AD NO. ___________________________
DTC PROJECT NO. 8-CO-160-UXO-021
REPORT NO. ATC 10514

STANDARDIZED

UXO TECHNOLOGY DEMONSTRATION SITE

SCORING RECORD NO. 933

SITE LOCATION:
ABERDEEN PROVING GROUND

DEMONSTRATOR:
NAVAL RESEARCH LABORATORY
1900 ELKIN STREET, SUITE 230
ALEXANDRIA, VA 22308

TECHNOLOGY TYPE/PLATFORM:
TEMTADS 2x2
PUSHCART CART

AREAS COVERED:
BLIND GRID
OPEN FIELD (INDIRECT FIRE AREA)

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

MARCH 2011

Prepared for:
SERDP/ESTCP
MUNITIONS MANAGEMENT
ARLINGTON, VA 22203

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

DISPOSITION INSTRUCTIONS

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None

14. ABSTRACT

This scoring record documents the efforts of the Environmental Security Technology Certification Program to detect and discriminate inert unexploded ordnance (UXO) utilizing the APG Standardized UXO Technology Demonstration Site calibration lanes and open field sites. This Scoring Record was coordinated by J. Stephen McClung and the Standardized UXO Technology Demonstration Site 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 Command, and the U.S. Army Aberdeen Test Center.

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Environmental Security Technology Certification Program, APG, Standardized UXO Technology Demonstration Site, blind grid, open field, indirect fire, pushcart.

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SECTION 1. GENERAL INFORMATION

1.1 BACKGROUND

Technologies under development for the detection and discrimination of military munitions (MM) (i.e., unexploded ordnance {UXO} and discarded military munitions {DMM}) require testing so that performance can be characterized. To that end, Standardized Test Sites have been developed at Aberdeen Proving Ground (APG), Maryland, and U.S. Army Yuma Proving Ground (YPG), Arizona. These test sites provide a diversity of geology, climate, terrain, and weather as well as diversity in munitions 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 (app E, ref 1).

The Standardized UXO Technology Demonstration Site Program is a multiagency program spearheaded by the U.S. Army Environmental Command (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 U.S. Army Environmental Quality Technology (EQT) Program.

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 with various targets, geology, clutter, density, topography, and vegetation.

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

c. To determine the 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 (GT), 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: 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 clutter detection (P_{cd}) or the probability of false positive (P_{fp}). Those that do not correspond to any known item are termed background alarms. The background alarms are addressed as either probability of background alarm (P_{ba}) or background alarm rate (BAR).

b. The response stage scoring evaluates the ability of the system to detect emplaced targets without regard to ability to discriminate munitions from other anomaly sources. For the blind grid response stage, the demonstrator provides a target response from each and every grid square along with a threshold 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, includes amplitudes both above and below the system noise level. For the open field, the demonstrator provides a list of all anomalies deemed to exceed a demonstrator selected target detection threshold. An item (either munition or clutter) is counted as detected if a demonstrator indicates an anomaly within a specified distance (Halo Radius (R_{halo})) of a ground truth item.

c. The discrimination stage evaluates the demonstrator's ability to correctly identify munitions as such and to reject clutter. For the blind grid discrimination stage, the demonstrator provides the output of the discrimination stage processing for each grid square. For the open field, the demonstrator provides the output of the discrimination stage processing for anomaly reported in the response stage. The values in these lists are prioritized based on the demonstrator's determination that a location is likely to contain munitions. Thus, higher output values are indicative of higher confidence that a munitions item is present at the specified location. For digital signal processing, priority ranking is based on algorithm output. For other discrimination approaches, priority ranking may be based on rule sets or human judgment. The demonstrator also specifies the threshold in the prioritized ranking that provides optimum performance, (i.e., that is expected to retain all detected munitions and reject the maximum amount of clutter).

d. The demonstrator is also scored on efficiency and rejection ratios, which measure the effectiveness of the discrimination stage processing. The goal of discrimination is to retain the greatest number of munitions detections from the anomaly list, while rejecting the maximum number of anomalies arising from nonmunitions items. Efficiency measures the fraction of detected munitions retained after discrimination, while the rejection ratio measures the fraction of false alarms rejected. Both measures are defined relative to the maximum number of munitions detectable by the sensor and its accompanying clutter detection/false positive rate or BAR.

e. Based on configuration of the GT at the standardized sites and the defined scoring methodology, in some cases, there exists the possibility of having anomalies within overlapping halos and/or multiple anomalies within halos. In these cases, the following scoring logic is implemented:

(1) In situations where multiple anomalies exist within a single R_{halo}, the anomaly with the strongest response or highest ranking will be assigned to that particular GT item. If the responses or rankings are equal, then the anomaly closest to the GT item will be assigned to the GT item. Remaining anomalies are retained and scored until all matching is complete.

(2) Anomalies located within any R_{halo} that do not get associated with a particular GT item are excess alarms and will be disregarded.

f. In some cases, groups of closely spaced munitions have overlapping halos. The following scoring logic is implemented (app A, fig. A-1 through A-9):

(1) Overall site scores (i.e., P_d) will consider only isolated munitions and clutter items.

(2) GT items that have overlapping halos (both munitions and clutter) will form a group and groups may form chains.

(3) Groups will have a complex halos composed of the composite halos of all its GT items.

(4) Groups will have three scoring factors: groups found, groups identified, and group coverage. Scores will be based on 1:1 matches of anomalies and GT.

(a) Groups Found (Found): the number of groups that have one or more GT items matched divided by the total number of groups. Demonstrators will be credited with detecting a group if any item within the group is matched to an anomaly in their lists.

(b) Groups Identified (ID): the number of groups that have two or more GT items matched divided by the total number of groups. Demonstrators will be credited with identifying that a group is present if multiple items within the composite halo are matched to anomalies in their lists.

(c) Group Coverage (Coverage): the number of GT items matched within groups divided by the total number of GT items within groups. This metric measures the demonstrator accuracy in determining the number of anomalies within a group. If five items are present and only two anomalies are matched, the demonstrator will score 0.4. If all five are matched, the demonstrator will score 1.0.

(5) Location error will not be reported for groups.

(6) Demonstrators will not be asked to call out groups in their scoring submissions. If multiple anomalies are indicated in a small area, the demonstrator will report all individual anomalies.

(7) Excess alarms within a halo will be disregarded.

g. All scoring factors are generated utilizing the Standardized UXO Probability and Plot Program, version 4.

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 clutter detection (P_{cd}).

(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}).

(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, depth, and density.

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

(3) Location accuracy for single munitions.

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

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

(6) Reacquisition/resurvey time and worker-hour requirements (if any).

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

SECTION 2. DEMONSTRATION

2.1 DEMONSTRATOR INFORMATION

2.1.1 Demonstrator Point of Contact (POC) and Address

POC: Mr. Dan Steinhurst
(202) 767-3556

Address: Naval Research Laboratory
1900 Elkin Street, Suite 230
Alexandria, VA 22308

2.1.2 System Description (provided by demonstrator)

a. The TEMTADS 2x2 Man-portable cart is a four-element transient electromagnetic induction (EMI) system designed and built by the Naval Research Laboratory to transition the EMI sensor technology of the TEMTADS towed array to a more compact, man-portable configuration for use in more limiting terrain. Like the towed array, this system is currently configured to operate in a cued mode, where the target location is already known. Each individual sensor includes a 35-cm transmit coil and an inner, 25-cm receive coil. Decay data are collected with a 500 kHz sample rate until 25 ms after turn off of the excitation pulse. These raw decay measurements are grouped into 115 logarithmically-spaced “gates” whose center times range from 42 μs to 24.35 ms with 5 percent widths. The sensor is deployed on a set of wheels resulting in a sensor-to-ground offset of approximately 25 cm.

b. Application of this technology is straightforward. A list of target positions is developed from a survey by some geophysical instrument; in the case of this demonstration, the earlier survey by the MTADS magnetometer array in May 2008. Each target position is flagged with a non-metallic pin flag using cm-level Global Positioning System (GPS). The cart is positioned over each target in turn. When positioned over the target, the system activates the array transmitters sequentially and collects decay from all four receive coils for each excitation. The cart is then moved 20 cm (one half a sensor width) forwards or backwards and a second set of data are collected. These data are then inverted for target characteristics.

Figure 1. The NRL TEMTADS pushcart.

2.1.3 <u>Data Processing Description (provided by demonstrator)</u>

a. Target selection criteria: Targets for this demonstration will be chosen from the target list developed after the MTADS magnetometer array survey of the site to be performed in May 2008. Details of data handling and target detection algorithms are contained in the demonstration plan for that survey.

b. Parameter estimation.

(1) Which characteristics will be extracted from each detected item and input to the discrimination algorithm (e.g., depth, size, polarizability coefficients, fit quality, etc.)? Principal axis polarizabilities and fit quality.

(2) Why have these characteristics been chosen and not others (e.g., empirical evidence of their ability to help discriminate, inclusion in a theoretical tradition, etc.)? Testing experience with this technology indicates they are best characteristics for UXO/clutter classification.

(3) How are these characteristics estimated (e.g., least-mean-squares fit to a dipole model, etc.), include the equations that are used for parameter estimation? Array data are least-squares fit to standard dipole response model for voltage in receive coil:

$$V(t) = \mu_0 n_R n_T I_0 \mathbf{C}_R \cdot \mathbf{C}_T \mathbf{B}(t)$$

Where I_0 is transmit current, n_R and n_T are number of turns in transmit and receive coils, $\mathbf{C}_R$ and $\mathbf{C}_T$ are transmit and receive coil response functions calculated from the coil geometry using Biot-Savart law, and **B** is the polarizability tensor. The principal axis polarizabilities are the eigenvalues of **B**, and fit quality is the squared correlation coefficient between the data and the model fit.

(4) What tunable parameters (if any) are used in the characterization process? (e.g., thresholds on background noise, etc.)? Polarizabilities for expected ordnance items determined from training data.

c. Classification.

(1) What algorithm is used for discrimination (e.g., multi-layer perception, support vector machine, etc.)? Generalized Likelihood.

(2) Why is this algorithm used and not others? It is appropriate for our procedure which compares fit quality using previously determined UXO polarizabilities with unconstrained fit quality and was proven effective in the Discrimination Study Pilot Program.

(3) Which parameters are considered as possible inputs to the algorithm? Constrained and unconstrained fit qualities.

(4) What are the outputs of the algorithm (probabilities, confidence levels)? Closeness of measured response to UXO response.

(5) How is the threshold set to decide where the munitions/non-munitions line lies in the discrimination process? Training data on UXO and clutter acquired in testing at our Blossom Point facility and other demonstration sites.

d. Training.

(1) Which tunable parameters have final values that are optimized over a training set of data and which have values that are set according to geophysical knowledge (i.e., intuition, experience, common sense)? Ratio of UXO-constrained fit quality to unconstrained fit quality is optimized over a training set of data.

