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DTC PROJECT NO. 8-CO-160-UXO-021
REPORT NO. ATC-8691

STANDARDIZED

UXO TECHNOLOGY DEMONSTRATION SITE

BLIND GRID SCORING RECORD NO. 50

SITE LOCATION:
ABERDEEN PROVING GROUND

DEMONSTRATOR:
GEOPHEX, LTD.
605 MERCURY ST.,
RALEIGH, NC 2603-2343

PREPARED BY:
U.S. ARMY ABERDEEN TEST CENTER
ABERDEEN PROVING GROUND, MD 21005-5059

OCTOBER 2003

Prepared for:
U.S. ARMY ENVIRONMENTAL CENTER
ABERDEEN PROVING GROUND, MD 21010-5401

U.S. ARMY DEVELOPMENTAL TEST COMMAND
ABERDEEN PROVING GROUND, MD 21005-5055

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None

14. ABSTRACT
This scoring record documents the efforts of GEOPHEX, Ltd.to detect and discriminate inert unexploded ordnance (UXO) utilizing the APG Standardized UXO Technology Demonstration Site Blind Grid. The scoring record was written by Larry Overbay utilizing methodology coordinated with the Standardized UXO Technology Demonstration Site Program Scoring Committee. Organizations on the committee include the U.S. Army Corps of Engineers, the Environmental Security Technology Certification Program, the Strategic Environmental Research and Development Program, the Institute for Defense Analysis, the U.S. Army Environmental Center, and the U.S. Army Aberdeen Test Center.

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SECTION 1. GENERAL INFORMATION

1.1 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 U.S. Army Environmental Center (AEC). 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).

1.2 SCORING OBJECTIVES

The objective in the Standardized UXO Technology Demonstration Site Program is to evaluate the detection and discrimination capabilities of a given technology under various field and soil conditions. Inert munitions and clutter items are positioned in various orientations and depths in the ground.

The evaluation objectives are as follows:

a. To determine detection and discrimination effectiveness under realistic scenarios that vary targets, geology, clutter, topography, and vegetation.

b. To determine cost, time and manpower requirements to operate the technology.

c. To determine demonstrator's ability to analyze survey data in a timely manner and provide prioritized "Target Lists" with associated confidence levels.

d. To provide independent site management to enable the collection of high quality, ground-truth, geo-referenced data for post-demonstration analysis.

1.2.1 Scoring Methodology

a. The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver-operating characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}), and those that do not correspond to any known item, termed background alarms.

b. The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the blind grid RESPONSE STAGE, the demonstrator provides the scoring committee with a target response from each and every grid square along with a noise level below which target responses are deemed insufficient to warrant further investigation. This list is generated with minimal processing and, since a value is provided for every grid square, will include signals both above and below the system noise level.

c. The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such and to reject clutter. For the blind grid DISCRIMINATION STAGE, the demonstrator provides the scoring committee with the output of the algorithms applied in the discrimination-stage processing for each grid square. The values in this list are prioritized based on the demonstrator's determination that a grid square is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For digital signal processing, priority ranking is based on algorithm output. For other discrimination approaches, priority ranking is based on human (subjective) judgment. The demonstrator also specifies the threshold in the prioritized ranking that provides optimum performance, (i.e. that is expected to retain all detected ordnance and rejects the maximum amount of clutter).

d. The demonstrator is also scored on EFFICIENCY and REJECTION RATIO, which measures the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from non-ordnance items. EFFICIENCY measures the fraction of detected ordnance retained after discrimination, while the REJECTION RATIO measures the fraction of false alarms rejected. Both measures are defined relative to performance at the demonstrator-supplied level below which all responses are considered noise, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

e. All scoring factors are generated utilizing the Standardized UXO Probability and Plot Program, version 3.1.1.

1.2.2 Scoring Factors

Factors to be measured and evaluated as part of this demonstration include:

a. Response Stage ROC curves:

(1) Probability of Detection (P_d^{res}).

(2) Probability of False Positive (P_{fp}^{res}).

(3) Background Alarm Rate (BAR^{res}) or Probability of Background Alarm (P_{BA}^{res}).

b. Discrimination Stage ROC curves:

(1) Probability of Detection (P_d^{disc}).

(2) Probability of False Positive (P_{fp}^{disc}).

(3) Background Alarm Rate (BAR^{disc}) or Probability of Background Alarm (P_{BA}^{disc}).

c. Metrics:

(1) Efficiency (E).

(2) False Positive Rejection Rate (R_{fp}).

(3) Background Alarm Rejection Rate (R_{BA}).

d. Other:

(1) Probability of Detection by Size and Depth.

(2) Classification by type (i.e., 20-mm, 40-mm, 105-mm, etc.).

(3) Location accuracy.

(4) Equipment setup, calibration time and corresponding man-hour requirements.

(5) Survey time and corresponding man-hour requirements.

(6) Re-acquisition/resurvey time and man-hour requirements (if any).

(7) Downtime due to system malfunctions and maintenance requirements.

1.3 STANDARD AND NONSTANDARD INERT ORDNANCE TARGETS

The standard and nonstandard ordnance items emplaced in the test areas are listed in Table 1. Standardized targets are members of a set of specific ordnance items that have identical properties to all other items in the set (caliber, configuration, size, weight, aspect ratio, material, filler, magnetic remanence, and nomenclature). Nonstandard targets are ordnance items having properties that differ from those in the set of standardized targets.

TABLE 1. INERT ORDNANCE TARGETS

Standard Type	Nonstandard (NS)
20-mm Projectile M55	20-mm Projectile M55
	20-mm Projectile M97
40-mm Grenades M385	40-mm Grenades M385
40-mm Projectile MKII Bodies	40-mm Projectile M813
BDU-28 Submunition	
BLU-26 Submunition	
M42 Submunition	
57-mm Projectile APC M86	
60-mm Mortar M49A3	60-mm Mortar (JPG)
	60-mm Mortar M49
2.75-inch Rocket M230	2.75-inch Rocket M230
	2.75-inch Rocket XM229
MK 118 ROCKEYE	
81-mm Mortar M374	81-mm Mortar (JPG)
	81-mm Mortar M374
105-mm Heat Rounds M456	
105-mm Projectile M60	105-mm Projectile M60
155-mm Projectile M483A1	155-mm Projectile M483A
	500-lb Bomb

SECTION 2. DEMONSTRATION

2.1 DEMONSTRATOR INFORMATION

2.1.1 Demonstrator POC and Address

Point of contact:
(919) 839-8515

Address: Geophex, Ltd.
605 Mercury Street
Raleigh, NC 2603-2343

2.1.2 System Description (Provided by Demonstrator)

GEM-3 electromagnetic induction (EMI) sensors are multi-frequency (up to 10 frequencies logarithmically spaced in the 30 Hz - 47930 Hz range) sensors consisting of three concentric coils and digital electronics. The outer coil is the primary transmitter, the inner coil the receiver, and the annular coil is a secondary (bucking) transmitter that creates a primary field cavity around the transmitter. The electronics includes a digitally controlled switching H-bridge transmitter current-source, a 24 bit A/D, and a digital signal processor (DSP) with random access memeory (RAM) and flash memory and serial data ports (RS-232). A user interface consists of a palm pack computer with Geophex software; the commercial differential Global Positioning System (DGPS) is fully integrated.

The system is a continuous wave frequency domain system in which data are recorded while the transmitter is on; the transmitter waveform consists of a continuous mix of superposed sine waves at the specified frequencies. The measured raw time-series data are voltages (pre-amplified) measured by the receiver coil and by a small reference coil located in the transmitter primary/bucking coil annular space (proportional to primary field and phase referenced to primary field), and sampled by the A/D. Data are pre-processed in units of 30 Hz intervals (base periods) and averaged over a selectable number of base periods, typically six for hand-held operation (net output rate of 5 Hertz).

