TECHNICAL PAPER

STANDARDIZED UXO DEMONSTRATION SITES

GEO-CENTERS, INC. – SIMULTANEOUS EM AND MAGNETOMETRY (MULTISENSOR STOLS)/TOWED – *OPEN FIELD SCORING RECORD NO. 298*

The Simultaneous EM and Magnetometry (Multisensor STOLS) in the towed platform is shown being demonstrated by Geo-Centers, Inc.

The Simultaneous EM and Magnetometry (Multisensor STOLS) in the towed platform was demonstrated by Geo-Centers, Inc. 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.

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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 Simultaneous EM and Magnetometry system (multisensor STOLS) is a towed vehicular array developed by GEO-CENTERS and Corps of Engineers – Huntsville Center (CEHNC) with funding from ESTCP under project UX-0208. The system simultaneously collects both total field magnetometer data and EM61 data on a single towed platform. GEO-CENTERS' existing Surface Towed Ordnance Location System (STOLS) was used as a host system; STOLS' custom-fabricated aluminum dune buggy with a low-magnetic self-signature, magnetometers, differential GPS, sensors, computers, and tractor-trailer for transportation were reused. The new Simultaneous Electromagnetic (EM) and Magnetometry system augments STOLS with interleaved sampling electronics that allow EM61 coils to be physically located on the same platform as the magnetometers without corrupting the magnetometer data. The electronics monitor the rising edge of the 75 Hz transmit pulse from the EM61, wait 8 ms for the pulse to die down, sample the magnetometers for 5 ms, then wait for the next transmit pulse and repeat the cycle. Data acquired last month at McKinley Test Range (Redstone Arsenal, Huntsville) show that magnetometer data quality with the EM system switched on is commeasurate with magnetometer data quality when the EM system is switched off. Magnetometer, EM61, and GPS data are acquired in a single file.

Along with new interleaved sampling, electronics is a new proof-of-concept non-metallic tow platform to host both the EM61 coils and the magnetometers in a low-noise environment. Constructed almost entirely from fiberglass, the only metallic components on the platform are the axles, the hub, and a small number of aluminum pop rivets. The wheels are composite. Even the tires have had the metal beads removed. Total metallic mass has been reduced by over 99 percent by weight as compared to the original aluminum STOLS tow platform. Certain key structural locations have been reinforced with marine-grade plywood. The proof-of-concept platform was recently fielded

successfully for a prove-out at McKinley Test Range. It should be noted that the platform was designed to fit into the existing budget for the ESTCP project, but was not designed for commercial surveys: it has no suspension, is speed-limited, and may not survive a fielding over rugged terrain without sustaining structural damage.

Five Geometrics 822A magnetometers updating and outputting at 75 Hz are deployed at 1/2 meter spacing. The magnetometers are 10 feet behind the tow vehicle. Three 1/2 meter Geonics EM61 coils (upper and lower) internally updating at 75 Hz and outputting at 10 Hz are deployed in a master/slave configuration on the rear of the platform, 8 feet behind the magnetometers, also at 1/2 meter spacing. The center line of the middle three magnetometers is coincident with the center line of the three EM61 coils. Both the magnetometers and the lower EM61 coils are mounted on pivots so they can swing up if they encounter an obstacle while moving forward.

Performance Summary

Results for the Open Field test broken out by size, depth and nonstandard ordnance are presented in the 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 Pfp 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 Open Field Results for the STOLS/Towed Array (EM Sensor)

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.50	0.55	0.40	0.40	0.55	0.65	0.55	0.45	0.40
P_d Low 90% Conf	0.46	0.51	0.35	0.35	0.47	0.55	0.52	0.40	0.30
P_d Upper 90% Conf	0.53	0.61	0.46	0.46	0.60	0.71	0.62	0.53	0.47
P_fa	0.40	-	-	-	-	-	0.35	0.45	0.55
P_fa Low 90% Conf	0.39	-	-	-	-	-	0.32	0.44	0.38
P_fa Upper 90% Conf	0.43	-	-	-	-	-	0.38	0.50	0.74
BAR	0.15	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.45	0.50	0.35	0.30	0.50	0.60	0.45	0.45	0.30
P_d Low 90% Conf	0.39	0.43	0.30	0.23	0.44	0.52	0.41	0.38	0.24
P_d Upper 90% Conf	0.46	0.53	0.41	0.33	0.57	0.68	0.52	0.50	0.40
P_fa	0.40	-	-	-	-	-	0.30	0.45	0.50
P_fa Low 90% Conf	0.36	-	-	-	-	-	0.28	0.42	0.32
P_fa Upper 90% Conf	0.40	-	-	-	-	-	0.33	0.48	0.68
BAR	0.05	-	-	-	-	-	-	-	-