(a) For those tunable parameters with final values set according to geophysical knowledge:

1 What is the reasoning behind choosing these particular values? NA.

2 Why were the final values not optimized over a training set of data? NA.

(b) For those tunable parameters with final values optimized over the training set data:

1 What training data is used (e.g., all data, a randomly chosen portion of data, etc.)? All training data on UXO and clutter acquired in testing at our Blossom Point facility.

2 What error metric is minimized during training (e.g., mean squared error, etc.)? Bhattacharyya distance.

3 What learning rule is used during training (e.g., gradient descent, etc.)? NA.

4 What criterion is used to stop training (e.g., number of iterations exceeds threshold, good generalization over validation set of data, etc.)? Limits of training data.

5 Are all tunable parameters optimized at once or in sequence ("in sequence" = parameters 1 is held constant at some common sense values while parameter 2 is optimized, and then parameter 2 is held constant at its optimized value while parameter 1 is optimized)? All at once.

(2) What are the final values of all tunable parameters for the characterization process? Best threshold setting.

2.1.4 Data Submission Format

Data were submitted for scoring in accordance with data submission protocols outlined on the USAEC Web site www.uxotestsites.org. These submitted data are not included in this report in order to protect GT information.

2.1.5 Demonstrator Quality Assurance (QA) and Quality Control (QC) (provided by demonstrator)

General system functionality and individual sensor response are checked daily to ensure adequate system performance. Before beginning survey work each day, one or more standard objects are measured. The resulting signals and inversion results are checked against standard values.

Every one to two hours, all survey data is transferred to the field data analyst for preliminary data quality checks. The individual sensor files are examined for completeness and consistency. It is at this stage that any sensor malfunctions, etc. are flagged and reported to the field crew for correction.

2.1.6 Additional Records

The following record(s) by this vendor can be accessed via the Internet as Microsoft Word documents at www.uxotestsites.org.

2.2 APG SITE INFORMATION

2.2.1 Location

The APG Standardized Test Site is located within a secured range area of the Aberdeen Area. 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 APG 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 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 www.uxotestsites.org 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 presented in Table 1. A test site layout is shown in Figure 2.

TABLE 1. TEST SITE AREAS

Area	Description
Calibration lanes	Contains 14 standard munitions items buried in six positions, with representation of clutter, at various angles and depths to allow demonstrators to calibrate their equipment.
Blind grid	Contains 400 grid cells in a 0.5-acre site. The center of each grid cell contains either munitions, clutter, or nothing.
Open field	A 10-acre site composed of generally open and flat terrain with minimal clutter and minor navigational obstacles. Vegetation height varies from 15 to 25 cm. This area is subdivided into four subareas (legacy, direct fire, indirect fire, and challenge).
	• *Open field (legacy)* The legacy subarea contains the same wide variety of randomly-placed munitions that were present in the open field prior to the January 2008 general reconfiguration of the site.
	• *Open field (direct fire)* The direct fire subarea contains only three munition types that could be typically found at an impact area of a direct fire weapons range. Munitions and clutter are placed in a pattern typical for these munitions.
	• *Open field (indirect fire)* The indirect fire subarea contains only three munition types that could be typically found at an impact area of an indirect fire weapons range. Munitions and clutter are placed in a pattern typical for these munitions.
	• *Open field (challenge)* The challenge subarea is easily reconfigurable to meet the specific needs and requirements of the demonstrator or the program sponsor. Any results from this area are not reported in the standardized scoring record.
Woods	1.34-acre area consisting of cleared woods (tree removal with only stumps remaining), partially cleared woods (including all underbrush and fallen trees), and virgin woods (i.e., woods in natural state with all trees, underbrush, and fallen trees left in place).
Moguls	1.30-acre area consisting of two areas (the rectangular or driving portion of the course and the triangular section with more difficult, nondrivable terrain). A series of craters (as deep as 0.91 m) and mounds (as high as 0.91 m) encompass this section.

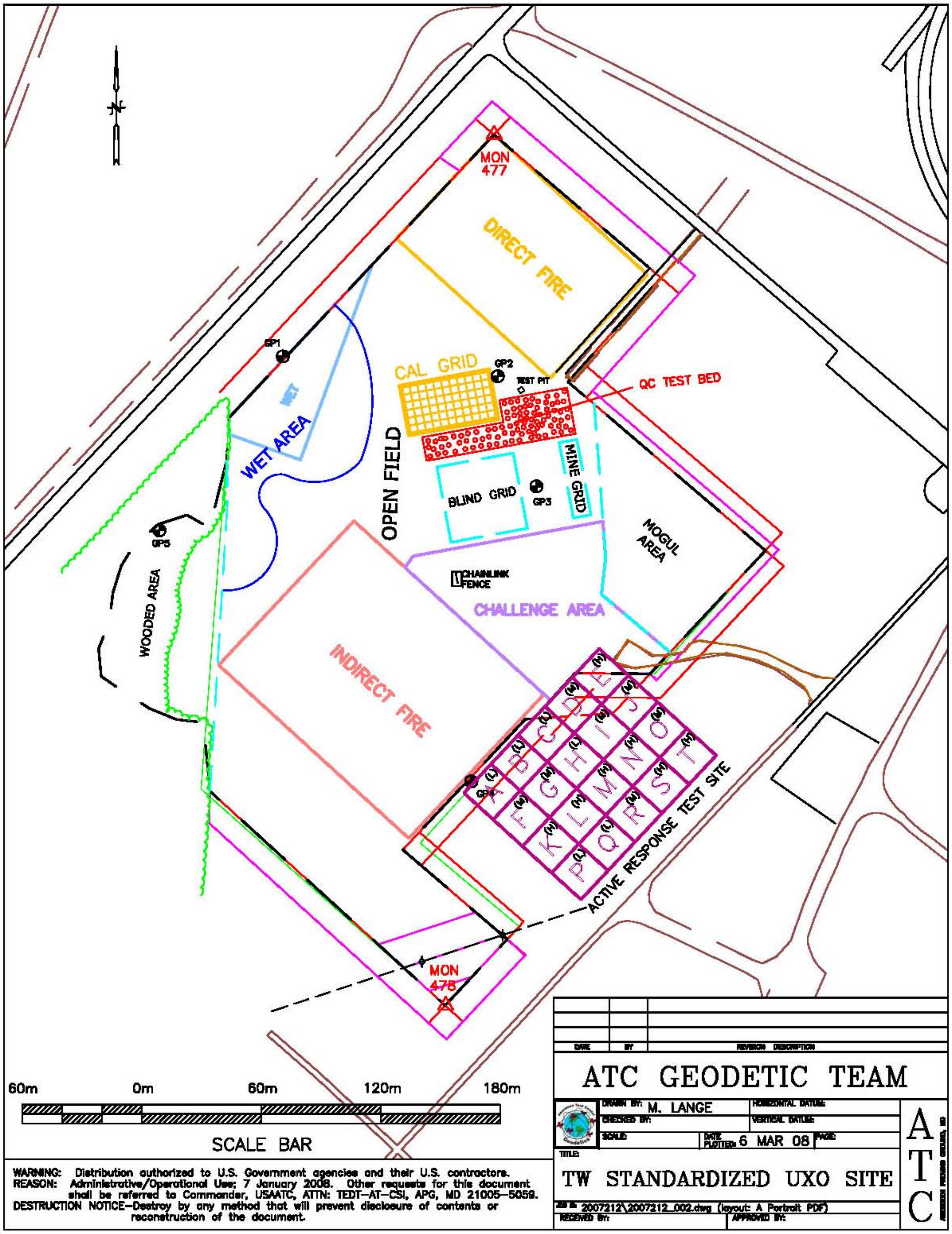


Figure 2. Test site layout.

2.2.4 Standard And Nonstandard Inert Munitions Targets

The standard and nonstandard munitions items emplaced in the test areas are presented in Table 2. Standardized targets are members of a set of specific munitions 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 inert munitions items having properties that differ from those in the set of standardized items.

TABLE 2. INERT MUNITIONS TARGETS

Item	Munition Type	Calibration Lanes	Blind Grid	Open Field Direct Fire	Open Field Indirect Fire	Open Field Legacy	Moguls	Woods
20-mm Projectile M55	S	X				X	X	X
25-mm Projectile M794	S	X	X	X				
37-mm Projectile M47	S	X	X	X				
40-mm Projectile MKII Bodies	S	X				X	X	X
BDU-28 Submunition	S	X				X	X	X
BLU-26 Submunition	S	X				X	X	X
M42 Submunition	S	X				X	X	X
57-mm Projectile APC M86	S	X				X	X	X
60-mm Mortar M49A3	S	X	X		X			
2.75-in. Rocket M230	S	X				X	X	X
81-mm Mortar M374	S	X	X		X	X	X	X
105-mm HEAT Rounds M456	S					X	X	X
105-mm HEAT Round M490	S	X	X	X				
105-mm Projectile M60	S	X	X		X	X	X	X
155-mm Projectile M483A1	S	X				X	X	X
20-mm Projectile M55	NS					X	X	X
20-mm Projectile M97	NS					X	X	X
40-mm Projectile M813	NS					X	X	X
60-mm Mortar (JPG)	NS					X	X	X
60-mm Mortar M49	NS					X	X	X
2.75-in. Rocket M230	NS					X	X	X
2.75-in. Rocket XM229	NS					X	X	X
81-mm Mortar (JPG)	NS					X	X	X
81-mm Mortar M374	NS					X	X	X
105-mm Projectile M60	NS					X	X	X
155-mm Projectile M483A	NS					X	X	X

HEAT = High-explosive antitank.
JPG = Jefferson Proving Ground.
NS = Nonstandard munition.
S = Standard munition.

2.3 ATC SURVEY COMMENTS

None.

SECTION 3. FIELD DATA

3.1 DATE OF FIELD ACTIVITIES (30 and 31 August, 1 and 2 September 2010)

3.2 AREAS TESTED/NUMBER OF HOURS

Areas tested and total numbers of hours operated at each site are presented in Table 3.

TABLE 3. AREAS TESTED AND NUMBER OF HOURS

Area	No. of Hours
Calibration lanes	1.50
Blind grid	6.00
Open field	19.83
Woods	-
Mogul	-
Mine grid	-

Note: Table 3 represents the total time spent in each area.

3.3 TEST CONDITIONS

3.3.1 Weather Conditions

An APG weather station located approximately 1 mile west of the test site was used to record average temperature and precipitation on a half-hour basis for each day of operation. The temperatures presented in Table 4 represent the average temperature during field operations from 0700 to 1700 hours, while precipitation data represent 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, 2010	Average Temperature, ^{o}F	Total Daily Precipitation, in.
30 August	85.9	0.00
31 August	87.1	0.00
1 September	86.5	0.00
2 September	85.1	0.00

3.3.2 Field Conditions

NRL surveyed the calibration grid, blind grid, and the indirect fire area of the open field. A few small puddles and wet areas from rain prior to testing were present.

3.3.3 Soil Moisture

Three soil probes were placed at various locations within the site to capture soil moisture data: blind grid, calibration, open field, and wooded areas. Measurements were collected in percent moisture and were taken twice daily (morning and afternoon) from five different soil depths (1 to 6 in., 6 to 12 in., 12 to 24 in., 24 to 36 in., and 36 to 48 in.) from each probe. Soil moisture logs are provided in Appendix C.

