TECHNICAL PAPER

STANDARDIZED UXO DEMONSTRATION SITES

G-TEK AUSTRALIA PTY LIMITED – MAGNETOMETER TM-4/SLING

MOGULS SCORING RECORD NO. 581

The Magnetometer TM-4 in the sling platform was demonstrated by G-Tek Australia PTY Limited at Yuma Proving Ground, Arizona (shown here at Aberdeen Proving Ground, Maryland).

The Magnetometer TM-4 in the sling platform was demonstrated by G-Tek Australia PTY Limited at the Yuma 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 TM-4 magnetometer system consists of a magnetometer control module produced by G-TEK, Cs Vapor type TMI Sensors by Geometrics, base-station magnetometer by G-Tek, DGPS (digital global positioning system) by NovAtel and an Odometer by G-Tek.

The TM-4 is a self-contained magnetometer system, which may be configured with up to four, optically pumped magnetic sensors each recording the total magnetic field intensity in units of nT to a resolution of 0.01 nT. These sensors will be mounted in an array oriented perpendicular to the survey direction permitting up to four sensor transects to be recorded simultaneously in the open terrain with high survey productivity. The proposed sensor separation is 300 mm and ground clearance 250 mm. The measurement rate from each sensor is selectable from nominally 50 per second at 0.003 nT resolution to 400 per second at 0.08 nT. The high measurement rate permits effective real-time filtering of 50/60 Hz electromagnetic interference prior to recording position or time-based measurements at intervals appropriate to the application (in this case 50 mm or 10 Hz). The TM-4 interfaces with both industry standard real-time kinematic (RTK) DGPS and proprietary cotton thread based odometer systems. This provides versatile time or position-based positioning that is adaptable to varied terrain and vegetation conditions. A key attribute of the TM-4 is the operating system software

that provides a continuous set of data quality monitors reducing the need to resurvey and improving data quality. In particular there are audio and graphic displays and alarms monitoring sensor signal quality, position data quality and navigation aids.

A two-person crew operates the TM-4 system. One-person carries the sensor array to which is attached the DGPS antenna and odometer system. This array measures 1500 mm length by the array width, which in this case will be 900 mm. The quad-sensor array weighs 10 kg. The second person operates the navigation and data acquisition hardware carried in a backpack with batteries. This backpack measures 600 by 400 by 250 mm and weighs approximately 12 kg. The user interface is a hand-held personal computer (PC). A 5-meter cable eliminating interference at the sensors from the other hardware separates the two operators. There are no specific safety hazards identified with the use of this equipment.

Performance Summary

Results for the Mogul 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 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.

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 (Ferrous Only)

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.35	0.40	0.30	0.30	0.35	0.55	0.45	0.25	0.30
P_d Low 90% Conf	0.30	0.31	0.22	0.22	0.25	0.35	0.36	0.13	0.08
P_d Upper 90% Conf	0.43	0.49	0.43	0.42	0.47	0.70	0.53	0.35	0.60
P_{fp}	0.50	-	-	-	-	-	0.50	0.50	0.00
P_{fp} Low 90% Conf	0.46	-	-	-	-	-	0.47	0.39	0.00
P_{fp} Upper 90% Conf	0.56	-	-	-	-	-	0.58	0.61	0.68
BAR	0.20	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.30	0.30	0.25	0.20	0.30	0.45	0.35	0.20	0.30
P_d Low 90% Conf	0.23	0.23	0.18	0.14	0.20	0.30	0.26	0.10	0.08
P_d Upper 90% Conf	0.36	0.40	0.38	0.32	0.41	0.65	0.43	0.32	0.60
P_{fp}	0.35	-	-	-	-	-	0.40	0.35	0.00
P_{fp} Low 90% Conf	0.33	-	-	-	-	-	0.33	0.26	0.00
P_{fp} Upper 90% Conf	0.42	-	-	-	-	-	0.43	0.49	0.68
BAR	0.10	-	-	-	-	-	-	-	-

Response Stage Noise Level: 20.00
Recommended Discrimination Stage Threshold: 0.50

Summary of Mogul Results (Full Ground Truth)

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.30	0.30	0.30	0.20	0.35	0.55	0.35	0.20	0.30
P_d Low 90% Conf	0.25	0.24	0.20	0.15	0.25	0.35	0.29	0.11	0.08
P_d Upper 90% Conf	0.37	0.39	0.39	0.30	0.47	0.70	0.44	0.31	0.60
P_{fp}	0.50	-	-	-	-	-	0.50	0.50	N/A
P_{fp} Low 90% Conf	0.46	-	-	-	-	-	0.47	0.39	N/A
P_{fp} Upper 90% Conf	0.56	-	-	-	-	-	0.58	0.61	0.68
BAR	0.20	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.25	0.25	0.25	0.15	0.30	0.45	0.30	0.15	0.30
P_d Low 90% Conf	0.19	0.18	0.16	0.10	0.20	0.30	0.21	0.09	0.08
P_d Upper 90% Conf	0.30	0.32	0.35	0.23	0.41	0.65	0.36	0.27	0.60
P_{fp}	0.35	-	-	-	-	-	0.40	0.35	N/A
P_{fp} Low 90% Conf	0.33	-	-	-	-	-	0.33	0.26	N/A
P_{fp} Upper 90% Conf	0.42	-	-	-	-	-	0.43	0.49	0.68
BAR	0.10	-	-	-	-	-	-	-	-

Response Stage Noise Level: 20.00
Recommended Discrimination Stage Threshold: 0.50

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.