



TECHNICAL PAPER

# STANDARDIZED UXO DEMONSTRATION SITES

## SHAW UXO MAPPER/PUSHCART (EM61 CONFIGURATION)

*BLIND GRID SCORING RECORD NO. 197*



The UXO Mapper/Pushcart (EM61 Configuration) as demonstrated by Shaw, Inc.

### *Shaw's geophysical mapping technology*

*is an engineered combination of off-the-shelf geophysical sensors, innovative navigation technologies, a flexible/configurable deployment system, and customized data acquisition software.*

*The UXO Mapper/Pushcart was demonstrated by Shaw, Inc., at the Aberdeen Proving Ground Blind Grid Area.*

*This technical paper contains the results of that demonstration. This technical paper is a reference document only and does not serve as an endorsement of the demonstrator's product by the US Army of 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 (APG), 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 Shaw UXO Mapper/Pushcart (EM61 Configuration) technology has both hardware and software components. System hardware consists of four integrated components: EM61 geophysical sensor, Shaw's composite-material cart survey system, the Leica TPS1100 dual laser robotic total station (RTS), and the Crossbow solid-state gyro. Shaw's UXO Mapper was engineered as a mapping device that can be customized to adapt to a wide range of conditions seen on unexploded ordnance (UXO) sites. Customizations available for survey optimization include: the number, spacing, and height of the sensors; the number of wheels (two or four) and wheel diameter (Shaw cart system); the forward sensor distances (relative to the wheel base); and handle configuration (to push, pull, or tow the Shaw cart system) allowing the flexibility to customize the configuration of the equipment to respond to local site conditions and maximize data quality.

For navigation, the Shaw UXO Mapper uses Robotic Total Station (RTS) technology. The Leica TSP1100 is a motorized RTS that uses automatic target recognition to track the location of the prism. The Leica TSP1100 has a highly accurate distance/azimuth measurement system to produce  $\pm 5$  mm  $\pm 2$  ppm accuracy, which translates to 0.25 inches (3D) at distances of up to 1400 feet.

The Shaw UXO Mapper has three software components. First, customized RTS firmware is used to track the roving prism. Developed specifically for Shaw's UXO mapping applications, this firmware allows for rapid collection of data to 4 hertz,

and outputs solutions to the base station and rover units. The firmware enables the user to optimize prism-tracking parameters for rapid recovery of lock if obstructed by trees during a survey. Second, Shaw's data control software determines precise time synchronization between the RTS and sensor time bases, ensuring accurate collection of all data. Third, Shaw's software for data merging accommodates various sensor navigation geometries used during data collection, and provides a robust framework to spatially configure sensors relative to each other and with respect to the prism location. Additionally, this software allows RTS and sensor data to be merged in either a straightforward interpolation mode (for open areas) or in a hybrid switching mode that alternates to "dead reckoning" for the brief periods when the RTS is obstructed by trees or similar vegetation.

This composite and fiberglass cart system deploys magnetometers, gradiometers, or EM sensors. The device has been modified to replace the standard configuration of the EM61 cart system. This adaptation is critical to collection of high-fidelity data, as the operator has enhanced control of the sensor in terms of sensor orientation.

The RTS tracks a prism mounted on the Shaw cart system in open and wooded conditions. The device tracks the prism to the centimeter level in three dimensions at a rate of up to 4 Hz. The RTS and modified deployment system allows collection of the high density, high-fidelity data needed for improved UXO detection and discrimination. Shaw's cart system allows for rapid collection of high-fidelity data from the magnetometer and EM sensors.

Shaw's standard data processing includes data leveling, statistical data assessment, grid generation, and customized data filtering to accentuate target signatures. Shaw uses software from the sensor manufacturers, in-house software, and Geosoft's Oasis Montaj, UX-Detect Software, and MATLAB to complete all tasks. Collected field data are downloaded from the data acquisition system as ASCII XYZ files. Custom Shaw software is used to download the data and for initial review, generation of summary statistics, and conversion data formats, gridding and analysis. All activities will be documented on the Data Processing Log.

## 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 SCORING SUMMARY

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
<b>RESPONSE STAGE</b>									
$P_d$	0.70	0.75	0.65	0.75	0.70	0.70	0.85	0.75	0.20
$P_d$ Low 90% Conf	0.64	0.65	0.53	0.63	0.55	0.45	0.75	0.63	0.08
$P_{fa}$	0.65	-	-	-	-	-	0.60	0.70	1.00
$P_{fa}$ Low 90% Conf	0.60	-	-	-	-	-	0.51	0.58	0.63
$P_{ms}$	0.05	-	-	-	-	-	-	-	-
<b>DISCRIMINATION STAGE</b>									
$P_d$	0.40	0.45	0.40	0.50	0.40	0.20	0.60	0.40	0.00
$P_d$ Low 90% Conf	0.35	0.34	0.29	0.39	0.27	0.05	0.46	0.29	0.00
$P_{fa}$	0.45	-	-	-	-	-	0.35	0.50	0.80
$P_{fa}$ Low 90% Conf	0.36	-	-	-	-	-	0.25	0.37	0.42
$P_{ms}$	0.00	-	-	-	-	-	-	-	-

Response Stage Noise Level: 3.59

Recommended Discrimination Stage Threshold: 6.90

*Note: The Response Stage noise level and recommended Discrimination Stage threshold values are provided by the demonstrator.*

