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DTC PROJECT NO. 8-CO-160-UXO-021
REPORT NO. ATC 10435

# STANDARDIZED

# UXO TECHNOLOGY DEMONSTRATION SITE

# SCORING RECORD NO. 930b

SITE LOCATION:
ABERDEEN PROVING GROUND

DEMONSTRATOR:
LAWRENCE BERKELEY NATIONAL
LABORATORY (LBL)
ONE CYCLOTRON ROAD
MS-90R1116
BERKELEY, CA 94720

TECHNOLOGY TYPE/PLATFORM:
STATISTICAL APPROACH
EM/HANDHELD

AREA COVERED:
BLIND GRID

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

NOVEMBER 2010

Prepared for:
SERDP/ESTCP
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ARLINGTON, VA 22203

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

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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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# 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 (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

Address: Lawrence Berkeley National Laboratory (LBL)
One Cyclotron Road
MS-90R1116
Berkeley, CA 94720

#### 2.1.2 System Description (provided by demonstrator)

a. The hand-held UXO discriminator (fig. 1) employs three orthogonal transmitters and ten pairs of differenced receivers. Each vertical face of the cube has three induction coils, and two horizontal faces have four induction coils, each sensitive to the magnetic field component normal to the face. Receivers on opposite faces of the cube are paired along the symmetry lines through the center of the system and each pair sees identical fields during the on-time of current pulses in the transmitter coils. They are wired in opposition to produce zero output during the on-time of the pulses in three orthogonal transmitters. This configuration dramatically reduces noise in measurements by canceling background electromagnetic fields (these fields are uniform over the scale of the receiver array and are consequently nulled by the differencing operation), and by canceling noise contributed by the tilt of the receivers in the Earth's magnetic field, thus greatly enhances receivers' sensitivity to gradients of the target response. The hand-held UXO discriminator (14-in (0.35 m) cube) is able to discriminate small (20 mm) objects at a depth of 0.45 m and large (105 and 155 mm) objects at the depth of 0.85 m and detect them down to 1.15 m.

b. Data acquisition is performed on a single board. The transmitter coils are powered separately from the data acquisition board. Pulsers provide resonant circuit switching to create bi-polar half-sine pulses of 300 ms width. The current has a ~40 A peak and a resonant circuit voltage of ~400 Volts, and the operational overall half-sine duty cycle is ~12%. Transients are digitized with a sampling interval of 4 µs. The sensors are critically damped 5-inch coils with a self-resonant frequency of 75 kHz. The data acquisition board has 12 high-speed ADC channels for output. Ten of these channels are used for the signal from receiver coils, and the remaining two channels provide information about the system (i.e. tilt information, transmitter current).

c. The hand-held UXO discriminator will be operated in the cued mode. The system will be brought to marked locations and run in the characterization/discrimination mode. The three discriminating polarizability responses along with the object depth and horizontal location with respect to the center of the bottom plane of the cube will be recorded and visually presented on the computer screen. Additional values recorded with each location are S/N ratio described below, and polarizability index, which is an average value of the product of time (in seconds) and polarizability rate (in $m^3/s$) over the 46 sample times logarithmically spaced from 80 to 1460 μs.

Figure 1. LBL EM/handheld.

c. Support equipment required. The equipment and supplies will be shipped to the test site. Personnel will fly and then drive to the site in rented vehicles. Equipment will be stored in a support building provided by the host facility or in our truck/storage containers. Batteries will be charged overnight in the support building.

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

a. The first step prior to data collection is a system calibration and a background level estimation. LBL measure the background noise with transmitters in off-position, and then we turn the transmitters on and measure the background field on all channels. This step is repeated at least twice to make sure the background field is stable and can be used as the baseline measurements that will be subtracted from the data. The next step is to take data over several calibration targets.