Response Stage Noise Level: -0.22
Recommended Discrimination Stage Threshold: 3.00

Summary of Open Field Results for the STOLS/Towed Array (MAG Sensor)

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
Ferrous Only Ground Truth									
RESPONSE STAGE									
P_d	0.45	0.45	0.40	0.20	0.50	0.70	0.45	0.45	0.45
P_d Low 90% Conf	0.40	0.42	0.34	0.17	0.42	0.62	0.37	0.39	0.36
P_d Upper 90% Conf	0.48	0.52	0.46	0.28	0.54	0.77	0.49	0.52	0.53
P_fa	0.40	-	-	-	-	-	0.30	0.50	0.70
P_fa Low 90% Conf	0.38	-	-	-	-	-	0.28	0.45	0.50
P_fa Upper 90% Conf	0.43	-	-	-	-	-	0.34	0.51	0.84
BAR	0.05	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.40	0.40	0.35	0.10	0.45	0.65	0.35	0.40	0.40
P_d Low 90% Conf	0.34	0.34	0.30	0.08	0.37	0.56	0.29	0.34	0.31
P_d Upper 90% Conf	0.41	0.44	0.42	0.18	0.49	0.72	0.40	0.47	0.48
P_fa	0.40	-	-	-	-	-	0.30	0.45	0.65
P_fa Low 90% Conf	0.36	-	-	-	-	-	0.27	0.43	0.43
P_fa Upper 90% Conf	0.41	-	-	-	-	-	0.33	0.49	0.79
BAR	0.05	-	-	-	-	-	-	-	-
Full Ground Truth									
RESPONSE STAGE									
P_d	0.45	0.50	0.40	0.30	0.50	0.70	0.45	0.50	0.45
P_d Low 90% Conf	0.42	0.43	0.36	0.24	0.43	0.63	0.38	0.42	0.36
P_d Upper 90% Conf	0.49	0.53	0.47	0.34	0.56	0.78	0.49	0.54	0.53
P_fa	0.35	-	-	-	-	-	0.35	0.30	0.20
P_fa Low 90% Conf	0.32	-	-	-	-	-	0.34	0.29	0.07
P_fa Upper 90% Conf	0.36	-	-	-	-	-	0.39	0.34	0.37
BAR	0.05	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.35	0.35	0.30	0.50	0.25	0.05	0.50	0.25	0.10
P_d Low 90% Conf	0.30	0.30	0.26	0.46	0.22	0.03	0.43	0.20	0.06
P_d Upper 90% Conf	0.37	0.39	0.37	0.57	0.33	0.12	0.54	0.31	0.18
P_fa	0.35	-	-	-	-	-	0.45	0.35	0.05
P_fa Low 90% Conf	0.35	-	-	-	-	-	0.40	0.30	0.01
P_fa Upper 90% Conf	0.39	-	-	-	-	-	0.46	0.36	0.22
BAR	0.05	-	-	-	-	-	-	-	-

Response Stage Noise Level: 2.81
Recommended Discrimination Stage Threshold: 1.00

Summary of Open Field Results for the STOLS/Towed Array (Combined EM/Mag Results)

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.55	0.60	0.45	0.40	0.55	0.70	0.60	0.50	0.45
P_d Low 90% Conf	0.50	0.53	0.41	0.37	0.51	0.62	0.54	0.43	0.37
P_d Upper 90% Conf	0.57	0.62	0.52	0.48	0.63	0.77	0.64	0.56	0.55
P_fa	0.45	-	-	-	-	-	0.40	0.50	0.75
P_fa Low 90% Conf	0.43	-	-	-	-	-	0.35	0.49	0.56
P_fa Upper 90% Conf	0.48	-	-	-	-	-	0.41	0.55	0.89
BAR	0.15	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.45	0.50	0.40	0.30	0.55	0.65	0.50	0.50	0.35
P_d Low 90% Conf	0.43	0.47	0.33	0.27	0.48	0.56	0.44	0.43	0.28
P_d Upper 90% Conf	0.51	0.57	0.45	0.38	0.61	0.72	0.55	0.55	0.45
P_fa	0.40	-	-	-	-	-	0.30	0.50	0.75
P_fa Low 90% Conf	0.40	-	-	-	-	-	0.29	0.47	0.56
P_fa Upper 90% Conf	0.44	-	-	-	-	-	0.35	0.53	0.89
BAR	0.10	-	-	-	-	-	-	-	-

Response Stage Noise Level: -6.50
Recommended Discrimination Stage Threshold: 2.99

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.uxoteststes.org.