



TECHNICAL PAPER

STANDARDIZED UXO DEMONSTRATION SITES

G-TEK AUSTRALIA PTY LIMITED – MAGNETOMETER TM-4/ MAN-PORTABLE - BLIND GRID SCORING RECORD NO. 268



The TM-4 Magnetometer in the man-portable platform is being shown by G-Tek Australia PTY Limited at Aberdeen Proving Ground, Maryland.

The TM-4 Magnetometer in the man-portable platform was demonstrated by G-Tek Australia at the Aberdeen Proving Ground Standardized Demonstration Site's Blind Grid 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 TM-4 is a self-contained magnetometer system that may be configured with up to four optically pumped magnetic sensors, each of which records 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 300mm and ground clearance, 250mm. 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 resolution. The high measurement rate permits effective real-time filtering of 50 to 60 Hz electromagnetic interference prior to recording position or time-based measurements at intervals appropriate to the application (in this case, 50mm or 10 Hz). The TM-4 interfaces with both the industry-standard real-time kinematic (RTK) differential DGPS and the 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, which provides a continuous set of data quality monitors, reducing the need to resurvey and improving data quality. In particular, audio and graphic displays and alarms monitor the quality of sensor signals and position data as well as aid navigation.

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. The

sensor array measures 1500mm in length by the array width, which in this case is 900mm. The quad-sensor array weighs 10kg. The second person operates the navigation and data acquisition hardware, which is carried in a backpack with batteries. This backpack measures 600mm by 400mm by 250mm and weighs approximately 12kg. The user interface is a hand-held personal computer (PC). A 5-meter cable eliminates interference at the sensors from the other hardware and separates the two operators. No specific safety hazards have been identified with the use of this equipment.

Data processing consists of magnetic base-station subtraction, optional band-pass spatial filtering to enhance particular source depths, grading, and imaging. Interpretation of picked anomalies involves classification (by type) and ranking (by probability UXO) using model inversion involving both magnetic remanence and the use of a database of anticipated UXO types. Products are data images and dig sheets conforming to DID OE-005-05.02 standards.

The TM-4 has been used with our odometer system by industry and Australian Department of Defense operators for more than 14 years, and with the DGPS for more than seven years. The odometer remains the positioning technology of choice in adverse terrains (such as wooded scenarios), while the DGPS is preferred in open environments. Combined, they meet the requirements of most situations.

The TM-4 magnetometer 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, when a UXO detection standard of survey coverage is required, G-TEK operators use a pre-established control grid and visual sighters for straight-line navigation, and the DGPS or odometer primarily for data positioning.

PERFORMANCE SUMMARY

Results for the Blind Grid test, broken out by size, depth and nonstandard ordnance, are presented in tables 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 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 BLIND GRID 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	0.65	0.75	0.50	0.60	0.70	0.80	0.75	0.70	0.40
P _d Low 90% Conf	0.59	0.65	0.38	0.48	0.56	0.55	0.63	0.58	0.20
P _d Upper 90% Conf	0.75	0.84	0.66	0.74	0.79	0.95	0.86	0.83	0.60
P _{fa}	0.75	-	-	-	-	-	0.75	0.70	1.00
P _{fa} Low 90% Conf	0.68	-	-	-	-	-	0.65	0.61	0.63
P _{fa} Upper 90% Conf	0.80	-	-	-	-	-	0.83	0.81	1.00
P _{na}	0.10	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P _d	0.65	0.75	0.40	0.55	0.65	0.80	0.70	0.70	0.40
P _d Low 90% Conf	0.55	0.65	0.27	0.42	0.51	0.55	0.55	0.54	0.20
P _d Upper 90% Conf	0.71	0.84	0.55	0.68	0.76	0.95	0.80	0.80	0.60
P _{fa}	0.60	-	-	-	-	-	0.60	0.55	0.80
P _{fa} Low 90% Conf	0.54	-	-	-	-	-	0.51	0.46	0.42
P _{fa} Upper 90% Conf	0.67	-	-	-	-	-	0.71	0.68	0.98
P _{na}	0.05	-	-	-	-	-	-	-	-

Response Stage Noise Level: 0.31
Recommended Discrimination Stage Threshold: 0.50

SUMMARY OF BLIND GRID 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	0.60	0.70	0.40	0.45	0.70	0.80	0.55	0.70	0.35
P _d Low 90% Conf	0.50	0.59	0.29	0.35	0.55	0.55	0.44	0.59	0.19
P _d Upper 90% Conf	0.65	0.77	0.53	0.56	0.79	0.95	0.66	0.83	0.56
P _{fa}	0.75	-	-	-	-	-	0.75	0.70	1.00
P _{fa} Low 90% Conf	0.68	-	-	-	-	-	0.65	0.61	0.63
P _{fa} Upper 90% Conf	0.80	-	-	-	-	-	0.83	0.81	1.00
P _{na}	0.10	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P _d	0.55	0.70	0.30	0.40	0.65	0.80	0.50	0.70	0.35
P _d Low 90% Conf	0.47	0.59	0.20	0.30	0.51	0.55	0.39	0.55	0.19
P _d Upper 90% Conf	0.62	0.77	0.44	0.52	0.76	0.95	0.61	0.80	0.56
P _{fa}	0.60	-	-	-	-	-	0.60	0.55	0.80
P _{fa} Low 90% Conf	0.54	-	-	-	-	-	0.51	0.46	0.42
P _{fa} Upper 90% Conf	0.67	-	-	-	-	-	0.71	0.68	0.98
P _{na}	0.05	-	-	-	-	-	-	-	-

Response Stage Noise Level: 0.31
Recommended Discrimination Stage Threshold: 0.50

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.

