Standardized UXO Demonstration Sites

US Army Corps Of Engineers Engineering Research and Development Center's Standard GEM-3 Pushcart System - *Blind Grid Scoring Record No. 141*

The Standard GEM-3 Pushcart System was demonstrated by US Army Corps of Engineers Engineering Research and Development Center.

Standard GEM-3 Pushcart System

The Standard GEM-3 Pushcart System is an electromagnetic induction system that was demonstrated as a pushcart platform. The US Army Corps of Engineers Engineering Research and Development Center demonstrated the sensor in the Aberdeen Proving Ground Blind Grid Area. This technical sheet contains the results of that demonstration. This technical sheet 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 Demonstration Sites Program.

Background

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 (ERDC) 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 second generation GEM-3 system (acquired 1999) is able to collect multiple channels of complex frequency domain electromagnetic induction (EMI) data over a wide range of audio frequencies (30 Hz to 21 kHz). The system is a wheeled pushcart with a 40-cm sensor head, a mounted electronics console, and a user interface. A real-time kinematic (RTK) global positioning system (GPS) is used to collect positioning data for the sensor head that is saved separate from the GEM-3 data file. The sensor head consists of three coils. The primary transmitter coil is the outer coil in the sensor head. The receiver coil is the inner coil in the sensor head. The bucking transmitter coil is the middle coil in the sensor head. The current in the bucking coil flows in the opposite direction of the current in the primary transmitter coil. This suppresses the dipole moment on the receiver coil that is directly from the primary transmitter coil. The electronics console contains the multifrequency current waveform

generator, the analog to digital (A/D) converter receiver electronics, the digital signal processor, and the power management module. The user interface utilizes a custom display system. The display system has three command buttons with a liquid crystal display (LCD). This system is used for data logging and allows for real-time control of the system. The display also allows for real-time display of a single frequency of the data collected. The RTK GPS requires a base station to be set up at a suitable reference point for radio communication with the mobile unit on the GEM-3 system. The GEM-3 system's acquisition of multifrequency data allows for performing what Geophex Ltd., the developer of the system, calls Electromagnetic Induction Spectroscopy (EMIS) on buried objects. EMIS provides a method to discriminate UXO targets from natural and man-made clutter objects by means of their unique, complex (inphase and quadrature) frequency responses.

Data Processing: The GEM-3 data acquired at the test site was processed using a combination of ERDC-developed programs and Geosoft's Oasis Montaj. First, basic data corrections such as background subtraction and time-synchronization between the sensor data and GPS data were performed. The raw data, after these basic corrections, were submitted in Geosoft XYZ format. Two response stage submissions were made within 30 days. One was based on a threshold applied to the total magnitude of the sensor inphase and quadrature response for all frequencies. The second was based on interactive histogram analysis of the data. Data from each of these detection schemes were used by the target discrimination algorithm to generate separate discrimination stage submissions. The discrimination algorithm compares sensor data collected near each detected anomaly with calibration data acquired over the target types of interest at the beginning of the data collection.

One of ERDC's primary objectives for this data acquisition was to get high-quality data to further our modeling and analysis research. ERDC plans to make further data submissions using other detection and discrimination algorithms on this same dataset, alone and in combination with data from other sensors.

Performance Summary

Results for the blind grid 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 ordnances emplaced. Depth is measured from the closest point of anomaly to the ground surface.

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 positives 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.

Blind Grid Performance Summary

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.25	0.30	0.15	0.20	0.25	0.30	0.40	0.15	0.00
P_d Low 90% Conf	0.18	0.23	0.06	0.13	0.16	0.12	0.28	0.06	0.00
P_{fp}	0.30	-	-	-	-	-	0.40	0.20	0.20
P_{fp} Low 90% Conf	0.24	-	-	-	-	-	0.31	0.11	0.02
P_{ba}	0.05	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.25	0.30	0.15	0.20	0.25	0.30	0.40	0.15	0.00
P_d Low 90% Conf	0.18	0.23	0.06	0.13	0.16	0.12	0.28	0.06	0.00
P_{fp}	0.30	-	-	-	-	-	0.40	0.20	0.20
P_{fp} Low 90% Conf	0.24	-	-	-	-	-	0.31	0.11	0.02
P_{ba}	0.05	-	-	-	-	-	-	-	-

Response Stage Noise Level: 50.00
Recommended Discrimination Stage Threshold: 50.00

Note: The response stage noise level and recommended discrimination stage threshold values are provided by the demonstrator.