



TECHNICAL PAPER

STANDARDIZED UXO DEMONSTRATION SITES

GEO-CENTERS, INC. – SIMULTANEOUS MULTI-SENSOR SURFACE TOWED ORDNANCE LOCATION SYSTEM (STOLS)/TOWED – OPEN FIELD SCORING RECORD NO. 299



The Simultaneous Multi-Sensor Surface Towed Ordnance Location System (STOLS) in the towed platform is shown being demonstrated by Geo-Centers, Inc.

The Simultaneous Multi-Sensor Surface Towed Ordnance Location System (STOLS) in the towed platform was demonstrated by Geo-Centers, Inc. at the Yuma 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 Multi-sensor Surface Towed Ordnance Location System (STOLS) is a Global Positioning System (GPS)-integrated vehicular towed array with the unique capability to simultaneously co-deploy total field magnetometers and electromagnetic (EM)61 sensors on a common platform. The system was developed by GEO-CENTERS and Corps of Engineers-Huntsville Center (CEHNC) under Environmental Security Technology Certification Projects (ESTCP) project UX-0208, the goal of which was to integrate EM61s into GEO-CENTERS' existing STOLS towed magnetometer array.

Also funded was the development of a fiberglass proof-of-concept platform to host both the magnetometers in a very low-noise environment. Major portions of GEO-CENTERS original STOLS magnetometer-only towed array were utilized; the existing aluminum-framed low-magnetic self-signature tow vehicle, five cesium vapor total field magnetometers, three channels of EM61 MK1 (single time gate) electronics, three 1/2 by 1/2 meter coils, Trimble real time kinematic (RTK) equipped GPS capable of centimeter-level accuracy in real time, and data acquisition and data processing infrastructure were leveraged by the ESTCP-funded effort. The system also uses a stationary reference magnetometer to track the diurnal variations of the Earth's ambient magnetic field.

The ESTCP-funded system has been significantly improved through an ongoing Cooperative Research and Development Agreement (CRADA) between CEHNC and GEO-CENTERS. These improvements include updating the EM61 system to include five 1 by 1/2 meter coils (making the EM swath the same as the magnetometer swath width) driven by MKII multiple time gate electronics, the addition of a suspension to the original proof-of-concept fiberglass towed platform, a ruggedized computer for data acquisition, and powering all EM61 electronics off a common isolated battery to eliminate drift and mitigate noise. The purchase of the new EM61 hardware was funded by ATC through the Army EQT program.

The magnetometers and EM61 coils are each at 1/2 meter spacing cross-track, with the five EM61 coils along the center line of the five magnetometers. The GPS antenna is directly over the center magnetometer. The down-track separation between the magnetometer array and the EM61 array is currently 8 feet, though this is an overly conservative artifact of the original ESTCP-funded design. Since the synchronized electronics sample the magnetometers during the period when the EM61 transmit pulse is quiet, the magnetometer sampling rate is the same as the EM61 transmit pulse rate – namely, 75 Hz. Like all COTS EM61s, the electronics average the data until they receive a signal from a tick wheel. An electrical circuit is used to divide the GPS 1 PPS into a 10 Hz tick signal and trigger the EM61 to output data. Thus, the EM61 data output rate is 10 Hz.

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 P_{fd} 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	0.70	0.70	0.75	0.65	0.75	0.90	0.70	0.75	0.60
P _d Low 90% Conf	0.69	0.66	0.70	0.59	0.70	0.83	0.69	0.70	0.47
P _d Upper 90% Conf	0.74	0.73	0.78	0.67	0.80	0.93	0.75	0.79	0.69
P _{fa}	0.70	-	-	-	-	-	-	0.65	0.75
P _{fa} Low 90% Conf	0.66	-	-	-	-	-	-	0.63	0.73
P _{fa} Upper 90% Conf	0.70	-	-	-	-	-	-	0.67	0.79
BAR	0.00	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P _d	0.40	0.40	0.35	0.05	0.70	0.85	0.25	0.60	0.55
P _d Low 90% Conf	0.36	0.37	0.33	0.05	0.65	0.81	0.21	0.56	0.45
P _d Upper 90% Conf	0.42	0.44	0.42	0.09	0.75	0.91	0.28	0.66	0.67
P _{fa}	0.45	-	-	-	-	-	-	0.40	0.65
P _{fa} Low 90% Conf	0.44	-	-	-	-	-	-	0.36	0.64
P _{fa} Upper 90% Conf	0.48	-	-	-	-	-	-	0.40	0.71
BAR	0.00	-	-	-	-	-	-	-	-

