



TECHNICAL PAPER

STANDARDIZED UXO DEMONSTRATION SITES

G-TEK AUSTRALIA PTY LIMITED TM-5 (DUAL SENSOR)/SLING

- OPEN FIELD SCORING RECORD NO. 148



The TM-5 EMU (Dual Sensor)/Sling detection platform as demonstrated by G-Tek Australia PTY Ltd at Yuma Proving Ground, Arizona.

The TM-5 EMU (Dual Sensor)/Sling detection platform was demonstrated by G-Tek Australia PTY Ltd. at the Yuma Proving Ground Open Field 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.



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, Maryland, and Yuma Proving Ground, 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 US Army Environmental Center. The US Army Aberdeen Test Center and the US Army Corps of Engineers Engineering Research and Development Center provide programmatic support. The program is being funded and supported by the Environmental Security Technology Certification Program, the Strategic Environmental Research and Development Program, and the Army Environmental Quality Technology Program.

DEMONSTRATOR'S SYSTEM AND DATA PROCESSING DESCRIPTION

The man-portable TM-5 electromagnetic unit (EMU) consists of the following components:

Item	Manufacturer	Model
Magnetometer control module	G-TEK	TM-5 EMU MPX
Multi-period, transient electromagnetic (EM) sensors	Minelab Electronics	F1B2
DGPS (digital Global Positioning System)	Ashtech	Z-Extreme
Odometer	G-TEK	TM-4D

The TM-5 EMU detector system may be configured with one or two sensors measuring the transient 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; DGPS is preferred in open environments. Combined, they meet the requirements of most situations.

Prior to performing a survey, the TM-5 EMU undergoes the following three procedures, taking 5 minutes to complete all three: (1) sensor pulse repetition frequency is swept over about 100 Hz, centered at 1200 Hz,

to select the frequency corresponding to the lowest receiver root mean square noise level, in order to minimize radio frequency interference; (2) sensors are ground-balanced to compute ground response parameters that are stored in memory so that the ground response may then be subtracted from the received signal in real-time; and (3) a control source known as an EMUlator is used check that sensor signal levels are within specification.

The sensors are a monocoil acting as both transmitter and receiver, operated as a vertical magnetic dipole, with 16 turns, a diameter of 18 inches, inductance of 300 mH, and resistance of 0.7 W. During surveying, the sensor coil height is maintained at an elevation of 100 mm, with the minimum hazards of electromagnetic radiation to ordnance (HERO) safe operating height calculated to be 10 cm above ground.

The transmitted waveform consists of two different length pulses (20 ms, 3.3 A and 50 ms, 830 mA), repeated at the rate of approximately 1200 Hz. The peak pulse amplitudes are based on an application of 5 volts, and at turnoff, the pulses ramp to zero in about 2 to 4 ms (corresponding to the self-induced electromagnetic force clipped to 187 volts). The theoretical bandwidth of about 500 kHz reduces to about 300 kHz after the addition of amplifiers and integrators. The detector is based on synchronous demodulation, sampling the secondary field decays over narrow integration gates. After subtracting the ground response and digitizing at approximately 60 Hz, the output is decimated to 32 samples per second that are recorded with a DGPS position at a >1 Hz rate. Amplifier gains are adjusted to provide digital output between +4096 units such that background noise is set to +1 to 2 units. A low-pass filter is applied at periodic intervals to reset the background signal to a zero mean. During a traverse, this filter is switched out so that the filter does not attenuate target responses, and the drift is removed from the digital record in post-processing with a high-pass filter.

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.

PERFORMANCE SUMMARY

Results for the open field test broken out by size, depth and nonstandard ordnance are presented in the summary of results table. 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.

OPEN FIELD SCORING SUMMARY

Metric	Overall	Standard	Non-Standard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P _d	0.80	0.80	0.80	0.80	0.75	0.90	0.85	0.80	0.40
P _d Low 90% Conf	0.78	0.76	0.77	0.76	0.71	0.82	0.82	0.77	0.31
P _{fa}	0.85	-	-	-	-	-	0.85	0.80	0.20
P _{fa} Low 90% Conf	0.82	-	-	-	-	-	0.83	0.79	0.05
BAR	0.10	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P _d	0.50	0.50	0.45	0.45	0.45	0.60	0.45	0.60	0.40
P _d Low 90% Conf	0.46	0.48	0.40	0.42	0.41	0.52	0.39	0.56	0.31
P _{fa}	0.50	-	-	-	-	-	0.40	0.70	0.20
P _{fa} Low 90% Conf	0.46	-	-	-	-	-	0.38	0.66	0.05
BAR	0.05	-	-	-	-	-	-	-	-

Response Stage Noise Level: -0.01

Recommended Discrimination Stage Threshold: 0.50

Note: The recommended stage threshold values are provided by the demonstrator.