3.4 FIELD ACTIVITIES

3.4.1 Setup/Mobilization

These activities included initial mobilization and daily equipment preparation and breakdown. A five-person crew took 45 minutes to perform the initial setup and mobilization. A total of 1 hour and 45 minutes of equipment preparation was accrued, and end of day equipment breakdown totaled 45 minutes.

3.4.2 Calibration

NRL spent a total of 1 hour 30 minutes in the calibration lanes, of which 1 hour and 15 minutes were spent collecting data.

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 requirements (section 5) except for downtime due to demonstration site issues. Demonstration site issues, while noted in the daily log, are considered nonchargeable downtime for the purposes of calculating labor costs and are not discussed. Breaks and lunches are discussed in this section and billed to the total site survey area.

3.4.3.1 Equipment/data checks, maintenance. Equipment data checks and maintenance activities accounted for 3 hours and 55 minutes of site usage time. These activities included changing out batteries and performing routine data checks to ensure the data were being properly recorded/collected. NRL spent 1 hour and 30 minutes for breaks and lunches.

3.4.3.2 Equipment failure or repair. One equipment failure or repair occurred during this survey. On 30 August 2010, the system overheated due to warm outside temperatures. After 70 minutes, the system cooled and the survey continued. NRL rectified the overheating by placing ice packs on the data collection unit and changing them out once an hour, usually during downloading data.

3.4.3.3 Weather. No weather delays occurred during the survey.

3.4.4 Data Collection

TABLE 5. TOTAL TIME
NRL, SPENT PER AREA

Area	Time, hr/min
Blind grid	4 hours/40 minutes
Open field	-
Legacy	-
Direct fire	-
Indirect fire	12 hours/5 minutes
Challenge	-
Wooded	-
Mine Grid	-
Moguls	-

Note: Table 5 represents the total time spent in each area collecting data.

3.4.5 Demobilization

The NRL survey crew conducted a demonstration of the calibration, blind grid and indirect fire area. Demobilization occurred on 2 September 2010. On that day, it took the crew 35 minutes to break down and pack up their equipment.

3.5 PROCESSING TIME

NRL submitted the raw data from the demonstration activities on the last day of the demonstration, as required. The scoring submittal data were provided in 12 October 2010.

3.6 DEMONSTRATOR'S FIELD PERSONNEL

Dan Steinhurst
Glenn Harbaugh
Nagi Kadhr
Tom Bell
Jim Kingdon

3.7 DEMONSTRATOR'S FIELD SURVEYING METHOD

NRL collected the data on a point to point basis, stopping at each cell in the calibration and blind grid, also stopping at various positions in the indirect fire.

3.8 SUMMARY OF DAILY LOGS

Daily logs capture all field activities during this demonstration and are provided in Appendix D.

SECTION 4. TECHNICAL PERFORMANCE RESULTS

4.1 ROC CURVES USING ALL MUNITIONS CATEGORIES

The probability of detection for the response stage (P_d^{res}) and the discrimination stage (P_d^{disc}) versus their respective probability of clutter detection or probability of false positive within each area are shown in Figures 3 through 8. The probabilities plotted against their respective background alarm rate within each area are shown in Figures 9 through 14. 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 GT.

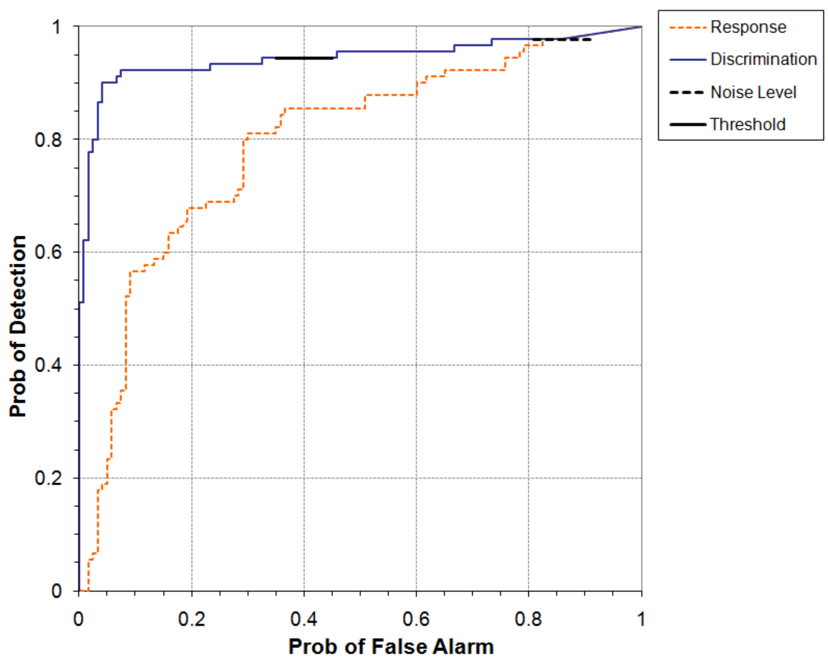


Figure 3. TEMTADS/pushcart blind grid probability of detection for response and discrimination stages versus their respective probability of false positive.

Not covered

Figure 4. TEMTADS/pushcart open field (direct fire) probability of detection for response and discrimination stages versus their respective probability of false positive.

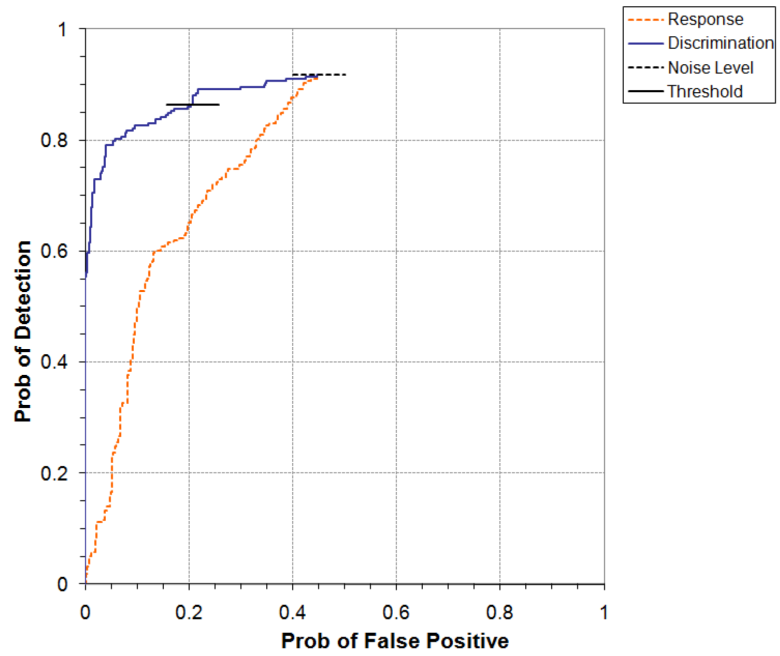


Figure 5. TEMTADS/pushcart open field (indirect fire) probability of detection for response and discrimination stages versus their respective probability of false positive.

Not covered

Figure 6. TEMTADS/pushcart open field (legacy) probability of detection for response and discrimination stages versus their respective probability of false positive.

Not covered

Figure 7. TEMTADS/pushcart wooded probability of detection for response and discrimination stages versus their respective probability of false positive.

Not covered

Figure 8. TEMTADS/pushcart mogul probability of detection for response and discrimination stages versus their respective probability of false positive.

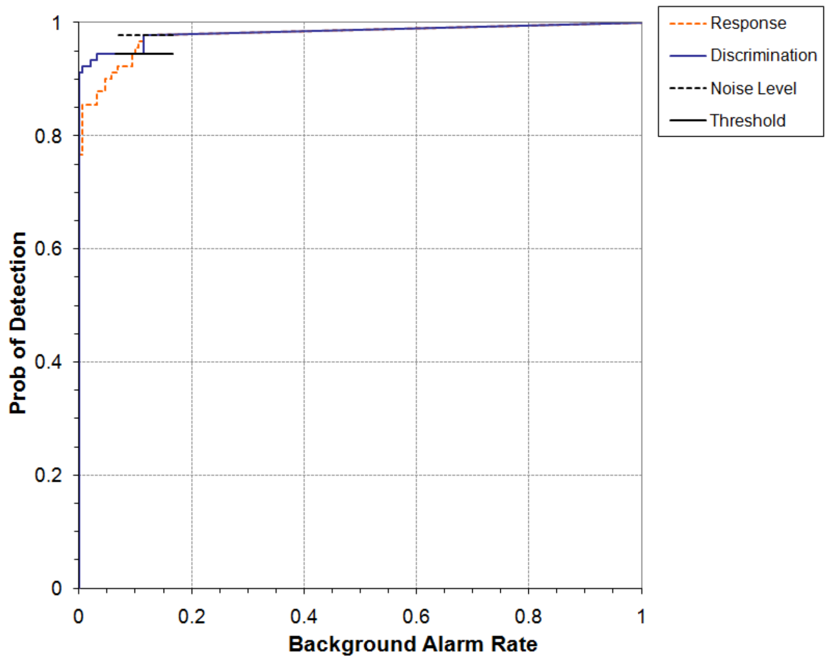


Figure 9. TEMTADS/pushcart blind grid probability of detection for response and discrimination stages versus their respective probability of background alarm.

Not covered

Figure 10. TEMTADS/pushcart open field (direct fire) probability of detection for response and discrimination stages versus their respective background alarm rate.

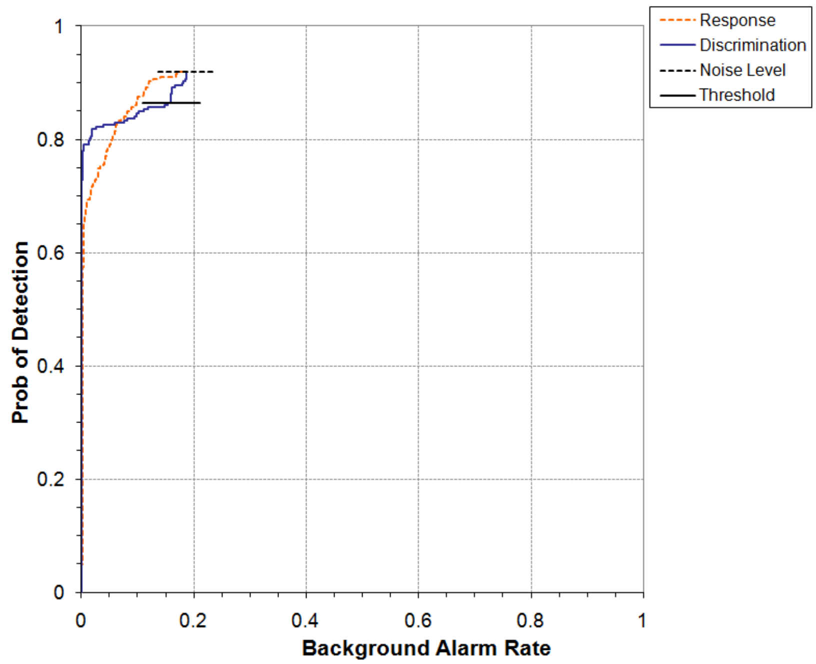


Figure 11. TEMTADS/pushcart open field (indirect fire) probability of detection for response and discrimination stages versus their respective background alarm rate.