b. Ten channels of field data are recorded at a rate of 250 k-samples/second for each of three transmitters. Field data are stacked together in a field programmable gate array (FPGA) and transferred to a field computer (laptop) forming a primitive stack. An even number of primitive stacks is averaged together to form stacked data for further processing. The peak transmitter current is estimated from the stacked transmitter current channel record, and the data are normalized by that value. Nominal transmitter shut-off time is estimated, and induction responses are computed at 46 logarithmically spaced times between 80 and 1460 μs, averaged in half-sine windows with widths 10% the center time after transmitter pulse shut-off. Responses are differenced with background responses collected over an area(s) determined to be free of metallic objects. The resulting thirty channels of normalized responses are then inverted for candidate object position and principal polarizabilities as a function of time after transmitter shut-off.

c. Calibration Grid. The calibration grid is 44×24 m area with cells in 11×6 layout. Each cell is 4×4 m with plastic markers at each corner. In addition to these markers the APG group will mark all 66 centers with plastic flags. LBL will take measurements along the lines 2 m apart, with 2 m distance between the measurements on each line. Soundings will be differenced with background reference soundings taken within the previous 30 to 40 minutes at a nearby site determined by the field operator to be free from metallic objects. An estimate of S/N will be made based on signal levels relative to median drift amounts recorded during the tests at our field test facility in California (RFS). The estimate is:

$$S/N = \frac{1}{\rho}\sum_{ijk}^{N}\rho\left(\frac{\left|S_{ijk}\right|}{N\ \mathrm{median}_{ijk}}\right)$$

where $\rho(r)$ is -1 times a log likelihood function estimated from median normalized system drifts between reference soundings taken before and after UXO soundings at our test facility, $S_{ijk}$ is the signal at the i'th time in the j'th receiver pair in response to the k'th transmitter, $\mathrm{median}_{ijk}$ is the median absolute value of drift for the ijk'th time receiver pair and transmitter combination in the stability measurements, N is the product of the number of receiver pairs (10), the number of transmitters (3), and the number of response time averages considered (46), and the summation is over receiver pairs transmitters and time average times. Frequent measurement of background reference soundings will allow evaluation of the system stability as configured at APG, and a subsequent re-evaluation of S/N levels in post-processing. This dataset (264 data points) will be used to produce the calibration grid S/N map. Sixty six responses measured at the center of each cell will be used as training data for the discrimination and identification of objects from the blind test grid. LBL will take additional sub-grid measurements around the cell center if recovered polarizabilities significantly depart from a nominal response of the object in that cell or S/N is too low. LBL will also experiment with the distance of the sensor cube to the object and find out how far from the system an object can be, and still be reliably discriminated.

d. Blind Test Grid. Soundings will be collected at centers of test grid cells (400 opportunities), and at 0.15 m before and 0.15 m after cell centers along survey lines, with the system oriented in a single direction. Soundings will be differenced with background reference soundings taken within the previous 30 to 40 minutes at a nearby site determined by the field operator to be free from metallic objects. An estimate of S/N will be calculated as described above. Cells with S/N values greater than 4 will be considered occupied. When S/N values are over 400 the system will be raised 0.25 m or 0.4 m to reduce the S/N below 400 and the measurements repeated.

e. When polarizability inversions from soundings taken at a common height agree in appearance, then the sounding nearest laterally to the interpreted object will be used for discrimination. Otherwise, provided that the central sounding has S/N larger than four, eight additional soundings will be acquired, at 0.3 m and 0.5 m offset on the arms of a cross centered on the cell center. When polarizability inversions from the soundings agree in appearance then the sounding nearest to the interpreted object will be used for discrimination. When a sub-set of inversions agree in appearance then the sub-set member closest to the interpreted object will be used for discrimination. When polarizability inversions from all soundings in a cell are of disparate appearance, multi-site inversion will be performed on the soundings, and if it fits the data to better than 50% at the site closest to the interpreted object, the resultant dipole polarizabilities will be used for discrimination, otherwise data from this cell will be considered as "can't analyze." Similarly, any sounding with an estimated S/N below 6, which our discrimination procedure estimates to be scrap, will be considered as "can't analyze." Again, frequent measurement of background reference soundings will allow evaluation of the system stability, and a subsequent re-evaluation of S/N levels in post-processing.

f. Principal polarizabilities from the soundings that have been selected for analysis will be analyzed using a variant of the empirical likelihood ratio method (outlined in Gasperikova, et al. 2009). In the empirical likelihood ratio method, probability densities of principal polarizability responses are estimated from training data from previously collected UXO responses and previously collected scrap responses separately.