The hand-held configuration, with a 40 cm diameter coil disk mounted on a composite material handle, is used in environments where a large sensor on a wheeled cart is not practical, such as dense brush, woods, or rugged terrain. In a previous demonstration the mogul area was surveyed with hand-held sensors. In this demonstration, the calibration grid, blind grid, and wooded area will be surveyed.

A detailed description of the system is provided in the Demonstration Test Plan.

Figure 1. Demonstrator's system.

2.1.3 Data Processing Description (Provided by Demonstrator)

The front-end data processing is performed in real-time by the system DSP. This processing consists of performing a partial Digital Fourier Transform (DFT) on the receiver and reference time series provided by the A/D at 96 kHz. The DFT frequency samples correspond to the logarithmically spaced transmitted frequencies characterizing the hybrid current waveform. Complex division of the receiver and reference DFT outputs are performed, and system transfer function (calibration) corrections are applied to generate inphase and quadrature measurements at each frequency. These data are recorded in the console flash memory and/or output to the user interface.

Further processing is performed in real-time by the user interface, consisting of a palm top computer with special software (WinceGEM). Target detection utilizes a composite measurement such as the sum of the quadratures over all frequencies, or a weighted average apparent conductivity over all frequencies, which drives audio (earphones are optional) and/or graphical signals to the operator. A manual audio gain setting is augmented with an auto gain ranging function to allow high sensitivity for weak targets and high dynamic range for precise location of strongly responding targets. For target discrimination, a spectral matching algorithm compares the measurement with a library of known possible target spectra; this algorithm allows for a linear combination of the intrinsic longitudinal and transverse target response. The quality of the best fit (i.e. rms or mean absolute error) is compared with a threshold for clutter declaration and used as a confidence measure.

The survey method in the calibration and blind grids will be done simply by occupying the potential target location points, preceded with a nearby background reading or (optionally) utilizing a continuous filtered background reading, and determining if a possible UXO (i.e. metallic object) is present based on audio/graphical response. If a potential UXO is detected, the operator initiates sampling for two seconds followed by execution of the discrimination (library matching) algorithm. The raw data as well as the matching results are recorded in the palm top with a manually entered target number.

In the wooded area, lanes 1 to 2 meters wide will be marked off with cord; the operator will survey these lanes in a sweeping search fashion, using the audio/graphical detection to locate potential targets. These will be marked with a numbered flag and the matching algorithm will be initiated by the operator as above; recorded results will be manually tagged with the flag number. Subsequent to surveying with the GEM, a DGPS rover with pole-mounted antenna will be used to locate the flags (recorded by the DGPS receiver with manual input of flag number). The GEM and GPS data will be post-processed to provide geo-referenced dig lists. If DGPS is not attainable because of tree interference with satellite signals, the location will be measured off from a point in which DGPS is available.

2.1.4 Data Submission Format

Data was submitted for scoring in accordance with data submission protocols outlined in the Standardized UXO Technology Demonstration Site Handbook. This submitted data is not included in this report in order to protect ground truth information.

2.1.5 Demonstrator Quality Assurance and Quality Control (Provided by Demonstrator)

Quality control will be performed by testing the systems with a test target (ferrite) each day, and verifying proper and consistent system measurements. Quality assurance will include a review of recorded data at the end of each day.

2.1.6 Additional Records

The following record(s) by this vendor can be accessed via the Internet as MS Word files at http://aec.army.mil/usaec/technology/uxo03.html.

2.2 ABERDEEN PROVING GROUND SITE INFORMATION

2.2.1 Location

The APG Standardized Test Site is located within a secured range area of the Aberdeen Area of APG. The Aberdeen Area of APG is located approximately 30 miles northeast of Baltimore at the northern end of the Chesapeake Bay. The Standardized Test Site encompasses 17 acres of upland and lowland flats, woods and wetlands.

2.2.2 Soil Type

According to the soils survey conducted for the entire area of Aberdeen Proving Ground in 1998, the test site consists primarily of Elkton Series type soil (ref 2). The Elkton Series consist of very deep, slowly permeable, poorly drained soils. These soils formed in silty aeolin sediments and the underlying loamy alluvial and marine sediments. They are on upland and lowland flats and in depressions of the Mid-Atlantic Coastal Plain. Slopes range from 0 to 2 percent.

ERDC conducted a site-specific analysis in May of 2002 (ref 3). The results basically matched the soil survey mentioned above. Seventy percent of the samples taken were classified as silty loam. The majority (77 percent) of the soil samples had a measured water content between 15- and 30-percent with the water content decreasing slightly with depth.

For more details concerning the soil properties at the APG test site, go to http://aec.army.mil/usaec/technology/uxo-soils.pdf on the web to view the entire soils description report.

2.2.3 Test Areas

A description of the test site areas at APG is included in Table 2.

TABLE 2. TEST SITE AREAS

Area	Description
Calibration Grid	Contains 14 standard ordnance items buried in six positions at various angles and depths to allow demonstrator to calibrate their equipment.
Blind Test Grid	Contains 400 grid cells in a 0.2-hectare (0.5 acre) site. The center of each grid cell contains ordnance, clutter or nothing.

SECTION 3. FIELD DATA

3.1 DATE OF FIELD ACTIVITIES (29 TO 30 April 2003)

3.2 AREAS TESTED/NUMBER OF HOURS

Areas tested and total number of hours operated at each site are summarized in Table 3.

TABLE 3. AREAS TESTED AND NUMBER OF HOURS

Area	Number of Hours
Calibration Lanes	3.5
Blind Test Grid	3.65

3.3 TEST CONDITIONS

3.3.1 Weather Conditions

An ATC weather station located approximately 2 miles west of the test site was used to record average temperature and precipitation on an hourly basis for each day of operation. The temperatures listed in Table 4 represent the average temperature during field operations from 0700 through 1700 hours while the precipitation data represents a daily total amount of rainfall. Hourly weather logs used to generate this summary are provided in Appendix B.

TABLE 4. TEMPERATURE/PRECIPITATION DATA SUMMARY

Date, 03	Average Temperature, ^{o}F	Total Daily Precipitation, in.
29 April	66.65	0.00
30 April	66.81	0.00

3.3.2 Field Conditions

Geophex surveyed the blind test grid with the handheld sensor on 29 and 30 April 2003. The blind grid area was muddy due to prior rain events before testing.

3.3.3 Soil Moisture

The soil moisture logs are included in Appendix C. Three soil probes were placed at various locations of the site to capture soil moisture data: open field, open field lowland (wet) and open field scenario 1 wooded area. Measurements were collected in percent moisture and were taken twice daily (morning and afternoon) from five different soil layers (0 to 6 in., 6 to 12 in., 12 to 24 in., 24 to 36 in. and 36 to 48 in.) from each probe.

The soil moisture data collected are summarized in Table 5. The average moisture content was calculated by averaging the morning and afternoon measurements for each layer of each probe for the duration of the field operations in the Blind Grid.

TABLE 5. SOIL MOISTURE DATA SUMMARY

Layer, in.	Average Moisture Content, %	Standard Deviation, %
Open Field Probe		
0 to 6	8.85	6.87
6 to 12	0.63	0.77
12 to 24	20.98	8.18
24 to 36	28.78	11.09
36 to 48	41.40	16.31

3.4 FIELD ACTIVITIES

3.4.1 Setup/Mobilization

These activities included initial mobilization and daily equipment preparation and breakdown. The two-person crew took 20 minutes to perform the initial setup and mobilization. Daily equipment preparation took 35 minutes while end of day equipment breakdown lasted 10 minutes. On 29 April 2003 daily set up was performed for preparation to utilize the calibration lanes. Therefore, the 20 minute setup time is reflected in the calibration time stated in Section 3.4.2. Daily start/stop activities totaled 25 minutes for the blind grid.

3.4.2 Calibration

The demonstrator spent 3 hours and 31 minutes in the calibration lanes on 29 April 2003. No other calibration activities were conducted while operating in the blind grid.