Not covered

Figure 12. TEMTADS/pushcart open field (legacy) probability of detection for response and discrimination stages versus their respective background alarm rate.

Not covered

Figure 13. TEMTADS/pushcart wooded probability of detection for response and discrimination stages versus their respective background alarm rate.

Not covered

Figure 14. TEMTADS/pushcart mogul probability of detection for response and discrimination stages versus their respective background alarm rate.

4.2 PERFORMANCE SUMMARIES

Results for each of the testing areas are presented in Tables 6 (for labor requirements, see section 5). 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 munitions related cleanup by minimizing false alarm digs and maximizing munitions recovery. The lower and upper 90-percent confidence limits on P_d, P_{cd}, and P_{fp} were calculated assuming that the number of detections and false positives are binomially distributed random variables.

TABLE 6a. BLIND GRID TEST AREA RESULTS

	Response Stage				**Discrimination Stage**			
Munitions[a] Scores	P_d^{res}: ***by type***				P_d^{disc}: ***by type***			
	All Types	**105-mm**	**81/60-mm**	**37/25-mm**	**All Types**	**105-mm**	**81/60-mm**	**37/25-mm**
	0.99 0.98 0.94	1.00 0.97 0.88	1.00 0.97 0.88	1.00 1.00 0.93	0.97 0.94 0.90	0.96 0.90 0.79	1.00 0.97 0.88	1.00 0.97 0.88
By Depth[b]								
0 to 4D	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4D to 8D	1.00	1.00	1.00	1.00	0.90	0.50	1.00	0.95
8D to 12D	0.78	0.83	0.00	1.00	0.78	0.83	0.00	1.00
Clutter Scores	P_{cd}				P_{fp}			
By Mass								
By Depth[b]	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 8 kg**	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 8 kg**
All Depth	0.90 0.86 0.81	0.79	0.90	1.00	0.46 0.40 0.34	0.64	0.14	0.40
0 to 0.15 m	0.86	0.79	0.91	1.00	0.41	0.64	0.11	0.67
0.15 to 0.3 m	0.88	0.80	0.86	1.00	0.31	0.60	0.29	0.00
0.3 to 0.6 m	NA	NA	NA	NA	NA	NA	NA	NA
Background Alarm Rates								
	P_{ba}^{res}: 0.12				P_{ba}^{disc}: 0.12			

[a]In cells with offset data entries, the numbers to the left are the result and the two numbers to the right are an upper and lower 90-percent confidence interval for an assumed binomial distribution.

[b]All depths are measured to the center of the object.

TABLE 6b. OPEN FIELD DIRECT FIRE TEST AREA RESULTS (not covered)

Response Stage					Discrimination Stage			
Munitions[a] Scores	P_d^{res}: *by type*				P_d^{disc}: *by type*			
	All Types	**105-mm**	**81-mm**	**60-mm**	**All Types**	**105-mm**	**81-mm**	**60-mm**
	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --
By Density								
High	--	--	--	--	--	--	--	--
Medium	--	--	--	--	--	--	--	--
Low	--	--	--	--	--	--	--	--
By Depth[b]								
0 to 4D	--	--	--	--	--	--	--	--
4D to 8D	--	--	--	--	--	--	--	--
8D to 12D	--	--	--	--	--	--	--	--
Clutter Scores	P_{cd}				P_{fp}			
By Mass								
By Depth[b]	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 8 kg**	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 8 kg**
All Depth	-- -- --	--	--	--	-- -- --	--	--	--
0 to 0.15 m	--	--	--	--	--	--	--	--
0.15 to 0.3 m	--	--	--	--	--	--	--	--
0.3 to 0.6 m	--	--	--	--	--	--	--	--
Background Alarm Rates								
	BAR^{res}: --				**BAR^{disc}**: --			
Groups								
Found	--				--			
Identified	--				--			
Coverage	--				--			

[a]In cells with offset data entries, the numbers to the left are the result and the two numbers to the right are an upper and lower 90-percent confidence interval for an assumed binomial distribution.
[b]All depths are measured to the center of the object.

TABLE 6c. OPEN FIELD INDIRECT FIRE TEST AREA RESULTS

	Response Stage				**Discrimination Stage**			
Munitions[a] Scores	***P_d^{res}: by type***				***P_d^{disc}: by type***			
	All Types	**105-mm**	**81-mm**	**60-mm**	**All Types**	**105-mm**	**81-mm**	**60-mm**
	0.94 0.92 0.89	0.96 0.93 0.88	0.97 0.94 0.89	0.93 0.89 0.83	0.89 0.86 0.83	0.89 0.84 0.78	0.92 0.88 0.82	0.92 0.88 0.82
By Density								
High	0.88	0.96	0.86	0.80	0.81	0.85	0.77	0.80
Medium	0.93	0.93	0.93	0.93	0.89	0.87	0.89	0.90
Low	0.94	0.90	1.00	0.91	0.89	0.81	0.94	0.91
By Depth[b]								
0 to 4D	0.94	0.94	1.00	0.95	0.93	0.87	1.00	0.95
4D to 8D	0.91	0.97	0.90	0.79	0.79	0.84	0.77	0.71
8D to 12D	0.72	0.50	0.89	0.67	0.72	0.50	0.89	0.67
Clutter Scores	***P_{cd}***				***P_{fp}***			
By Mass								
By Depth[b]	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 8 kg**	**All Mass**	**0 to 0.25 kg**	**>0.25 to 1 kg**	**>1 to 8 kg**
All Depth	0.49 0.45 0.42	0.40	0.44	0.72	0.24 0.21 0.18	0.26	0.14	0.22
0 to 0.15 m	0.43	0.40	0.44	0.71	0.21	0.25	0.13	0.33
0.15 to 0.3 m	0.57	0.44	0.56	0.71	0.20	0.31	0.19	0.12
0.3 to 0.6 m	0.50	1.00	0.17	0.80	0.17	1.00	0.17	0.00
Background Alarm Rates								
	BAR^{res}: 0.19				**BAR^{disc}:** 0.16			
Groups								
Found	0.93				0.80			
Identified	0.33				0.13			
Coverage	0.62				0.46			

[a]In cells with offset data entries, the numbers to the left are the result and the two numbers to the right are an upper and lower 90-percent confidence interval for an assumed binomial distribution.
[b]All depths are measured to the center of the object.

TABLE 6d. OPEN FIELD LEGACY TEST AREA RESULTS (not covered)

	Response Stage					Discrimination Stage				
Munitions[a] Scores	P_d^{res}: *by type*					P_d^{disc}: *by type*				
	All Types	**Small**	**Medium**	**Large**		**All Types**	**Small**	**Medium**	**Large**	
	-- -- --	-- -- --	-- -- --	-- -- --		-- -- --	-- -- --	-- -- --	-- -- --	
By Depth[b]										
0 to 4D	--	--	--	--		--	--	--	--	
4D to 8D	--	--	--	--		--	--	--	--	
8D to 12D	--	--	--	--		--	--	--	--	
> 12D	--	--	--	--		--	--	--	--	
Clutter Scores	P_{cd}					P_{fp}				
By Mass										
By Depth[b]	**All Mass**	0 to 0.25 kg	**>0.25 to 1 kg**	**>1 to 10 kg**	**> 10 kg**	**All Mass**	0 to 0.25 kg	**>0.25 to 1 kg**	**>1 to 8 kg**	**< 10kg**
All Depth	-- -- --	--	--	--	--	-- -- --	--	--	--	--
0 to 0.15 m	--	--	--	--	--	--	--	--	--	--
0.15 to 0.3 m	--	--	--	--	--	--	--	--	--	--
0.3 to 0.6 m	--	--	--	--	--	--	--	--	--	--
> 0.6 m	--	--	--	--	--	--	--	--	--	--
Background Alarm Rates										
	BAR^{res}:					**BAR^{disc}:**				
Groups										
Found	--					--				
Identified	--					--				
Coverage	--					--				

[a]In cells with offset data entries, the numbers to the left are the result and the two numbers to the right are an upper and lower 90-percent confidence interval for an assumed binomial distribution.
[b]All depths are measured to the center of the object.

TABLE 6e. WOODED TEST AREA RESULTS (not covered)

	Response Stage				Discrimination Stage			
Munitions[a] Scores	***P_d^{res}: by type***				***P_d^{disc}: by type***			
	All Types	**Small**	**Medium**	**Large**	**All Types**	**Small**	**Medium**	**Large**
	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --
By Depth[b]								
0 to 4D	--	--	--	--	--	--	--	--
4D to 8D	--	--	--	--	--	--	--	--
8D to 12D	--	--	--	--	--	--	--	--
> 12D	--	--	--	--	--	--	--	--

Clutter Scores	***P_{cd}***					***P_{fp}***				
	By Mass									
By Depth[b]	**All Mass**	0 to 0.25 kg	**>0.25 to 1 kg**	**>1 to 10 kg**	**> 10 kg**	**All Mass**	0 to 0.25 kg	**>0.25 to 1 kg**	**>1 to 8 kg**	**< 10kg**
All Depth	-- -- --	--	--	--	--	-- -- --	--	--	--	--
0 to 0.15 m	--	--	--	--	--	--	--	--	--	--
0.15 to 0.3 m	--	--	--	--	--	--	--	--	--	--
0.3 to 0.6 m	--	--	--	--	--	--	--	--	--	--
> 0.6 m	--	--	--	--	--	--	--	--	--	--

Background Alarm Rates		
	BAR^{res}:	**BAR^{disc}:**

Groups								
Found	--				--			
Identified	--				--			
Coverage	--				--			

aIn cells with offset data entries, the numbers to the left are the result and the two numbers to the right are an upper and lower 90-percent confidence interval for an assumed binomial distribution.
bAll depths are measured to the center of the object.

TABLE 6f. MOGUL TEST AREA RESULTS (not covered)

	Response Stage				Discrimination Stage			
Munitions[a] Scores	***P_d^{res}: by type***				***P_d^{disc}: by type***			
	All Types	**Small**	**Medium**	**Large**	**All Types**	**Small**	**Medium**	**Large**
	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --	-- -- --
By Depth[b]								
0 to 4D	--	--	--	--	--	--	--	--
4D to 8D	--	--	--	--	--	--	--	--
8D to 12D	--	--	--	--	--	--	--	--
> 12D	--	--	--	--	--	--	--	--

Clutter Scores	***P_{cd}***					***P_{fp}***				
	By Mass									
By Depth[b]	**All Mass**	0 to 0.25 kg	**>0.25 to 1 kg**	**>1 to 10 kg**	**> 10 kg**	**All Mass**	0 to 0.25 kg	**>0.25 to 1 kg**	**>1 to 8 kg**	**< 10kg**
All Depth	-- -- --	--	--	--	--	-- -- --	--	--	--	--
0 to 0.15 m	--	--	--	--	--	--	--	--	--	--
0.15 to 0.3 m	--	--	--	--	--	--	--	--	--	--
0.3 to 0.6 m	--	--	--	--	--	--	--	--	--	--
> 0.6 m	--	--	--	--	--	--	--	--	--	--
	Background Alarm Rates									
	BAR^{res}:					**BAR^{disc}:**				
	Groups									
Found	--					--				
Identified	--					--				
Coverage	--					--				

[a]In cells with offset data entries, the numbers to the left are the result and the two numbers to the right are an upper and lower 90-percent confidence interval for an assumed binomial distribution.
[b]All depths are measured to the center of the object.

