TECHNICAL PAPER

Standardized UXO Demonstration Sites

G-Tek Australia PTY Limited – EM TM-5/Sling

DESERT EXTREME SCORING RECORD NO. 144

The EM TM-5 in the sling platform is shown being demonstrated by G-Tek Australia PTY Limited.

The EM TM-5 in the sling platform was demonstrated by G-Tek Australia at the Yuma Proving Ground Standardized Demonstration Site's Desert Extreme 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 man portable TM-5 electromagnetic unit (EMU) consists of a magnetometer control module produced by G-TEK, multi-period, transient electromagnetic (EM) sensors by Minelab Electronics, DGPS (digital Global Positioning System) by Ashtech, and an odometer by G-TEK.

The TM-5 EMU detector system may be configured with one or two sensors measuring the transient electromagnetic (EM) response. In the application proposed, two sensors will be mounted in an array, oriented perpendicular to the survey direction and delivering a 1.2-meter swath width. In the dual-sensor mode, the TM-5 EMU is operated by a single person.

The TM-5 EMU interfaces with both industry standard real-time kinematic (RTK) DGPS and proprietary cotton thread based odometer systems, providing versatile positioning adaptable to varied terrain and vegetation conditions. The TM-5 EMU has been successfully used for over five years. The odometer remains the positioning technology of choice in adverse terrains, while DGPS is preferred in open environments. Combined, they meet the requirements of most situations.

The TM-5 EMU detector system interfaces with both industry standard RTK DGPS and proprietary cotton thread based odometer systems, providing versatile time or position-based positioning that is adaptable to varied terrain and vegetation conditions. In both cases, where UXO detection standards of survey coverage are required, G-TEK operators use a pre-established control grid and visual sighters for straight-line navigation, and the DGPS or odometer for data positioning only.

Using DGPS in the Open Area. DGPS is the technology of choice in situations where satellite coverage is reliable. In this case, any of the industry standard RTK systems (with the precise 1-pulse-per-second facility) may be used, although in this program we propose using the Ashtech Z-Extreme system (with NovAtel RT-2 as a backup). The preference is to establish a Global Positioning System (GPS) base station on a monument that is within 1 km of the survey area and to use a radio link to the roving GPS receiver. In the roving instrumentation, sensor data are merged, synchronized with the transformed DGPS positions, and recorded. In this way, sensor data are positioned with an accuracy of better than 5 cm. Prior to commencing the survey, the roving GPS is located at a known reference to confirm the integrity of the system and transformations used. The real-time DGPS will be used to establish a control grid using non-metallic pegs at intervals appropriate to the level of visibility. At YPG a control line interval of 25 or 50 meters is anticipated. The non-metallic polychains will then be laid as control lines, perpendicular to the proposed survey direction. Visual sighters will be located along the first survey line and used as a visual aid to navigation. As each sighter is reached, it will be moved 0.8 meters laterally to the position of the return survey line.

Using the Odometer in the Wooded Area. The control grid setup combines the use of DGPS and cotton odometer survey techniques. Navigation is done the same as described above. However, 5 meters before the commencement of each new transect, the cotton thread is tied to either vegetation or a small peg anchored to the ground. When each control line is reached, a distance mark is recorded in the TM-5 EMU prior to moving the cone. At the completion of each survey grid section, the cotton is gathered and removed from the site. In post-processing, linear error distribution delivers positional accuracy that is typically less than 0.1 percent of the distance between control lines (0.1 percent of 25 meters delivers 2.5 cm accuracy in this case). Because the odometer is used in more adverse terrain, including forests, protocols have been developed using the electronic notepad facility of the TM-5 EMU for recording the location of obstacles (e.g., trees) and the direction taken around them. If a UXO is detected close to a tree, the validation team will know which side of the tree to search. Experience over many years surveying in forested conditions has indicated that an rms target position error of less than 30 mm can be anticipated with the greatest errors occurring where obstacles are circumvented. These errors are not cumulative and are comparable with the interpreted target position errors achieved using DGPS.

Performance Summary

Results for the Desert Extreme 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.

Summary of Desert Extreme Results for TM-5/Sling

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.45	0.45	0.45	0.50	0.40	0.55	0.50	0.40	0.40
P_d Low 90% Conf	0.40	0.38	0.36	0.39	0.27	0.38	0.40	0.31	0.11
P_d Upper 90% Conf	0.52	0.53	0.56	0.56	0.49	0.72	0.56	0.53	0.75
P_{fp}	0.70	-	-	-	-	-	0.70	0.65	0.00
P_{fp} Low 90% Conf	0.65	-	-	-	-	-	0.65	0.57	0.00
P_{fp} Upper 90% Conf	0.72	-	-	-	-	-	0.74	0.74	0.90
BAR	0.05	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.40	0.40	0.40	0.45	0.35	0.45	0.40	0.40	0.40
P_d Low 90% Conf	0.34	0.34	0.28	0.35	0.23	0.28	0.33	0.29	0.11
P_d Upper 90% Conf	0.46	0.50	0.48	0.52	0.44	0.62	0.48	0.50	0.75
P_{fp}	0.45	-	-	-	-	-	0.40	0.60	0.00
P_{fp} Low 90% Conf	0.42	-	-	-	-	-	0.37	0.52	0.00
P_{fp} Upper 90% Conf	0.50	-	-	-	-	-	0.48	0.69	0.90
BAR	0.05	-	-	-	-	-	-	-	-

Response Stage Noise Level: 9.01
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.