3.4.3 Downtime Occasions

Occasions of downtime are grouped into five categories: equipment/data checks or equipment maintenance, equipment failure and repair, weather, Demonstration Site issues, or breaks/lunch. All downtime is included for the purposes of calculating labor costs (section 5) except for downtime due to Demonstration Site issues. Demonstration Site issues, while noted in the Daily Log, are considered non-chargeable downtime for the purposes of calculating labor costs and are not discussed. Breaks and lunches are not discussed either.

3.4.3.1 **Equipment/data checks, maintenance.** Equipment/data checks and maintenance activities accounted for 45 minutes of site usage time. These activities included changing out batteries and routine data checks to ensure data were being properly recorded/collected.

3.4.3.2 **Equipment failure or repair.** No equipment or failure incidents occurred while operating in the blind grid.

3.4.3.3 **Weather.** No delays occurred due to weather.

3.4.4 Data Collection

The demonstrator spent 2 hours and 29 minutes collecting data in the blind grid. This time excludes break/lunches and downtimes described in section 3.4.3.

3.4.5 Demobilization

The demobilization time for the handheld sensor took 10 minutes. It was just a matter of walking to the van to and putting it away.

3.5 PROCESSING TIME

Geophex submitted the raw data from demonstration activities on the last day of the demonstration, as required. The scoring submission data was also provided within the required 30-day timeframe.

3.6 DEMONSTRATOR'S FIELD PERSONNEL

Supervisor: Geophysicist
Data Analysist: Software Engineer
Field Survey: Geoscientist

3.7 DEMONSTRATOR'S FIELD SURVEYING METHOD

Geophex started surveying the blind test grid in the northeast portion and surveyed in an east/west direction. One lane was surveyed and then the demonstrator returned to the beginning of the next lane (example: 1A, 1B, 1C then 2A, 2B, 2C) until completion.

3.8 SUMMARY OF DAILY LOGS

No significant events occurred during the demonstration. Appendix D contains a detailed description of field operations.

SECTION 4. TECHNICAL PERFORMANCE RESULTS

4.1 ROC CURVES USING ALL ORDNANCE CATEGORIES

Figure 2 shows the probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of false positive. Figure 3 shows both probabilities plotted against their respective probability of background alarm. Both figures use horizontal lines to illustrate the performance of the demonstrator at two demonstrator-specified points: at the system noise level for the response stage, representing the point below which targets are not considered detectable, and at the demonstrator's recommended threshold level for the discrimination stage, defining the subset of targets the demonstrator would recommend digging based on discrimination. Note that all points have been rounded to protect the ground truth.

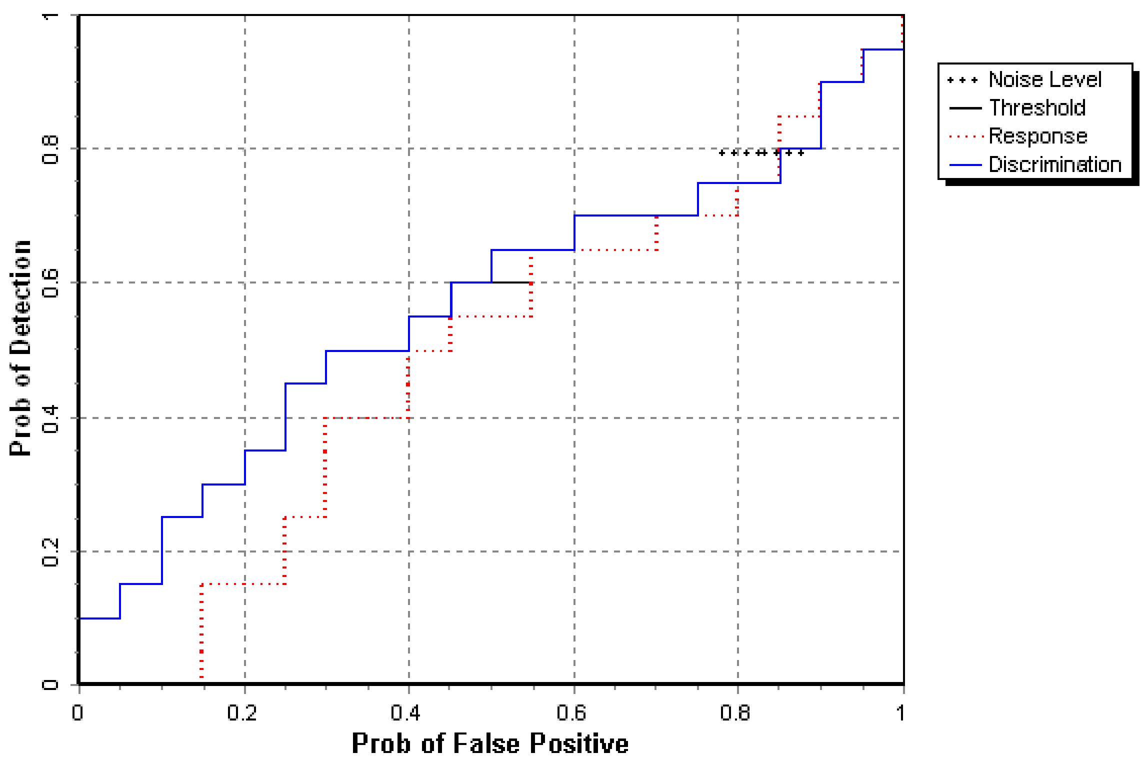

Figure 2. Blind grid probability of detection for response and discrimination stages versus their respective probability of false positive over all ordnance categories combined.

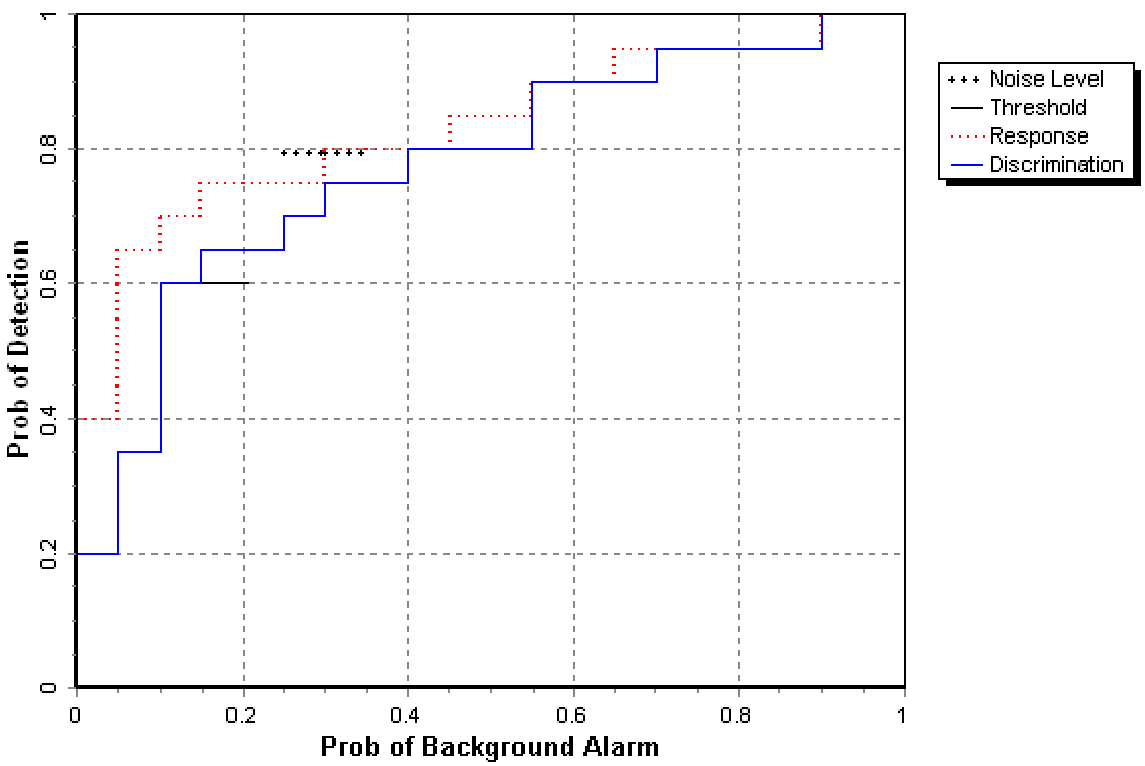

Figure 3. Blind grid probability of detection for response and discrimination stages versus their respective probability of background alarm over all ordnance categories combined.