4.3 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 presented in Tables 7a through 7d.

TABLE 7a. BLIND GRID EFFICIENCY AND REJECTION RATES

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At operating point	0.97	0.53	0.04
With no loss of P_d	1.00	0.15	0.04

TABLE 7b. OPEN FIELD (DIRECT) EFFICIENCY AND REJECTION RATES (not covered)

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At operating point	-	-	-
With no loss of P_d	-	-	-

TABLE 7c. OPEN FIELD (INDIRECT) EFFICIENCY AND REJECTION RATES

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At operating point	0.94	0.54	0.15
With no loss of P_d	1.00	0.01	0.00

TABLE 7d. OPEN FIELD (LEGACY) EFFICIENCY AND REJECTION RATES (not covered)

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At operating point	-	-	-
With no loss of P_d	-	-	-

TABLE 7e. WOODED EFFICIENCY AND REJECTION RATES (not covered)

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At operating point	-	-	-
With no loss of P_d	-	-	-

TABLE 7f. MOGUL EFFICIENCY AND REJECTION RATES (not covered)

	Efficiency (E)	False Positive Rejection Rate	Background Alarm Rejection Rate
At operating point	-	-	-
With no loss of P_d	-	-	-

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

TABLE 8a. BLIND GRID CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS MUNITIONS

Size	Percentage Correct
25 mm	100
37 mm	93
60 mm	93
81 mm	73
105 mm	67
105 artillery	73
Overall	83

TABLE 8b. OPEN FIELD DIRECT FIRE CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS MUNITIONS (not covered)

Size	Percentage Correct
25 mm	-
37 mm	-
105 mm	-
Overall	-

TABLE 8c. OPEN FIELD INDIRECT FIRE CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS MUNITIONS

Size	Percentage Correct
60 mm	76
81 mm	76
105 mm	77
Overall	76

TABLE 8d. OPEN FIELD LEGACY CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS MUNITIONS (not covered)

Size	Percentage Correct
Small	-
Medium	-
Large	-
Overall	-

TABLE 8e. WOODED CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS MUNITIONS (not covered)

Size	Percentage Correct
Small	-
Medium	-
Large	-
Overall	-

TABLE 8f. MOGUL CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS MUNITIONS (not covered)

Size	Percentage Correct
Small	-
Medium	-
Large	-
Overall	-

4.4 LOCATION ACCURACY

The mean location error and standard deviations appear in Tables 9a through 9f. These calculations are based on average missed distance for munitions correctly identified during the response stage. Depths are measured from the center of the munitions to the surface. For the blind grid, only depth errors are calculated because (X, Y) positions are known to be the centers of the grid square.

TABLE 9a. BLIND GRID MEAN LOCATION ERROR AND STANDARD DEVIATION

	Mean	Standard Deviation
Northing	NA	NA
Easting	NA	NA
Depth	0.01	0.14

TABLE 9b. OPEN FIELD DIRECT FIRE MEAN LOCATION ERROR AND STANDARD DEVIATION (not covered)

	Mean	Standard Deviation
Northing	-	-
Easting	-	-
Depth	-	-

TABLE 9c. OPEN FIELD INDIRECT FIRE MEAN LOCATION ERROR AND STANDARD DEVIATION

	Mean	Standard Deviation
Northing	-0.02	0.10
Easting	0.03	0.09
Depth	0.00	0.17

TABLE 9d. OPEN FIELD LEGACY MEAN LOCATION ERROR AND STANDARD DEVIATION (not covered)

	Mean	Standard Deviation
Northing	-	-
Easting	-	-
Depth	-	-

TABLE 9e. WOODED MEAN LOCATION ERROR AND STANDARD DEVIATION (not covered)

	Mean	Standard Deviation
Northing	-	-
Easting	-	-
Depth	-	-

TABLE 9f. MOGUL MEAN LOCATION ERROR AND STANDARD DEVIATION (not covered)

	Mean	Standard Deviation
Northing	-	-
Easting	-	-
Depth	-	-

SECTION 5. 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 munitions item.

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

Military Munitions (MM): Specific categories of MM that may pose unique explosive safety risks, including UXO as defined in 10 USC 101(e)(5), DMM as defined in 10 USC 2710(e)(2) and/or munitions constituents (e.g., TNT, RDX) as defined in 10 USC 2710(e)(3) that are present in high enough concentrations to pose an explosive hazard.

Emplaced Munitions: A munitions item buried by the government at a specified location in the test site.

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

R_{halo}: A predetermined radius about an emplaced item (clutter or munitions) within which an anomaly identified by the demonstrator as being of interest is considered to be a detection of that item. For the purpose of this program, a circular halo 0.5 meters in radius is placed around the center of the object for all clutter and munitions items.

Small Munitions: Caliber of munitions less than or equal to 40 mm (includes 20-mm projectile, 25-mm projectile, 37-mm projectile, 40-mm projectile, submunitions BLU-26, BLU-63, and M42).

Medium Munitions: Caliber of munitions greater than 40 mm and less than or equal to 81 mm (includes 57-mm projectile, 60-mm mortar, 2.75-inch rocket, and 81-mm mortar).

Large Munitions: Caliber of munitions greater than 81 mm (includes 105-mm HEAT, 105-mm projectile, and 155-mm projectile).

Group: Two or more adjacent GT items with overlapping halos.

GT: Ground truth

Response Stage Noise Level: The level that represents the signal level 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 is expected to provide optimum performance of the system by retaining all detectable munitions 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: 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 clutter detection (P_{cd}) or probability of false positive (P_{fp}). Those that do not correspond to any known item are termed background alarms.

The response stage is a measure of whether the sensor can detect an object of interest. For a channel instrument, this value should be closely related to the amplitude of the signal. The demonstrator must report the response level (threshold) below which target responses are deemed insufficient to warrant further investigation. At this stage, minimal processing may be done. This includes filtering long- and short-scale variations, bias removal, and scaling. This processing should be detailed in the data submission.

For a multichannel instrument, the demonstrator must construct a quantity analogous to amplitude. The demonstrator should consider what combination of channels provides the best test for detecting any object that the sensor can detect. The average amplitude across a set of channels is an example of an acceptable response stage quantity. Other methods may be more appropriate for a given sensor. Again, minimal processing can be done, and the demonstrator should explain how this quantity was constructed in their data submission.

The discrimination stage evaluates the demonstrator's ability to correctly identify munitions 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 munitions. Thus, higher output values are indicative of higher confidence that a munitions 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 munitions 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.

GROUP SCORING FACTORS

Based on configuration of the GT at the standardized sites and the defined scoring methodology, there exists munitions groups defined as having overlapping halos. In these cases, the following scoring logic is implemented (fig. A-1 through A-9):

a. Overall site scores (i.e., P_d) will consider only isolated munitions and clutter items.

b. GT items that have overlapping halos (both munitions and clutter) will form a group and groups may form chains.

c. Groups will have a complex halos composed of all the composite halos of all its GT items.

d. Groups will have three scoring factors: groups found groups identified and group coverage. Scores will be based on 1:1 matches of anomalies and GT.

(1) Groups Found (Found): the number of groups that have one or more GT items matched divided by the total number of groups. Demonstrators will be credited with detecting a group if any item within the group is matched to an anomaly in their list.

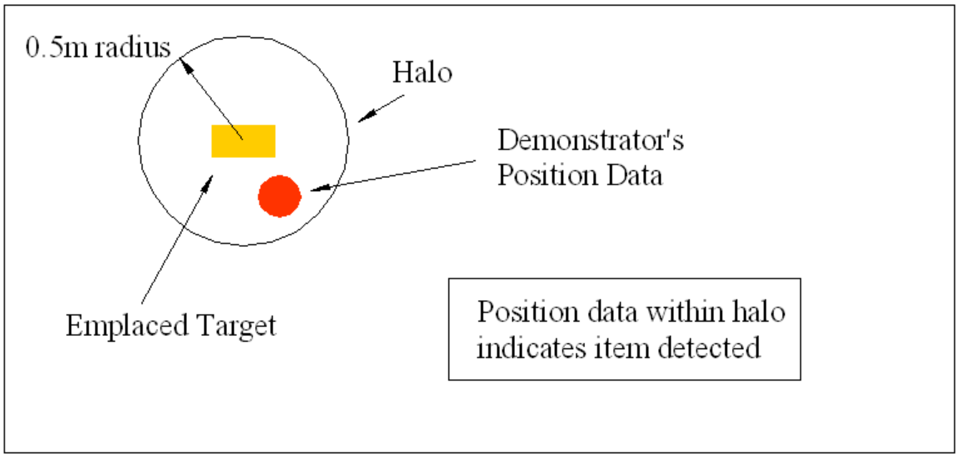
(2) Groups Identified (ID): the number of groups that have two or more GT items matched divided by the total number of groups. Demonstrators will be credited with identifying that a group is present if multiple items within the composite halo are matched to anomalies in their list.

(3) Group Coverage (Coverage): the number of GT items matched within groups divided by the total number of GT items within groups. This metric measures the demonstrator accuracy in determining the number of anomalies within a group. If five items are present and only two anomalies are matched, the demonstrator will score 0.4. If all five are matched the demonstrator will score 1.0.

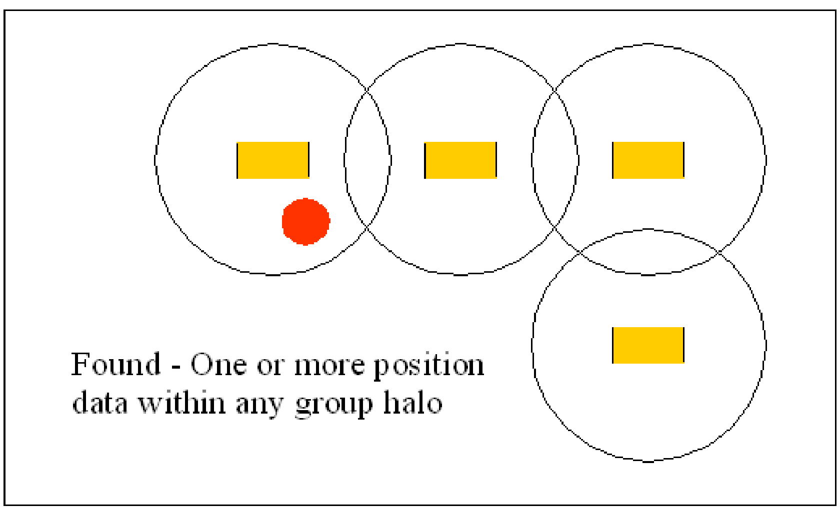
e. Location error will not be reported for groups.

f. Demonstrators will not be asked to call out groups in their scoring submissions. If multiple anomalies are indicated in a small area, the demonstrator will report all individual anomalies.

