



TECHNICAL PAPER

STANDARDIZED UXO DEMONSTRATION SITES

SHAW, INC. – UXO MAPPER/PUSHCART

BLIND GRID SCORING RECORD NO. 404



The UXO Mapper in the pushcart platform is shown being demonstrated by Shaw, Inc.

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

Shaw's geophysical mapping technology is an engineered combination of off-the-shelf geophysical sensors, navigation technologies, a flexible/configurable deployment system, and customized data acquisition software. For this demonstration a G858 magnetometer configuration has been selected.

System hardware consists of four integrated components: (1) G858 magnetometer sensors, (2) Shaw's composite-material cart survey system, (3) Leica TPS1100 dual laser robotic total station (RTS), and (4) 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 UXO sites. The customizations available for survey optimization (including the number, spacing, and height of the sensors; the number of wheels (2 or 4) and wheel diameter; the forward sensor distances (relative to the wheelbase); and the handle configuration (to push, pull, or tow the system)) allow the flexibility to customize the equipment configuration to respond to local site conditions and maximize data quality.

For navigation, the Shaw UXO Mapper uses RTS technology. The Leica TSP1100 RTS is a motorized robotic total station that uses automatic target recognition to track the location of the prism and has a highly accurate distance/azimuth measurement system to produce +5-mm +2-ppm accuracy, which

The UXO Mapper
in the pushcart platform
was demonstrated by Shaw, Inc. 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.

For more information

US Army Environmental Center
Public Affairs Office
410-436-2556, fax 410-436-1693
e-mail: usaecpao@aec.apgea.army.mil
<http://aec.army.mil>
<http://www.uxotestsites.org>

translates to 0.25 inches (three dimensions) 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 the rapid collection of data at a rate of up to 4 Hz 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. In addition, this software allows RTS and sensor data to be merged in either a straight-forward interpolation mode (for open areas) or a hybrid switching mode that alternates to "dead reckoning" for the brief periods when the RTS is obstructed in the woods.

This composite and fiberglass cart system deploys magnetometers, gradiometers, or electromagnetic (EM) sensors. The device has been modified to replace the standard configuration of the EM61 cart system. This adaptation is critical to the 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 both 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 the rapid collection of high-fidelity data from both magnetometer and EM sensors.

PERFORMANCE SUMMARY

Results for the Blind Grid test broken out by size, depth and nonstandard ordnance are presented in table below. Results by size and depth include both standard and non-standard 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.

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	0.70	0.75	0.70	0.55	0.80	0.90	0.65	0.80	0.70
P _d Low 90% Conf	0.63	0.63	0.53	0.42	0.69	0.66	0.52	0.65	0.48
P _d Upper 90% Conf	0.79	0.82	0.80	0.58	0.90	0.99	0.77	0.88	0.85
P _{fa}	0.85	-	-	-	-	-	0.85	0.85	1.00
P _{fa} Low 90% Conf	0.79	-	-	-	-	-	0.74	0.76	0.63
P _{fa} Upper 90% Conf	0.90	-	-	-	-	-	0.90	0.92	1.00
P _{na}	0.45	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P _d	0.30	0.35	0.20	0.10	0.40	0.50	0.30	0.30	0.25
P _d Low 90% Conf	0.21	0.24	0.10	0.04	0.27	0.27	0.17	0.20	0.09
P _d Upper 90% Conf	0.37	0.44	0.34	0.22	0.52	0.73	0.41	0.46	0.44
P _{fa}	0.45	-	-	-	-	-	0.45	0.45	0.40
P _{fa} Low 90% Conf	0.38	-	-	-	-	-	0.35	0.35	0.11
P _{fa} Upper 90% Conf	0.52	-	-	-	-	-	0.55	0.56	0.75
P _{na}	0.05	-	-	-	-	-	-	-	-

Response Stage Noise Level: 9.55
Recommended Discrimination Stage Threshold: 6.95

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	0.65	0.70	0.55	0.45	0.80	0.90	0.55	0.75	0.65
P _d Low 90% Conf	0.56	0.59	0.43	0.35	0.68	0.66	0.44	0.63	0.44
P _d Upper 90% Conf	0.71	0.77	0.68	0.56	0.90	0.99	0.66	0.86	0.81
P _{fa}	0.85	-	-	-	-	-	0.85	0.85	1.00
P _{fa} Low 90% Conf	0.79	-	-	-	-	-	0.74	0.76	0.63
P _{fa} Upper 90% Conf	0.90	-	-	-	-	-	0.90	0.92	1.00
P _{na}	0.45	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P _d	0.25	0.30	0.15	0.05	0.40	0.50	0.20	0.30	0.20
P _d Low 90% Conf	0.18	0.21	0.08	0.03	0.27	0.27	0.12	0.20	0.08
P _d Upper 90% Conf	0.31	0.39	0.27	0.15	0.52	0.73	0.30	0.45	0.42
P _{fa}	0.45	-	-	-	-	-	0.45	0.45	0.40
P _{fa} Low 90% Conf	0.38	-	-	-	-	-	0.35	0.35	0.11
P _{fa} Upper 90% Conf	0.52	-	-	-	-	-	0.55	0.56	0.75
P _{na}	0.05	-	-	-	-	-	-	-	-

Response Stage Noise Level: 9.55
Recommended Discrimination Stage Threshold: 6.95

Note: The recommended discrimination stage threshold values are provided by the demonstrator. No discrimination algorithm was applied. Therefore, the discrimination stage results are not applicable.

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.