4.2 ROC CURVES USING ORDNANCE LARGER THAN 20 MM

Figure 4 shows the probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of false positive when only targets larger than 20-mm are scored. Figure 5 shows both probabilities plotted against their respective probability of background alarm. Both figures use horizontal lines to illustrate the performance of the demonstrator at two demonstrator-specified points: at the system noise level for the response stage, representing the point below which targets are not considered detectable, and at the demonstrator's recommended threshold level for the discrimination stage, defining the subset of targets the demonstrator would recommend digging based on discrimination. Note that all points have been rounded to protect the ground truth.

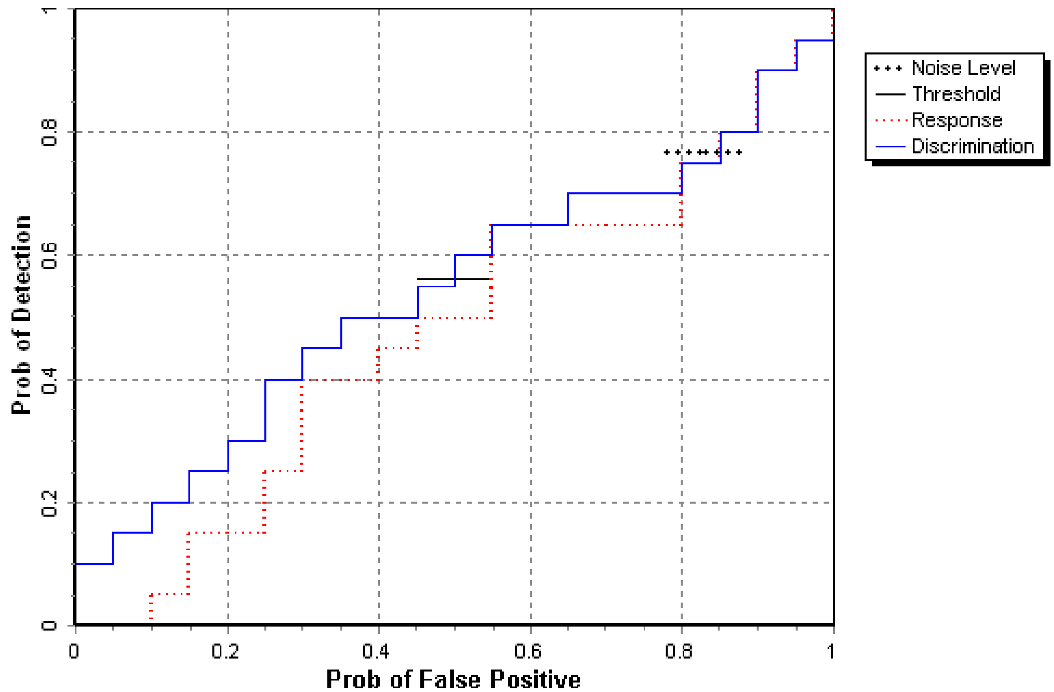

Figure 4. Blind grid probability of detection for response and discrimination stages versus their respective probability of false positive for all ordnance larger than 20 mm.

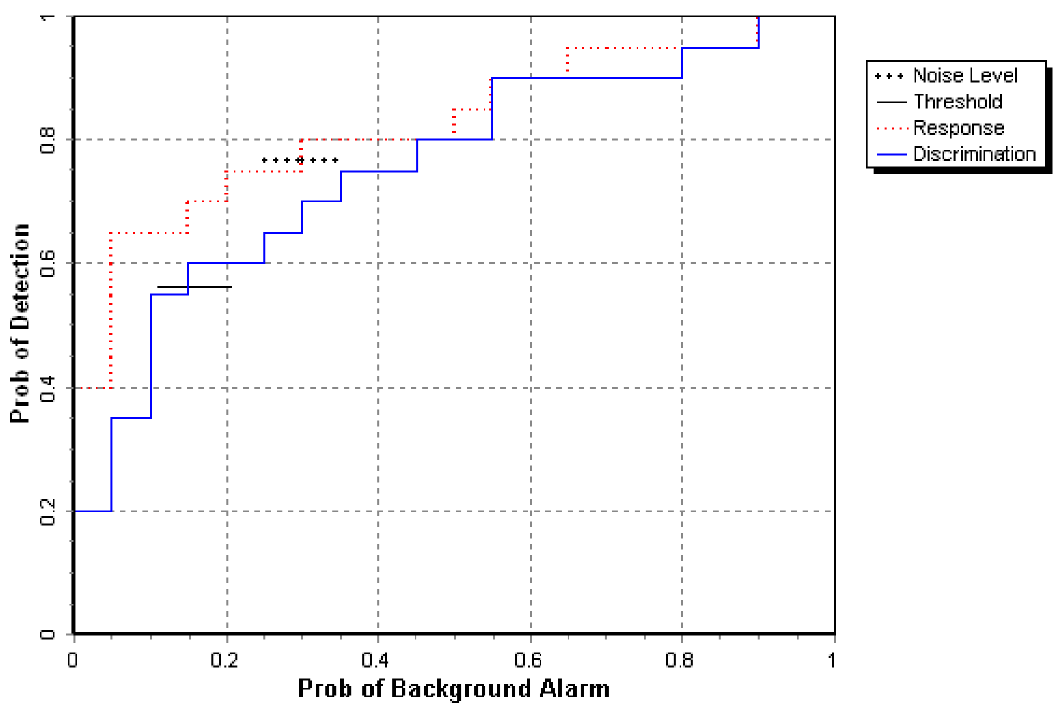

Figure 5. Blind grid probability of detection for response and discrimination stages versus their respective probabilities of background alarm for all ordnance larger than 20 mm.

4.3 PERFORMANCE SUMMARIES

Results for the Blind Grid test broken out by size, depth and nonstandard ordnance are presented in Table 6. (For cost results, see section 5.) 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. (See Appendix A for size definitions.) 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 positive was calculated assuming that the number of detections and false positives are binomially distributed random variables. All results in Table 6 have been rounded to protect the ground truth. However, lower confidence limits were calculated using actual results.

TABLE 6. SUMMARY OF BLIND GRID RESULTS

				By Size			By Depth, m		
Metric	**Overall**	**Standard**	**Non-Standard**	**Small**	**Medium**	**Large**	**< 0.3**	**0.3 to <1**	**>= 1**
RESPONSE STAGE									
P_d	0.80	0.85	0.75	0.90	0.65	0.80	1.00	0.65	0.40
P_d Low 90% Conf	0.73	0.74	0.62	0.82	0.51	0.55	0.95	0.51	0.19
P_{fp}	0.85	-	-	-	-	-	0.85	0.80	1.00
P_{fp} Low 90% Conf	0.77	-	-	-	-	-	0.76	0.68	0.63
P_{ba}	0.30	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.60	0.55	0.65	0.70	0.55	0.30	0.85	0.45	0.10
P_d Low 90% Conf	0.53	0.46	0.54	0.61	0.42	0.12	0.74	0.33	0.01
P_{fp}	0.50	-	-	-	-	-	0.50	0.50	0.60
P_{fp} Low 90% Conf	0.43	-	-	-	-	-	0.39	0.39	0.25
P_{ba}	0.15	-	-	-	-	-	-	-	-

Response Stage Noise Level:10.00
Recommended Discrimination Stage Threshold: 5.00

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

4.4 EFFICIENCY, REJECTION RATES, AND TYPE CLASSIFICATION

Efficiency and rejection rates are calculated to quantify the discrimination ability at specific points of interest on the ROC curve: (1) at the point where no decrease in P_d is suffered (i.e., the efficiency is by definition equal to one) and (2) at the operator selected threshold. These values are reported in Table 7.