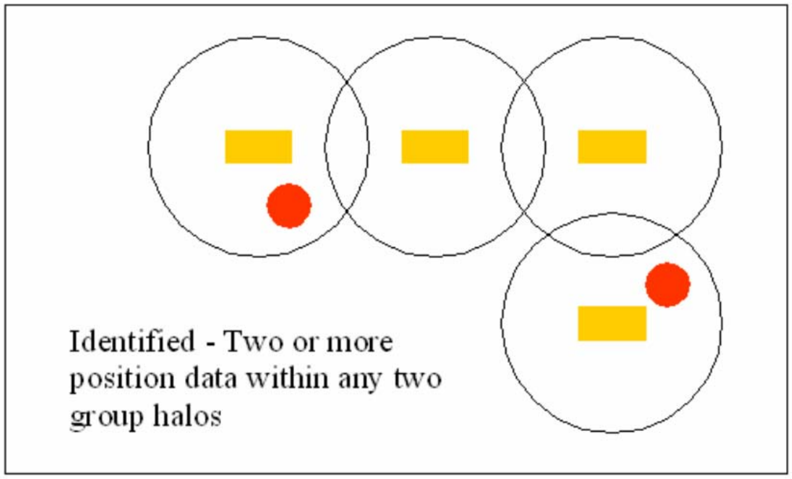
g. Excess alarms within a halo will be disregarded.



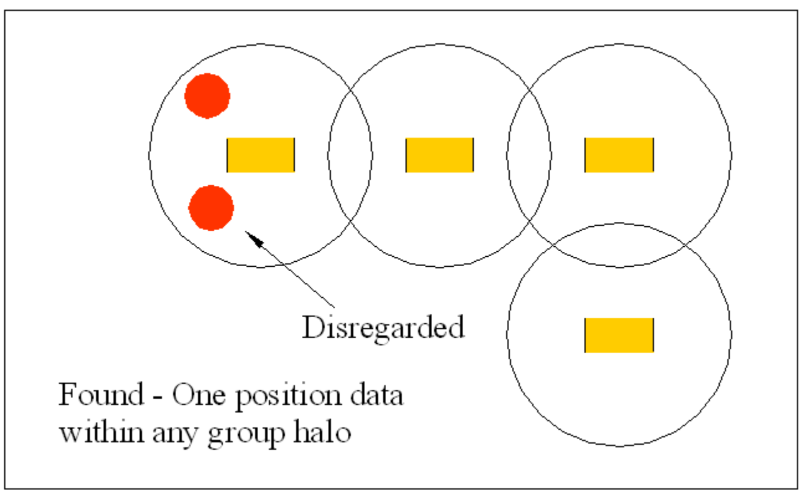
A-1. Example of detected item.



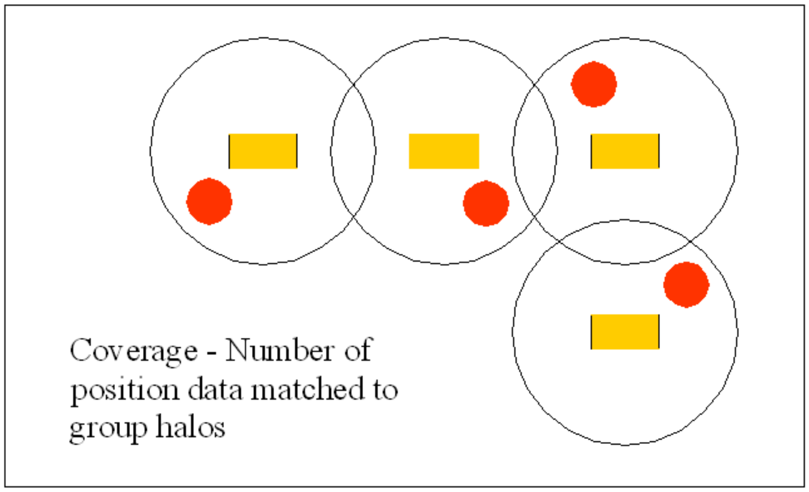
A-2. Example of group found (found).



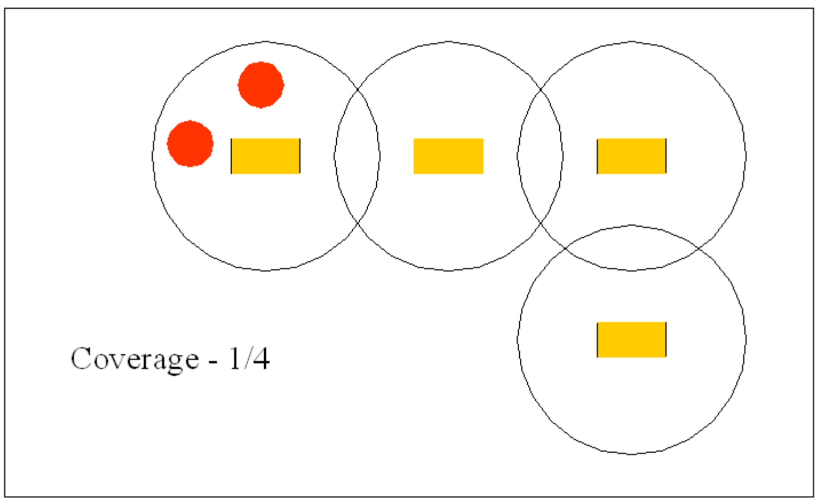
A-3. Example of group identified (ID).



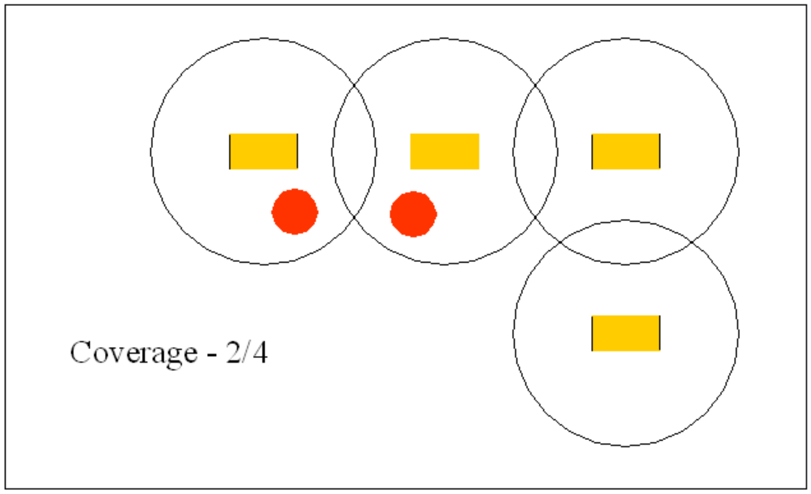
A-4. Example of excess alarms disregarded.



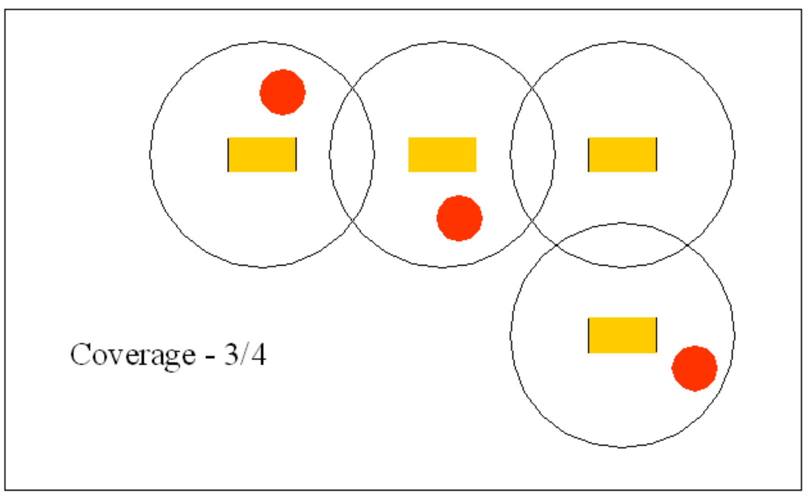
A-5. Example of a group.



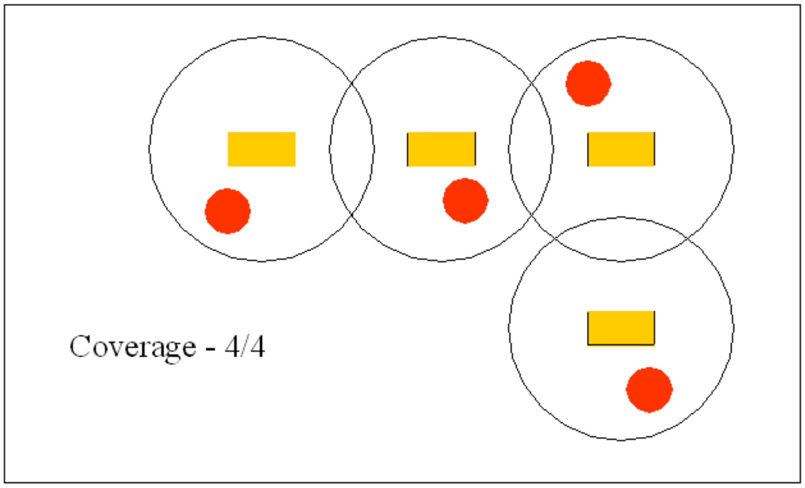
A-6. Example of group (1/4 = 0.25).



A-7. Example of group (2/4 = 0.5).



A-8. Example of group (3/4 = 0.75).



A-9. Example of group (4/4 = 1.0).

RESPONSE STAGE DEFINITIONS

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

Response Stage Clutter Detection (cd^{res}): An anomaly location that is within R_{halo} of an emplaced clutter item.

Response Stage Probability of Clutter Detection (P_{cd}^{res}): P_{cd}^{res} = (No. of response-stage clutter detections)/(No. of emplaced clutter items).

Response Stage Background Alarm (ba^{res}): An anomaly in a blind grid cell that contains neither emplaced munitions nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced munitions 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 any challenge area (including the direct and indirect firing sub areas) only: BAR^{res} = (No. of response-stage background alarms)/(arbitrary constant).

Note that the quantities P_d^{res}, P_{cd}^{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 $P_d^{res}(t^{res})$, $P_{cd}^{res}(t^{res})$, $P_{ba}^{res}(t^{res})$, and $BAR^{res}(t^{res})$.