Response Stage Noise Level: -0.90

Recommended Discrimination Stage Threshold: 4.00

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	0.40	0.40	0.40	0.15	0.50	0.80	0.35	0.60	0.30
P _d Low 90% Conf	0.39	0.38	0.37	0.14	0.45	0.76	0.29	0.56	0.20
P _d Upper 90% Conf	0.45	0.47	0.46	0.21	0.57	0.87	0.37	0.67	0.41
P _{fa}	0.50	-	-	-	-	-	-	0.45	0.60
P _{fa} Low 90% Conf	0.48	-	-	-	-	-	-	0.44	0.58
P _{fa} Upper 90% Conf	0.52	-	-	-	-	-	-	0.48	0.65
BAR	0.05	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P _d	0.40	0.40	0.35	0.10	0.50	0.80	0.30	0.60	0.30
P _d Low 90% Conf	0.36	0.37	0.32	0.09	0.44	0.75	0.24	0.55	0.18
P _d Upper 90% Conf	0.42	0.46	0.41	0.16	0.55	0.86	0.32	0.67	0.39
P _{fa}	0.50	-	-	-	-	-	-	0.45	0.60
P _{fa} Low 90% Conf	0.47	-	-	-	-	-	-	0.42	0.58
P _{fa} Upper 90% Conf	0.50	-	-	-	-	-	-	0.46	0.65
BAR	0.05	-	-	-	-	-	-	-	-
Full Ground Truth									
RESPONSE STAGE									
P _d	0.35	0.35	0.40	0.10	0.50	0.80	0.25	0.55	0.30
P _d Low 90% Conf	0.33	0.30	0.35	0.10	0.45	0.76	0.24	0.48	0.20
P _d Upper 90% Conf	0.39	0.37	0.44	0.15	0.57	0.87	0.31	0.59	0.40
P _{fa}	0.50	-	-	-	-	-	-	0.45	0.60
P _{fa} Low 90% Conf	0.48	-	-	-	-	-	-	0.44	0.58
P _{fa} Upper 90% Conf	0.52	-	-	-	-	-	-	0.48	0.65
BAR	0.05	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P _d	0.35	0.30	0.35	0.10	0.50	0.80	0.25	0.55	0.25
P _d Low 90% Conf	0.31	0.29	0.30	0.07	0.44	0.75	0.20	0.48	0.18
P _d Upper 90% Conf	0.36	0.36	0.39	0.11	0.55	0.86	0.27	0.58	0.38
P _{fa}	0.50	-	-	-	-	-	-	0.45	0.60
P _{fa} Low 90% Conf	0.47	-	-	-	-	-	-	0.42	0.58
P _{fa} Upper 90% Conf	0.50	-	-	-	-	-	-	0.46	0.65
BAR	0.05	-	-	-	-	-	-	-	-

Response Stage Noise Level: -0.90

Recommended Discrimination Stage Threshold: 0.04

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	0.70	0.70	0.75	0.65	0.75	0.90	0.75	0.75	0.60
P _d Low 90% Conf	0.69	0.67	0.70	0.61	0.71	0.83	0.69	0.70	0.47
P _d Upper 90% Conf	0.75	0.74	0.79	0.68	0.81	0.93	0.76	0.79	0.69
P _{fa}	0.70	-	-	-	-	-	-	0.65	0.78
P _{fa} Low 90% Conf	0.68	-	-	-	-	-	-	0.65	0.75
P _{fa} Upper 90% Conf	0.72	-	-	-	-	-	-	0.69	0.81
BAR	0.05	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P _d	0.45	0.40	0.45	0.15	0.70	0.90	0.30	0.60	0.60
P _d Low 90% Conf	0.40	0.39	0.38	0.11	0.63	0.83	0.27	0.56	0.47
P _d Upper 90% Conf	0.45	0.46	0.47	0.16	0.74	0.93	0.34	0.66	0.69
P _{fa}	0.55	-	-	-	-	-	-	0.50	0.75
P _{fa} Low 90% Conf	0.54	-	-	-	-	-	-	0.47	0.72
P _{fa} Upper 90% Conf	0.58	-	-	-	-	-	-	0.51	0.79
BAR	0.05	-	-	-	-	-	-	-	-

Response Stage Noise Level: 0.16

Recommended Discrimination Stage Threshold: 0.60

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.