TABLE 7. EFFICIENCY AND REJECTION RATES

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At Operating Point	0.76	0.40	0.47
With No Loss of P_d	1.00	0.00	0.02

At the demonstrator's recommended setting, the ordnance items that were detected and correctly discriminated were further scored on whether their correct type could be identified (table 8). Correct type examples include "20-mm projectile, 105 HEAT Projectile, and 2.75-in. Rocket". A list of the standard type declaration required for each ordnance item was provided to demonstrators prior to testing. For example, the standard type for the three example items are 20mmP, 105H, and 2.75in, respectively.

TABLE 8. CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS UXO

Size	% Correct
Small	63.3
Medium	41.2
Large	0.0
Overall	52.0

4.5 LOCATION ACCURACY

The mean location error and standard deviations appear in Table 9. These calculations are based on average missed depth for ordnance correctly identified in the discrimination stage. Depths are measured from the closest point of the ordnance to the surface. For the blind grid, only depth errors are calculated, since (x, y) positions are known to be the centers of each grid square.

TABLE 9. MEAN LOCATION ERROR AND STANDARD DEVIATION (M)

	Mean	Standard Deviation
Depth	0.02	0.21

SECTION 5. ON-SITE LABOR COSTS

A standardized estimate for labor costs associated with this effort was calculated as follows: the first person at the test site was designated "supervisor", the second person was designated "data analyst", and the third and following personnel were considered "field support". Standardized hourly labor rates were charged by title: supervisor at $95.00/hour, data analyst at $57.00/hour, and field support at $28.50/hour.

Government representatives monitored on-site activity. All on site activities were grouped into one of ten categories: initial setup/mobilization, daily setup/stop, calibration, collecting data, downtime due to break/lunch, downtime due to equipment failure, downtime due to equipment/data checks or maintenance, downtime due to weather, downtime due to demonstration site issue, or demobilization. See Appendix D for the daily activity log. See section 3.4 for a summary of field activities.

The standardized cost estimate associated with the labor needed to perform the field activities is presented in Table 10. Note that calibration time includes time spent in the Calibration Lanes as well as field calibrations. "Site survey time" includes daily setup/stop time, collecting data, breaks/lunch, downtime due to equipment/data checks or maintenance, downtime due to failure, and downtime due to weather.

TABLE 10. ON-SITE LABOR COSTS

	No. People	Hourly Wage	Hours	Cost
INITIAL SETUP				
Supervisor	1	$95.00	0.33	$31.35
Data Analyst	1	57.00	0.33	$18.81
Field Support	1	28.50	0.33	$9.41
SubTotal				**$59.57**
CALIBRATION				
Supervisor	1	$95.00	3.5	$332.50
Data Analyst	1	57.00	3.5	$199.50
Field Support	1	28.50	3.5	$99.75
SubTotal				**$631.75**
SITE SURVEY				
Supervisor	1	$95.00	3.65	$346.75
Data Analyst	1	57.00	3.65	$208.05
Field Support	1	28.50	3.65	$104.03
SubTotal				**$658.83**

See notes at end of table.

TABLE 10 (CONT'D)

	No. People	Hourly Wage	Hours	Cost
DEMOBILIZATION				
Supervisor	1	$95.00	0.16	$15.20
Data Analyst	1	57.00	0.16	$9.12
Field Support	1	28.50	0.16	$4.56
SubTotal				**$28.88**
TOTAL				**$1,379.03**

Notes: Calibration time includes time spent in the Calibration Lanes as well as calibration before each data run.
Site Survey time includes daily setup/stop time, collecting data, breaks/lunch, downtime due to system maintenance, failure, and weather.

SECTION 6. COMPARISON OF RESULTS TO DATE

No comparisons to date.

SECTION 7. APPENDIXES

APPENDIX A. TERMS AND DEFINITIONS

GENERAL DEFINITIONS

Anomaly: Location of a system response deemed to warrant further investigation by the demonstrator for consideration as an emplaced ordnance item.

Detection: An anomaly location that is within R_{halo} of an emplaced ordnance item.

Emplaced Ordnance: An ordnance item buried by the government at a specified location in the test site.

Emplaced Clutter: A clutter item (i.e., non-ordnance item) buried by the government at a specified location in the test site.

R_{halo}: A pre-determined radius about the periphery of an emplaced item (clutter or ordnance) within which a location identified by the demonstrator as being of interest is considered to be a response from that item. If multiple declarations lie within R_{halo} of any item (clutter or ordnance), the declaration with the highest signal output within the R_{halo} will be utilized. For the purpose of this program, a circular halo 0.5 meters in radius will be placed around the center of the object for all clutter and ordnance items less than 0.6 meters in length. When ordnance items are longer than 0.6 meters, the halo becomes an ellipse where the minor axis remains 1 meter and the major axis is equal to the length of the ordnance plus 1 meter.

Small Ordnance: Caliber of ordnance less than or equal to 40 mm (includes 20-mm projectile, 40-mm projectile, submunitions BLU-26, BLU-63, and M42).

Medium Ordnance: Caliber of ordnance greater than 40-mm and less than or equal to 81-mm (includes 57-mm projectile, 60-mm mortar, 2.75 in. Rocket, MK118 Rockeye, 81-mm mortar).

Large Ordnance: Caliber of ordnance greater than 81-mm (includes 105-mm HEAT, 105-mm projectile, 155-mm projectile, 500 pound bomb).

Shallow: Items buried less than 0.3 meters below ground surface.

Medium: Items buried greater than or equal to 0.3 meters and less than 1 meter below ground surface.

Deep: Items buried greater than or equal to 1 meter below ground surface.

Response Stage Noise Level: The level that represents the point below which anomalies are not considered detectable. Demonstrators are required to provide the recommended noise level for the Blind Grid Test area.

Discrimination Stage Threshold: The demonstrator selected threshold level that they believe provides optimum performance of the system by retaining all detectable ordnance and rejecting the maximum amount of clutter. This level defines the subset of anomalies the demonstrator would recommend digging based on discrimination.

Binomially Distributed Random Variable: A random variable of the type which has only two possible outcomes, say success and failure, is repeated for n independent trials with the probability p of success and the probability 1-p of failure being the same for each trial. The number of successes x observed in the n trials is an estimate of p and is considered to be a binomially distributed random variable.

RESPONSE AND DISCRIMINATION STAGE DATA

The scoring of the demonstrator's performance is conducted in two stages. These two stages are termed the RESPONSE STAGE and DISCRIMINATION STAGE. For both stages, the probability of detection (P_d) and the false alarms are reported as receiver operating characteristic (ROC) curves. False alarms are divided into those anomalies that correspond to emplaced clutter items, measuring the probability of false positive (P_{fp}) and those that do not correspond to any known item, termed background alarms.

The RESPONSE STAGE scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate ordnance from other anomalies. For the RESPONSE STAGE, the demonstrator provides the scoring committee with the location and signal strength of all anomalies that the demonstrator has deemed sufficient to warrant further investigation and/or processing as potential emplaced ordnance items. This list is generated with minimal processing (e.g., this list will include all signals above the system noise threshold). As such, it represents the most inclusive list of anomalies.

The DISCRIMINATION STAGE evaluates the demonstrator's ability to correctly identify ordnance as such, and to reject clutter. For the same locations as in the RESPONSE STAGE anomaly list, the DISCRIMINATION STAGE list contains the output of the algorithms applied in the discrimination-stage processing. This list is prioritized based on the demonstrator's determination that an anomaly location is likely to contain ordnance. Thus, higher output values are indicative of higher confidence that an ordnance item is present at the specified location. For electronic signal processing, priority ranking is based on algorithm output. For other systems, priority ranking is based on human judgment. The demonstrator also selects the threshold that the demonstrator believes will provide "optimum" system performance, (i.e., that retains all the detected ordnance and rejects the maximum amount of clutter).