DISCRIMINATION STAGE DEFINITIONS

Discrimination: The application of a signal processing algorithm or human judgment to sensor data to discriminate munitions from clutter. Discrimination should identify anomalies that the demonstrator has high confidence correspond to munitions, as well as those that the demonstrator has high confidence correspond to nonmunitions 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 munitions 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 munitions nor an emplaced clutter item. An anomaly location in the open field or scenarios that is outside R_{halo} of any emplaced munitions 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 CHARACTERISTIC (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 versus P_{cd} or P_{fp} and P_d versus 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] P_d versus P_{fp} and P_d versus BAR being combined into ROC curves are shown in Figure A-10. Note that the "res" and "disc" superscripts have been suppressed from all the variables for clarity.

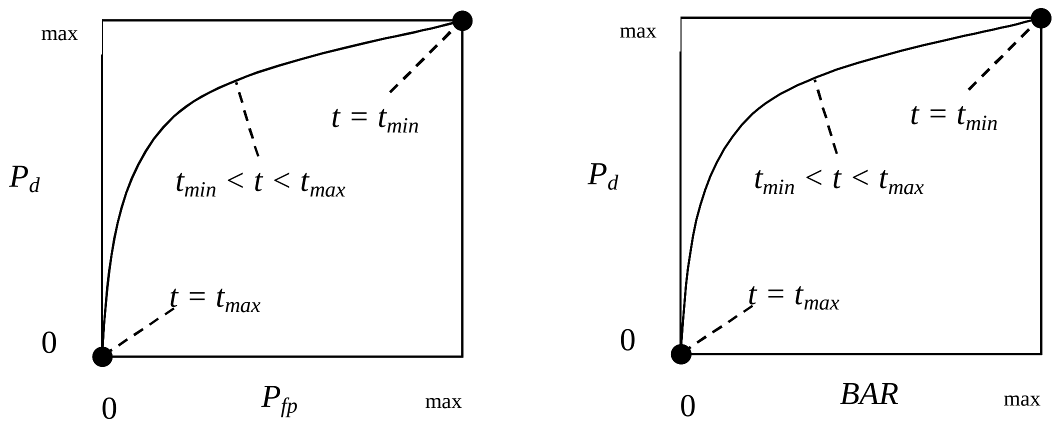


Figure A-10. ROC curves for open field testing. Each curve applies to both the response and discrimination stages.

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 munitions detections from the anomaly list while rejecting the maximum number of anomalies arising from nonmunitions items. The efficiency measures the fraction of detected munitions 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 munitions detectable by the sensor and its accompanying clutter detection rate/false positive rate or background alarm rate.

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[1]Strictly speaking, ROC curves plot the P_d versus P_{ba} over a predetermined and fixed number of detection opportunities (some of the opportunities are located over munitions 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.

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 munitions initially detected in the response stage were retained at the specified threshold in the discrimination stage, t^{disc}.

False Positive Rejection Rate (R_{fp}): $R_{fp} = 1 - [P_{fp}^{disc}(t^{disc})/P_{cd}^{res}(t_{min}^{res})]$: 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.

CHI-SQUARE COMPARISON

The Chi-square test for differences in probabilities (or 2 by 2 contingency table) is used to analyze two samples drawn from two different populations to see if both populations have the same or different proportions of elements in a certain category. More specifically, two random samples are drawn, one from each population, to test the null hypothesis that the probability of event A (some specified event) is the same for both populations.

The test statistic of the 2 by 2 contingency table is the Chi-square distribution with one degree of freedom. When an association between a more challenging terrain feature and relatively degraded performance is sought, a one-sided test is performed. A two-sided 2 by 2 contingency table is used in the Standardized UXO Technology Demonstration Site Program to compare performance between any two areas or subareas when the direction of degradation cannot be predetermined.

For a one-sided test, a significance level of 0.05 is used to set the critical decision limit. It is a critical decision limit because if the test statistic calculated from the data exceeds this value, then the lower proportion tested will be considered significantly less than the greater one (degraded). If the test statistic calculated from the data is less than this value, then no degradation can be said to exist because of the terrain feature introduced.

For a two-sided test, a significance level of 0.10 is used to allow 0.05 on either side of the decision. It is a critical decision limit because if the test statistic calculated from the data exceeds this value, then the two proportions tested will be considered significantly different. If the test statistic calculated from the data is less than this value, then the two proportions tested will be considered not significantly different.

An exception must be applied when either a 0 or 100 percent success rate occurs in the sample data. The Chi-square test cannot be used in these instances. Instead, Fischer's test is used, and the critical decision limit for one-sided tests is the chosen significance level, which in this case is 0.05. With Fischer's test, if the test statistic is less than the critical value, then the proportions are considered to be significantly different.

An example follows that illustrates Standardized UXO Technology Demonstration Site blind grid results compared to those from the open field legacy. It should be noted that a significant result does not prove a cause-and-effect relationship exists between the two populations of interest; however, it does serve as a tool to indicate that one data set has experienced a degradation or change in system performance at a large enough level than can be accounted for merely by chance or random variation. Note also that a result that is not significant indicates that there is not enough evidence to declare that anything more than chance or random variation within the same population is at work between the two data sets being compared.

Demonstrator X achieves the following overall results after surveying the blind grid and open field (legacy) using the same system (results indicate the number of munitions detected divided by the number of munitions emplaced):

	Blind grid	Open field
P_d^{res}	100/100 = 1.0	8/10 = .80

P_d^{res}: BLIND GRID versus OPEN FIELD (legacy). Using the example data above to compare probabilities of detection in the response stage, all 100 munitions out of 100 emplaced munitions items were detected in the blind grid while 8 munitions out of 10 emplaced were detected in the open field. Fischer's test must be used since a 100 percent success rate occurs in the data. Fischer's test uses the four input values to calculate a test statistic of 0.0075 that is compared against the critical value of 0.05. Since the test statistic is less than the critical value, the smaller response stage detection rate (0.80) is considered to be significantly less at the 0.05 level of significance. While a significant result does not prove a cause-and-effect relationship exists between the change in survey area and degradation in performance, it does indicate that the detection ability of demonstrator X's system seems to have been degraded in the open field relative to results from the blind grid using the same system. This is an example of a one-sided Chi-squared test.

APPENDIX B. DAILY WEATHER LOGS

Date, 10	Time, [a]EST	Average Temperature, °F	Total Precipitation, in.
30 Aug	0700	68.7	0.00
	0800	75.7	0.00
	0900	81.9	0.00
	1000	85.3	0.00
	1100	87.8	0.00
	1200	89.6	0.00
	1300	90.3	0.00
	1400	91.0	0.00
	1500	91.4	0.00
	1600	91.9	0.00
	1700	91.4	0.00
31 Aug	0700	68.4	0.00
	0800	75.2	0.00
	0900	83.7	0.00
	1000	88.0	0.00
	1100	90.5	0.00
	1200	92.3	0.00
	1300	93.4	0.00
	1400	92.8	0.00
	1500	91.9	0.00
	1600	91.9	0.00
	1700	90.5	0.00
1 Sep	0700	69.6	0.00
	0800	77.7	0.00
	0900	82.6	0.00
	1000	85.5	0.00
	1100	87.6	0.00
	1200	90.7	0.00
	1300	91.8	0.00
	1400	91.4	0.00
	1500	91.9	0.00
	1600	91.8	0.00
	1700	90.9	0.00
2 Sep	0700	75.4	0.00
	0800	78.8	0.00
	0900	81.7	0.00
	1000	83.8	0.00
	1100	85.1	0.00
	1200	86.7	0.00
	1300	88.2	0.00
	1400	89.1	0.00
	1500	89.1	0.00
	1600	89.4	0.00
	1700	88.7	0.00

[a]Eastern Standard Time.

APPENDIX C. SOIL MOISTURE

Date: 30 Aug 10			
Probe Location	**Layer, in.**	**A.M. Reading, %**	**P.M. Reading, %**
Wet area	0 to 6	-	-
	6 to 12	-	-
	12 to 24	-	-
	24 to 36	-	-
	36 to 48	-	-
Wooded area	0 to 6	-	-
	6 to 12	-	-
	12 to 24	-	-
	24 to 36	-	-
	36 to 48	-	-
Open area	0 to 6	-	5.4
	6 to 12	-	6.8
	12 to 24	-	8.8
	24 to 36	-	20.4
	36 to 48	-	21.7
Calibration lanes	0 to 6	12.1	-
	6 to 12	21.6	-
	12 to 24	22.4	-
	24 to 36	26.4	-
	36 to 48	35.2	-
Blind grid/moguls	0 to 6	9.7	9.6
	6 to 12	19.6	19.4
	12 to 24	22.4	22.3
	24 to 36	26.8	26.7
	36 to 48	31.4	31.4

Date: 31 Aug 10			
Probe Location	**Layer, in.**	**A.M. Reading, %**	**P.M. Reading, %**
Wet area	0 to 6	-	-
	6 to 12	-	-
	12 to 24	-	-
	24 to 36	-	-
	36 to 48	-	-
Wooded area	0 to 6	-	-
	6 to 12	-	-
	12 to 24	-	-
	24 to 36	-	-
	36 to 48	-	-
Open area	0 to 6	5.3	5.2
	6 to 12	6.7	6.7
	12 to 24	8.6	8.5
	24 to 36	20.2	20.1
	36 to 48	21.5	21.6
Calibration lanes	0 to 6	-	-
	6 to 12	-	-
	12 to 24	-	-
	24 to 36	-	-
	36 to 48	-	-
Blind grid/moguls	0 to 6	-	9.4
	6 to 12	-	19.2
	12 to 24	-	22.2
	24 to 36	-	26.4
	36 to 48	-	31.1

Date: 1 Sep 10			
Probe Location	**Layer, in.**	**A.M. Reading, %**	**P.M. Reading, %**
Wet area	0 to 6	-	-
	6 to 12	-	-
	12 to 24	-	-
	24 to 36	-	-
	36 to 48	-	-
Wooded area	0 to 6	-	-
	6 to 12	-	-
	12 to 24	-	-
	24 to 36	-	-
	36 to 48	-	-
Open area	0 to 6	5.1	5.0
	6 to 12	6.4	6.3
	12 to 24	8.2	8.1
	24 to 36	19.9	19.9
	36 to 48	21.4	21.3
Calibration lanes	0 to 6	-	-
	6 to 12	-	-
	12 to 24	-	-
	24 to 36	-	-
	36 to 48	-	-
Blind grid/moguls	0 to 6	-	-
	6 to 12	-	-
	12 to 24	-	-
	24 to 36	-	-
	36 to 48	-	-

Date: 2 Sep 10			
Probe Location	**Layer, in.**	**A.M. Reading, %**	**P.M. Reading, %**
Wet area	0 to 6	-	-
	6 to 12	-	-
	12 to 24	-	-
	24 to 36	-	-
	36 to 48	-	-
Wooded area	0 to 6	-	-
	6 to 12	-	-
	12 to 24	-	-
	24 to 36	-	-
	36 to 48	-	-
Open area	0 to 6	5.0	-
	6 to 12	6.1	-
	12 to 24	8.0	-
	24 to 36	19.7	-
	36 to 48	21.2	-
Calibration lanes	0 to 6	-	-
	6 to 12	-	-
	12 to 24	-	-
	24 to 36	-	-
	36 to 48	-	-
Blind grid/moguls	0 to 6	-	-
	6 to 12	-	-
	12 to 24	-	-
	24 to 36	-	-
	36 to 48	-	-

