual representation of the GEM-5 array with single Tx (red) and symmetric positioning of Rx differencing coil pairs to null the primary field (the system for this demonstration has seven Rx pairs; the red Q-coil represents a target).

The system is a continuous-wave frequency-domain electromagnetic interference (EMI) sensor that uses a hybrid current waveform to provide simultaneous multifrequency (typically 10 log-spaced) energy in the 90-Hz to 90-kHz band, with each Rx DSP performing digital Fourier transforms at the selected frequencies. The upper Rx coil provides primary field reference (amplitude and phase) for Rx output normalization (units of parts per million (ppm) of the primary field generated electromagnetic field (EMF)).



The GEM-5 Single Sensor in the towed platform is shown as demonstrated by Geophex, Ltd.

The GEM-5 in the towed platform was demonstrated by Geophex, Ltd. at the Aberdeen Proving Ground Standardized Demonstration Site's Open Field 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

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PERFORMANCE SUMMARY

Results for the Open Field 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 OPEN FIELD RESULTS FOR THE GEM-5/TOWED ARRAY

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.60	0.65	0.45	0.60	0.60	0.60	0.70	0.55	0.35
P_d Low 90% Conf	0.55	0.61	0.39	0.53	0.53	0.51	0.63	0.50	0.26
P_d Upper 90% Conf	0.62	0.70	0.52	0.66	0.63	0.67	0.72	0.63	0.43
P_f	0.50	-	-	-	-	-	0.50	0.50	0.30
P_f Low 90% Conf	0.48	-	-	-	-	-	0.47	0.48	0.18
P_f Upper 90% Conf	0.53	-	-	-	-	-	0.53	0.54	0.50
P_{fa}	0.60	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.35	0.35	0.25	0.25	0.45	0.20	0.45	0.30	0.05
P_d Low 90% Conf	0.29	0.33	0.20	0.18	0.39	0.13	0.39	0.23	0.01
P_d Upper 90% Conf	0.36	0.41	0.31	0.30	0.49	0.26	0.49	0.36	0.09
P_f	0.15	-	-	-	-	-	0.20	0.15	0.05
P_f Low 90% Conf	0.15	-	-	-	-	-	0.17	0.12	0.01
P_f Upper 90% Conf	0.18	-	-	-	-	-	0.21	0.17	0.22
P_{fa}	0.10	-	-	-	-	-	-	-	-

Response Stage Noise Level: 20.00

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.