Note: The two lists provided by the demonstrator contain identical numbers of potential target locations. They differ only in the priority ranking of the declarations.

RESPONSE STAGE DEFINITIONS

Response Stage Probability of Detection (P_d^{res}): P_d^{res} = (No. of response-stage detections)/(No. of emplaced ordnance in the test site).

Response Stage False Positive (fp^{res}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Response Stage Probability of False Positive (P_{fp}^{res}): P_{fp}^{res} = (No. of response-stage false positives)/(No. of emplaced clutter items).

Response Stage Background Alarm (ba^{res}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Response Stage Probability of Background Alarm (P_{ba}^{res}): Blind Grid only: P_{ba}^{res} = (No. of response-stage background alarms)/(No. of empty grid locations).

Response Stage Background Alarm Rate (BAR^{res}): Open Field only: BAR^{res} = (No. of response-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{res}, P_{fp}^{res}, P_{ba}^{res}, and BAR^{res} are functions of t^{res}, the threshold applied to the response-stage signal strength. These quantities can therefore be written as $P_d^{res}(t^{res})$, $P_{fp}^{res}(t^{res})$, $P_{ba}^{res}(t^{res})$, and $BAR^{res}(t^{res})$.

DISCRIMINATION STAGE DEFINITIONS

Discrimination: The application of a signal processing algorithm or human judgment to response-stage data that discriminates ordnance from clutter. Discrimination should identify anomalies that the demonstrator has high confidence correspond to ordnance, as well as those that the demonstrator has high confidence correspond to nonordnance or background returns. The former should be ranked with highest priority and the latter with lowest.

Discrimination Stage Probability of Detection (P_d^{disc}): P_d^{disc} = (No. of discrimination-stage detections)/(No. of emplaced ordnance in the test site).

Discrimination Stage False Positive (fp^{disc}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Discrimination Stage Probability of False Positive (P_{fp}^{disc}): P_{fp}^{disc} = (No. of discrimination stage false positives)/(No. of emplaced clutter items).

Discrimination Stage Background Alarm (ba^{disc}): An anomaly in a blind grid cell that contains neither emplaced ordnance nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced ordnance or emplaced clutter item.

Discrimination Stage Probability of Background Alarm (P_{ba}^{disc}): P_{ba}^{disc} = (No. of discrimination-stage background alarms)/(No. of empty grid locations).

Discrimination Stage Background Alarm Rate (BAR^{disc}): BAR^{disc} = (No. of discrimination-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{disc}, P_{fp}^{disc}, P_{ba}^{disc}, and BAR^{disc} are functions of t^{disc}, the threshold applied to the discrimination-stage signal strength. These quantities can therefore be written as $P_d^{disc}(t^{disc})$, $P_{fp}^{disc}(t^{disc})$, $P_{ba}^{disc}(t^{disc})$, and $BAR^{disc}(t^{disc})$.

RECEIVER-OPERATING CHARACERISTIC (ROC) CURVES

ROC curves at both the response and discrimination stages can be constructed based on the above definitions. The ROC curves plot the relationship between P_d vs. P_{fp} and P_d vs. BAR or P_{ba} as the threshold applied to the signal strength is varied from its minimum (t_{min}) to its maximum (t_{max}) value.[1] Figure 1 shows how P_d vs. P_{fp} and P_d vs. BAR are combined into ROC curves. Note that the "res" and "disc" superscripts have been suppressed from all the variables for clarity.

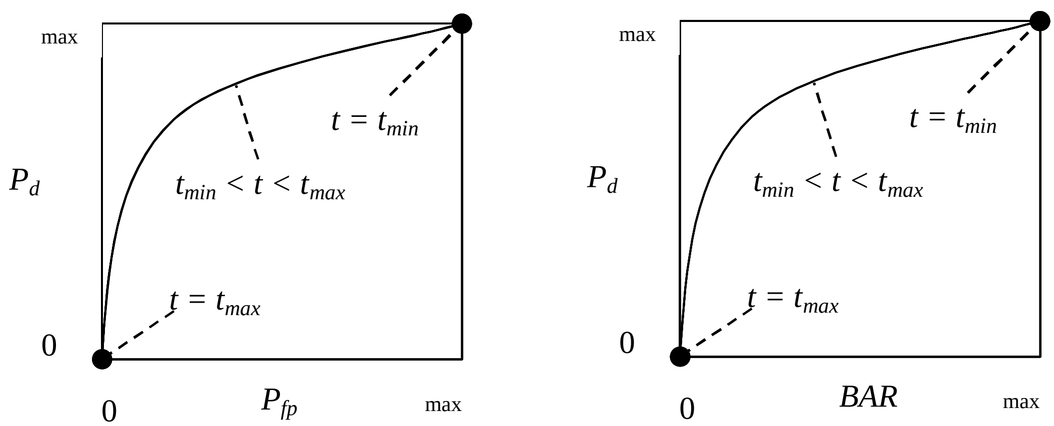

Figure A-1. ROC curves for open-field testing. Each curve applies to both the response and discrimination stages.

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[1]Strictly speaking, ROC curves plot the P_d vs. P_{ba} over a pre-determined and fixed number of detection opportunities (some of the opportunities are located over ordnance and others are located over clutter or blank spots). In an open field scenario, each system suppresses its signal strength reports until some bare-minimum signal response is received by the system. Consequently, the open field ROC curves do not have information from low signal-output locations, and, furthermore, different contractors report their signals over a different set of locations on the ground. These ROC curves are thus not true to the strict definition of ROC curves as defined in textbooks on detection theory. Note, however, that the ROC curves obtained in the Blind Grid Test sites are true ROC curves.

METRICS TO CHARACTERIZE THE DISCRIMINATION STAGE

The demonstrator is also scored on efficiency and rejection ratio, which measure the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of ordnance detections from the anomaly list, while rejecting the maximum number of anomalies arising from nonordnance items. The efficiency measures the amount of detected ordnance retained by the discrimination, while the rejection ratio measures the fraction of false alarms rejected. Both measures are defined relative to the entire response list, i.e., the maximum ordnance detectable by the sensor and its accompanying false positive rate or background alarm rate.

Efficiency (E): $E = P_d^{disc}(t^{disc})/P_d^{res}(t_{min}^{res})$; Measures (at a threshold of interest), the degree to which the maximum theoretical detection performance of the sensor system (as determined by the response stage tmin) is preserved after application of discrimination techniques. Efficiency is a number between 0 and 1. An efficiency of 1 implies that all of the ordnance initially detected in the response stage was retained at the specified threshold in the discrimination stage, t^{disc}.

False Positive Rejection Rate (R_{fp}): $R_{fp} = 1 - [P_{fp}^{disc}(t^{disc})/P_{fp}^{res}(t_{min}^{res})]$; Measures (at a threshold of interest), the degree to which the sensor system's false positive performance is improved over the maximum false positive performance (as determined by the response stage tmin). The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all emplaced clutter initially detected in the response stage were correctly rejected at the specified threshold in the discrimination stage.

Background Alarm Rejection Rate (R_{ba}):

BLIND GRID: $R_{ba} = 1 - [P_{ba}^{disc}(t^{disc})/P_{ba}^{res}(t_{min}^{res})]$
OPEN FIELD: $R_{ba} = 1 - [BAR^{disc}(t^{disc})/BAR^{res}(t_{min}^{res})])$

Measures the degree to which the discrimination stage correctly rejects background alarms initially detected in the response stage. The rejection rate is a number between 0 and 1. A rejection rate of 1 implies that all background alarms initially detected in the response stage were rejected at the specified threshold in the discrimination stage.