APPENDIX D. DAILY ACTIVITY LOGS

Date	No. of People	AreaTested	Status Start Time	Status Stop Time	Duration min.	Operational Status	Operational Status Comments	Track Method	Pattern	Field Conditions	
8/30/2010	5	CALIBRATION LANES	0745	0830	45	INITIAL SET-UP	INITIAL MOBILIZATION	GPS	POINTS	HOT DRY	SUNNY
8/30/2010	5	CALIBRATION LANES	0830	0945	75	COLLECTING DATA	COLLECT DATA	GPS	POINTS	HOT DRY	SUNNY
8/30/2010	5	CALIBRATION LANES	0945	1000	15	DOWNTIME DUE TO EQUIP MAINT/CHECK	DATA EQUIPMENT CHECK	GPS	POINTS	HOT DRY	SUNNY
8/30/2010	5	BLIND TEST GRID	1000	1235	155	COLLECTING DATA	COLLECT DATA	GPS	POINTS	HOT DRY	SUNNY
8/30/2010	5	BLIND TEST GRID	1235	1245	10	DOWNTIME DUE TO EQUIP MAINT/CHECK	DOWNLOAD DATA	GPS	POINTS	HOT DRY	SUNNY
8/30/2010	5	BLIND TEST GRID	1245	1410	85	COLLECTING DATA	COLLECT DATA	GPS	POINTS	HOT DRY	SUNNY
8/30/2010	5	BLIND TEST GRID	1410	1520	70	DOWNTIME DUE TO EQUIPMENT FAILURE	FAILURE, SYSTEM OVERHEATED, COOLED THEN PROCEEDED	GPS	POINTS	HOT DRY	SUNNY
8/30/2010	5	BLIND TEST GRID	1520	1550	30	COLLECTING DATA	COLLECT DATA	GPS	POINTS	HOT DRY	SUNNY
8/30/2010	5	OPEN FIELD	1550	1610	20	COLLECTING DATA	COLLECT DATA INDIRECT FIRE	GPS	POINTS	HOT DRY	SUNNY
8/30/2010	5	OPEN FIELD	1610	1620	10	DOWNTIME DUE TO EQUIP MAINT/CHECK	DOWNLOAD DATA	GPS	POINTS	HOT DRY	SUNNY
8/30/2010	5	OPEN FIELD	1620	1630	10	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	POINTS	HOT DRY	SUNNY
8/31/2010	5	OPEN FIELD	0735	0800	25	DAILY START, STOP	SET UP EQUIPMENT	GPS	POINTS	HOT DRY	SUNNY
8/31/2010	5	OPEN FIELD	0800	0855	55	COLLECTING DATA	COLLECT DATA INDIRECT FIRE	GPS	POINTS	HOT DRY	SUNNY
8/31/2010	5	OPEN FIELD	0855	0905	10	DOWNTIME DUE TO EQUIP MAINT/CHECK	DOWNLOAD DATA	GPS	POINTS	HOT DRY	SUNNY
8/31/2010	5	OPEN FIELD	0905	1020	75	COLLECTING DATA	COLLECT DATA INDIRECT FIRE	GPS	POINTS	HOT DRY	SUNNY
8/31/2010	5	OPEN FIELD	1020	1035	15	DOWNTIME DUE TO EQUIP MAINT/CHECK	DOWNLOAD DATA, CHANGE BATTERIES	GPS	POINTS	HOT DRY	SUNNY
8/31/2010	5	OPEN FIELD	1035	1130	55	COLLECTING DATA	COLLECT DATA INDIRECT FIRE	GPS	POINTS	HOT DRY	SUNNY
8/31/2010	5	OPEN FIELD	1130	1140	10	DOWNTIME DUE TO EQUIP MAINT/CHECK	DOWNLOAD DATA	GPS	POINTS	HOT DRY	SUNNY
8/31/2010	5	OPEN FIELD	1140	1245	65	BREAK/LUNCH	BREAK/LUNCH	GPS	POINTS	HOT DRY	SUNNY
8/31/2010	5	OPEN FIELD	1245	1340	55	COLLECTING DATA	COLLECT DATA INDIRECT FIRE	GPS	POINTS	HOT DRY	SUNNY
8/31/2010	5	OPEN FIELD	1340	1350	10	DOWNTIME DUE TO EQUIP MAINT/CHECK	DOWNLOAD DATA	GPS	POINTS	HOT DRY	SUNNY

Date	No. of People	AreaTested	Status Start Time	Status Stop Time	Duration min.	Operational Status	Operational Status Comments	Track Method	Pattern	Field Conditions	
8/31/2010	5	OPEN FIELD	1350	1435	45	COLLECTING DATA	COLLECT DATA INDIRECT FIRE	GPS	POINTS	HOT DRY	SUNNY
8/31/2010	5	OPEN FIELD	1435	1445	10	DOWNTIME DUE TO EQUIP MAINT/CHECK	DOWNLOAD DATA	GPS	POINTS	HOT DRY	SUNNY
8/31/2010	5	OPEN FIELD	1445	1600	75	COLLECTING DATA	COLLECT DATA INDIRECT FIRE	GPS	POINTS	HOT DRY	SUNNY
8/31/2010	5	BLIND TEST GRID	1600	1610	10	COLLECTING DATA	COLLECT DATA	GPS	POINTS	HOT DRY	SUNNY
8/31/2010	5	OPEN FIELD	1610	1615	5	DOWNTIME DUE TO EQUIP MAINT/CHECK	DOWNLOAD DATA	GPS	POINTS	HOT DRY	SUNNY
8/31/2010	5	OPEN FIELD	1615	1630	15	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	POINTS	HOT DRY	SUNNY
9/1/2010	5	OPEN FIELD	0735	0750	15	DAILY START, STOP	SET UP EQUIPMENT	GPS	POINTS	HOT DRY	SUNNY
9/1/2010	5	OPEN FIELD	0750	0845	55	COLLECTING DATA	COLLECT DATA INDIRECT FIRE	GPS	POINTS	HOT DRY	SUNNY
9/1/2010	5	OPEN FIELD	0845	0855	10	DOWNTIME DUE TO EQUIP MAINT/CHECK	DOWNLOAD DATA	GPS	POINTS	HOT DRY	SUNNY
9/1/2010	5	OPEN FIELD	0855	0950	55	COLLECTING DATA	COLLECT DATA INDIRECT FIRE	GPS	POINTS	HOT DRY	SUNNY
9/1/2010	5	OPEN FIELD	0950	1000	10	DOWNTIME DUE TO EQUIP MAINT/CHECK	DOWNLOAD DATA	GPS	POINTS	HOT DRY	SUNNY
9/1/2010	5	OPEN FIELD	1000	1100	60	COLLECTING DATA	COLLECT DATA INDIRECT FIRE	GPS	POINTS	HOT DRY	SUNNY
9/1/2010	5	OPEN FIELD	1100	1110	10	DOWNTIME DUE TO EQUIP MAINT/CHECK	DOWNLOAD DATA	GPS	POINTS	HOT DRY	SUNNY
9/1/2010	5	OPEN FIELD	1110	1130	20	COLLECTING DATA	COLLECT DATA INDIRECT FIRE	GPS	POINTS	HOT DRY	SUNNY
9/1/2010	5	OPEN FIELD	1130	1155	25	BREAK/LUNCH	BREAK/LUNCH	GPS	POINTS	HOT DRY	SUNNY
9/1/2010	5	OPEN FIELD	1155	1245	50	DOWNTIME DUE TO EQUIP MAINT/CHECK	DATA EQUIPMENT CHECK	GPS	POINTS	HOT DRY	SUNNY
9/1/2010	5	OPEN FIELD	1245	1410	85	COLLECTING DATA	COLLECT DATA INDIRECT FIRE	GPS	POINTS	HOT DRY	SUNNY
9/1/2010	5	OPEN FIELD	1410	1435	25	DOWNTIME DUE TO EQUIP MAINT/CHECK	DATA EQUIPMENT CHECK	GPS	POINTS	HOT DRY	SUNNY
9/1/2010	5	OPEN FIELD	1435	1535	60	COLLECTING DATA	COLLECT DATA INDIRECT FIRE	GPS	POINTS	HOT DRY	SUNNY
9/1/2010	5	OPEN FIELD	1535	1550	15	DOWNTIME DUE TO EQUIP MAINT/CHECK	DOWNLOAD DATA	GPS	POINTS	HOT DRY	SUNNY
9/1/2010	5	OPEN FIELD	1550	1610	20	DAILY START, STOP	EQUIPMENT BREAKDOWN	GPS	POINTS	HOT DRY	SUNNY

Date	No. of People	AreaTested	Status Start Time	Status Stop Time	Duration min.	Operational Status	Operational Status Comments	Track Method	Pattern	Field Conditions	
9/2/2010	5	OPEN FIELD	0740	0845	65	DAILY START, STOP	SET UP EQUIPMENT	GPS	POINTS	HOT DRY	SUNNY
9/2/2010	5	OPEN FIELD	0845	0855	10	COLLECTING DATA	COLLECT DATA INDIRECT FIRE	GPS	POINTS	HOT DRY	SUNNY
9/2/2010	5	OPEN FIELD	0855	0930	35	DOWNTIME DUE TO EQUIP MAINT/CHECK	DATA EQUIPMENT CHECK	GPS	POINTS	HOT DRY	SUNNY
9/2/2010	5	OPEN FIELD	0930	1005	35	DEMOBILIZATION	DEMOBILIZATION	GPS	POINTS	HOT DRY	SUNNY

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

APG	=	Aberdeen Proving Ground
ATC	=	U.S. Army Aberdeen Test Center
ATSS	=	Aberdeen Test Support Services
BAR	=	background alarm rate
DMM	=	discarded military munitions
EMI	=	electromagnetic interference
EQT	=	Environmental Quality Technology
ERDC	=	U.S. Army Corps of Engineers Engineering Research and Development Center
EST	=	Eastern Standard Time
ESTCP	=	Environmental Security Technology Certification Program
GPS	=	Global Positioning System
GT	=	ground truth
HDSD	=	Homeland Defense and Sustainment Division
HEAT	=	high-explosive antitank
JPG	=	Jefferson Proving Ground
MM	=	military munitions
NS	=	nonstandard munition
POC	=	point of contact
QA	=	quality assurance
QC	=	quality control
ROC	=	receiver-operating characteristic
S	=	standard munition
SAIC	=	Science Applications International Corporation
SCEMP	=	Simplified Combined EMI Magnetometer Prototype
SERDP	=	Strategic Environmental Research and Development Program
USAEC	=	U.S. Army Environmental Command
UXO	=	unexploded ordnance
YPG	=	U.S. Army Yuma Proving Ground

APPENDIX G. DISTRIBUTION LIST

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