APPENDIX B. DAILY WEATHER LOGS

TABLE B-1. WEATHER LOG

Weather Data from Phillips Airfield						
Date	Time, EDST	Average Temperature, °F	Maximum Temperature, °F	Minimum Temperature, °F	RH, %	Precipitation, in.
28-Apr-03		8.47	9.04	7.909	89.30	0.00
28-Apr-03	01:00	8.09	8.84	7.31	90.40	0.00
28-Apr-03	02:00	7.677	8.31	6.643	93.40	0.00
28-Apr-03	03:00	6.44	7.443	5.646	96.90	0.00
28-Apr-03	04:00	5.945	6.582	5.458	97.60	0.00
28-Apr-03	05:00	5.579	6.326	5.126	97.20	0.00
28-Apr-03	06:00	5.951	6.792	5.459	96.90	0.00
28-Apr-03	07:00	9.49	12.11	6.659	92.00	0.00
28-Apr-03	08:00	13.93	15.89	11.98	72.80	0.00
28-Apr-03	09:00	18.21	20.13	15.82	50.67	0.00
28-Apr-03	10:00	21.49	22.64	19.73	35.86	0.00
28-Apr-03	11:00	22.62	23.49	22.03	29.48	0.00
28-Apr-03	12:00	23.52	23.88	23.02	26.76	0.00
28-Apr-03	13:00	23.96	24.47	23.34	29.50	0.00
28-Apr-03	14:00	24.28	24.67	23.87	29.06	0.00
28-Apr-03	15:00	24.41	24.79	24.06	30.15	0.00
28-Apr-03	16:00	24.5	24.79	24.19	31.95	0.00
28-Apr-03	17:00	24.22	24.79	23.73	33.33	0.00
28-Apr-03	18:00	23.15	23.86	22.27	37.22	0.00
28-Apr-03	19:00	21.59	22.47	20.55	42.97	0.00
28-Apr-03	20:00	18.7	20.75	17.37	56.01	0.00
28-Apr-03	21:00	16.97	17.44	16.59	67.01	0.00
28-Apr-03	22:00	16.39	17.12	15.80	69.33	0.00
28-Apr-03	23:00	15.6	15.93	15.13	79.05	0.00
29-Apr-03		15.51	16.00	15.00	86.20	0.00
29-Apr-03	1:00	15.27	16.00	14.67	89.30	0.00
29-Apr-03	02:00	14.85	15.60	13.80	89.30	0.00
29-Apr-03	03:00	13.84	14.87	12.94	93.40	0.00
29-Apr-03	04:00	12.63	13.47	11.76	98.00	0.00
29-Apr-03	05:00	11.22	11.89	10.16	99.70	0.00
29-Apr-03	06:00	10.69	11.29	10.22	100.00	0.00
29-Apr-03	07:00	12.72	15.29	10.63	100.00	0.00
29-Apr-03	08:00	16.15	17.87	14.69	92.80	0.00
29-Apr-03	09:00	19.52	21.58	17.73	72.73	0.00
29-Apr-03	10:00	22.5	24.36	21.24	60.76	0.00
29-Apr-03	11:00	23.95	25.61	21.54	39.87	0.00
29-Apr-03	12:00	20.03	21.54	18.49	59.31	0.00
29-Apr-03	13:00	18.86	20.17	18.16	73.89	0.00
29-Apr-03	14:00	21.44	22.56	20.10	68.00	0.00
29-Apr-03	15:00	22.26	23.54	21.48	64.28	0.00

TABLE B-1 (CONT'D)

Weather Data from Phillips Airfield						
Date	Time, EDST	Average Temperature, ^oF	Maximum Temperature, ^oF	Minimum Temperature, ^oF	RH, %	Precipitation, in.
29-Apr-03	16:00	23.64	24.34	23.14	56.98	0.00
29-Apr-03	17:00	23.91	24.53	23.20	55.76	0.00
29-Apr-03	18:00	23.76	24.20	23.20	47.62	0.00
29-Apr-03	19:00	22.51	23.47	21.22	46.01	0.00
29-Apr-03	20:00	19.91	21.48	17.50	55.89	0.00
29-Apr-03	21:00	16.77	17.84	15.06	70.18	0.00
29-Apr-03	22:00	14.57	15.46	13.34	79.09	0.00
29-Apr-03	23:00	13.04	13.60	12.07	89.10	0.00

APPENDIX C. SOIL MOISTURE

Geophex Soil Moisture Logs (28 and 29 April 2003)

Date: 28 April 2003
Times: 0935 hrs (AM) , 1605 hrs (PM)

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	77.8	78.2
	6 to 12	65.9	66.8
	12 to 24	73.1	77.1
	24 to 36	61.9	62.1
	36 to 48	52.3	51.2
Wooded Area	0 to 6	NO READINGS! SUBMERGED PROBE.	
	6 to 12		
	12 to 24		
	24 to 36		
	36 to 48		
Open Area	0 to 6	15.8	16.2
	6 to 12	1.2	1.3
	12 to 24	22.7	22.9
	24 to 36	30.2	29.9
	36 to 48	42.8	43.1

Date: 29 April 2003
Time: 0920 hrs (AM), 1605 (PM)

Probe Location:	Layer, in.	AM Reading, %	PM Reading, %
Wet Area	0 to 6	78.4	77.2
	6 to 12	64.2	65.8
	12 to 24	73.8	74.1
	24 to 36	62.9	60.3
	36 to 48	51.1	50.9
Wooded Area	0 to 6	84.3	84.9
	6 to 12	64.8	64.9
	12 to 24	62.9	63.4
	24 to 36	88.3	87.9
	36 to 48	48.3	48.7
Open Area	0 to 6	13.1	16.2
	6 to 12	0.6	1.4
	12 to 24	21.9	22.9
	24 to 36	29.0	29.5
	36 to 48	41.9	42.7

APPENDIX D. DAILY LOGS

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
TEAM 1		CART										
4/28/2003	1	CALIBRATION LANES	845	1220	215	SETUP/DAILY START/ STOP/CALIBRATION	SET UP/ MOBILIZATION	NA	NA	NA	SUNNY	MUDDY
4/28/2003	1	CALIBRATION LANES	1220	1408	108	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
4/28/2003	1	CALIBRATION LANES	1408	1428	20	DOWNTIME DUE TO EQUIP MAIN/CHECK	CHANGE BATTERY	NA	NA	NA	SUNNY	MUDDY
4/28/2003	1	CALIBRATION LANES	1428	1520	48	DOWNTIME DUE TO EQUIP MAIN/CHECK	DOWNLOADING DATA	NA	NA	NA	SUNNY	MUDDY
4/28/2003	1	BLIND TEST GRID	1520	1631	71	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
4/28/2003	1	BLIND TEST GRID	1631	1650	19	DOWNTIME DUE TO EQUIP MAIN/CHECK	CHANGE BATTERY	NA	NA	NA	SUNNY	MUDDY
4/28/2003	1	BLIND TEST GRID	1650	1905	135	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
4/28/2003	1	BLIND TEST GRID	1905	1915	10	SETUP/DAILY START/ STOP/CALIBRATION	END OF DAILY OPERATIONS/ EQUIPMENT BREAKDOWN	NA	NA	NA	SUNNY	MUDDY
4/29/2003	1	BLIND TEST GRID	800	900	60	SETUP/DAILY START/ STOP/CALIBRATION	SET UP/ MOBILIZATION	NA	NA	NA	CLOUDY	MUDDY
4/29/2003	1	BLIND TEST GRID	900	1045	105	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
4/29/2003	1	BLIND TEST GRID	1045	1103	18	DOWNTIME DUE TO EQUIP MAIN/CHECK	CHANGE BATTERY	NA	NA	NA	CLOUDY	MUDDY
4/29/2003	1	BLIND TEST GRID	1103	1357	174	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
4/29/2003	1	OPEN FIELD	1357	1415	18	SETUP/DAILY START/STOP/CALIBRATION	SET UP CONES	NA	NA	NA	CLOUDY	MUDDY
4/29/2003	1	OPEN FIELD	1415	1610	115	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
4/29/2003	1	OPEN FIELD	1610	1650	40	BREAK/LUNCH	BREAK/LUNCH	NA	NA	NA	CLOUDY	MUDDY
4/29/2003	1	OPEN FIELD	1650	1855	125	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
4/29/2003	1	OPEN FIELD	1855	1915	20	DOWNTIME DUE TO EQUIP MAIN/CHECK	DOWNLOADING DATA	NA	NA	NA	CLOUDY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
4/29/2003	1	OPEN FIELD	1915	1930	15	SETUP/DAILY START/ STOP/CALIBRATION	END OF DAILY OPERATIONS/ EQUIPMENT BREAKDOWN	NA	NA	NA	CLOUDY	MUDDY
4/30/2003	1	OPEN FIELD	800	845	45	SETUP/DAILY START/ STOP/CALIBRATION	SET UP/ MOBILIZATION	NA	NA	NA	CLOUDY	MUDDY
4/30/2003	1	OPEN FIELD	845	1150	189	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
4/30/2003	1	OPEN FIELD	1150	1225	31	DOWNTIME DUE TO EQUIP MAIN/CHECK	CHECK DATA	NA	NA	NA	CLOUDY	MUDDY
4/30/2003	1	OPEN FIELD	1225	1305	40	BREAK/LUNCH	BREAK/LUNCH	NA	NA	NA	CLOUDY	MUDDY
5/1/2003	1	OPEN FIELD	803	1041	158	SETUP/DAILY START/ STOP/CALIBRATION	SET UP/ MOBILIZATION	NA	NA	NA	SUNNY	MUDDY
5/1/2003	1	OPEN FIELD	1041	1130	49	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
5/1/2003	1	OPEN FIELD	1130	1152	22	DOWNTIME DUE TO EQUIP MAIN/CHECK	CHANGE BATTERY	NA	NA	NA	SUNNY	MUDDY
5/1/2003	1	OPEN FIELD	1152	1239	47	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
5/1/2003	1	OPEN FIELD	1239	1323	44	SETUP/DAILY START/ STOP/CALIBRATION	SET UP CONES	NA	NA	NA	SUNNY	MUDDY
5/1/2003	1	OPEN FIELD	1323	1438	75	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
5/1/2003	1	OPEN FIELD	1438	1449	11	DOWNTIME DUE TO EQUIP MAIN/CHECK	DOWNLOADING DATA	NA	NA	NA	SUNNY	MUDDY
5/1/2003	1	OPEN FIELD	1449	1530	41	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
5/2/2003	1	OPEN FIELD	755	954	119	SETUP/DAILY START/ STOP/CALIBRATION	SET UP/ MOBILIZATION	NA	NA	NA	CLOUDY	MUDDY
5/2/2003	1	OPEN FIELD	954	1035	41	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
5/2/2003	1	OPEN FIELD	1035	1116	41	DOWNTIME DUE TO EQUIP MAIN/CHECK	DOWNLOADING DATA	NA	NA	NA	CLOUDY	MUDDY
5/2/2003	1	OPEN FIELD	1116	1320	124	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
5/2/2003	1	OPEN FIELD	1320	1405	45	DOWNTIME DUE TO EQUIP MAIN/CHECK	DOWNLOADING DATA	NA	NA	NA	CLOUDY	MUDDY
5/2/2003	1	OPEN FIELD	1405	1455	50	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	CLOUDY	MUDDY
5/2/2003	1	OPEN FIELD	1455	1535	40	DOWNTIME DUE TO EQUIP MAIN/CHECK	DOWNLOADING DATA	NA	NA	NA	CLOUDY	MUDDY
5/2/2003	1	OPEN FIELD	1535	1625	50	DOWNTIME DUE TO EQUIP MAIN/CHECK	CHECK DATA	NA	NA	NA	CLOUDY	MUDDY

Date	No. of People	Area Tested	Status Start Time	Status Stop Time	Duration, min	Operational Status	Operational Status - Comments	Track Method	Track Method=Other Explain	Pattern	Field Conditions	
5/6/2003	1	OPEN FIELD	1240	1245	5	SETUP/DAILY START/ STOP/CALIBRATION	SET UP/ MOBILIZATION	NA	NA	NA	SUNNY	MUDDY
5/6/2003	1	OPEN FIELD	1245	1303	18	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
5/6/2003	1	OPEN FIELD	1303	1351	48	DOWNTIME DUE TO EQUIP MAIN/CHECK	CHANGE BATTERY	NA	NA	NA	SUNNY	MUDDY
5/6/2003	1	OPEN FIELD	1351	1607	136	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
5/6/2003	1	OPEN FIELD	1607	1640	33	DOWNTIME DUE TO EQUIP MAIN/CHECK	DOWNLOADING DATA	NA	NA	NA	SUNNY	MUDDY
5/6/2003	1	OPEN FIELD	1640	1710	30	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
5/7/2003	1	OPEN FIELD	900	931	31	SETUP/DAILY START/ STOP/CALIBRATION	SET UP/ MOBILIZATION	NA	NA	NA	SUNNY	MUDDY
5/7/2003	1	OPEN FIELD	931	1041	70	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
5/7/2003	2	OPEN FIELD	1041	1044	3	EQUIPMENT FAILURE	GPS SYSTEM NOT WORKING	NA	NA	NA	SUNNY	MUDDY
5/7/2003	2	OPEN FIELD	1044	1054	10	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
5/7/2003	2	OPEN FIELD	1054	1143	49	EQUIPMENT FAILURE	GPS SYSTEM NOT WORKING	NA	NA	NA	SUNNY	MUDDY
5/7/2003	2	OPEN FIELD	1143	1205	23	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
5/7/2003	2	OPEN FIELD	1205	1245	40	EQUIPMENT FAILURE	GPS SYSTEM NOT WORKING	NA	NA	NA	SUNNY	MUDDY
5/7/2003	2	OPEN FIELD	1245	1338	53	BREAK/LUNCH	BREAK/LUNCH	NA	NA	NA	SUNNY	MUDDY
5/7/2003	2	OPEN FIELD	1338	1400	22	COLLECT DATA	COLLECT DATA	GPS	NA	LINEAR	SUNNY	MUDDY
5/7/2003	2	OPEN FIELD	1400	1408	8	DOWNTIME DUE TO EQUIP MAIN/CHECK	DOWNLOADING DATA	NA	NA	NA	SUNNY	MUDDY
5/7/2003	2	OPEN FIELD	1408	1515	67	DEMOBILIZATION	DEMOBILIZATION	NA	NA	NA	SUNNY	MUDDY

APPENDIX E. REFERENCES

1. Standardized UXO Technology Demonstration Site Handbook, DTC Project No. 8-CO-160-000-473, Report No. ATC-8349, March 2002.

2. Aberdeen Proving Ground Soil Survey Report, October 1998.

3. Data Summary, UXO Standardized Test Site: APG Soils Description, May 2002.

APPENDIX F. ABBREVIATIONS

AEC	=	U.S. Army Environmental Center
APG	=	Aberdeen Proving Ground
ATC	=	U.S. Army Aberdeen Test Center
CAD	=	computer-aided design
DGPS	=	differential Global Positioning System
ERDC	=	U.S. Army Corp of Engineers Engineering, Research and Development Center
ESTCP	=	Environmental Security Technology Certification Program
EQT	=	Army Environmental Quality Technology Program
GPR	=	ground-penetrating radar
GPS	=	Global Positioning System
GX	=	Geosoft executable
HH	=	handheld
MS	=	Microsoft
POC	=	point of contact
PVC	=	polyvinyl chloride
QC	=	quality control
ROC	=	receiver-operating characteristic
RTK	=	real time kinematic
SAR	=	synthetic-aperture radar
SERDP	=	Strategic Environmental Research and Development Program
UXO	=	unexploded ordnance

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