g. LBL condense each polarizability response down to a set of $n_{feat} = 10$ numbers, nine of which are averages of products of major, intermediate, and minor principal polarizabilities with time, in three time bands. The logarithm of their vector magnitude is used as the tenth parameter, and the first nine values are normalized by that magnitude. Parameter vectors of this form are differenced with the vector of their component median values over the training data for their class (UXO or scrap) for use in forming damped trimmed covariance matrices $C^{uxo}$ and $C^{scrap}$, for UXO and scrap responses, which are used in forming the empirical probability densities for UXO and scrap training data.

h. The empirical densities for polarizability responses of UXO and scrap are formed by centering a generalized Cauchy density at each of the different polarizability responses from the class and summing over the responses from the class. The generalized Cauchy density that is used for a class is based on the damped trimmed estimate of the response covariance matrix for the class $C^{class}$, with length scale reduced by a factor of $(n^{class})^{-1/n_{feat}}$, so that the contribution from each response fills $1/n^{class}$ of the volume occupied by the whole distribution, where $n^{class}$ is the number of responses being summed over to form the density estimate. The overall form is:

$$f^{(class)}(v_j^{(class)}) = K \sum_{i \, in \, class} \frac{1}{\left[1 + (v_j^{(class)} - v_i^{(class)})^t (C^{(class)})^{-1} (v_j^{(class)} - v_i^{(class)}) \gamma (n^{(class)})^{2/n_{feat}}\right]^{m^{(class)}/2}}$$

where $\gamma = 0.2986/m^{class}$, and $v_j$ is the vector point where the density is being evaluated, $v_i$ are the training response vectors the density is based on, and K is:

$$K = \frac{1}{2}\left(\frac{\gamma}{\pi}\right)^{n_{feeat}/2} \frac{\Gamma(m^{class}/2)}{\Gamma(m^{class} - n_{feat}/2)} (\det(C^{(class)}))^{-1/2}$$

where $\Gamma()$ is the gamma function, and $m^{class}$ is a parameter which is adjusted using cross validation to maximize the likelihood of the training data.

i. The probability that a response vector $v_j$ is due to UXO is:

$$p^{(uxo)}(v_j) = \frac{\alpha_{uxo}^2 f^{(uxo)}(v_j)}{\alpha_{uxo}^2 f^{(uxo)}(v_j) + \alpha_{scrap}^2 f^{(scrap)}(v_j)}$$

where $\alpha^2_{uxo}$ and $\alpha^2_{scrap}$ are a priori relative probabilities of UXO and scrap, and only the ratio of $\alpha^2_{uxo}/\alpha^2_{scrap}$ is significant.

j. In artillery ranges where no cleanup has been done, assuming a dud rate of 0.1 and that ordnance is blown into five detectable pieces, a reasonable value for $\alpha^2_{uxo}/\alpha^2_{scrap}$ would be 0.02. However, in a small test grid, constructed to emphasize the ability of equipment to discriminate between UXO and scrap, it is reasonable to emplace a much higher ratio of UXO to scrap, such as 1:1, which would suggest using a value of $\alpha^2_{uxo}/\alpha^2_{scrap} = 1$. In our 2006 survey at the YPG blind test grid LBL estimated there were 230 occupied cells and 183 UXO, yielding a UXO/scrap ratio of 183/47 suggesting using $\alpha^2_{uxo}/\alpha^2_{scrap} = 3.89$. Using this value, all responses with $p^{(uxo)}(v_j) \geq 0.0005$ will be considered UXO. Probabilities estimated using the empirical likelihood ratio discrimination method tend to vary by orders of magnitude so the exact value of $\alpha^2_{uxo}/\alpha^2_{scrap}$ will probably only affect four to six objects with $p^{(uxo)}$ near the cut-off value.

k. Just as UXO and scrap class polarizability response densities are estimated, LBL estimate densities for the polarizability responses of different types of UXO. However, due to the limited number of responses of individual UXO in our response library, LBL use the overall UXO trimmed covariance matrix estimate $C^{uxo}$ in place of individual UXO type covariance matrices in their estimated distributions. Similarly, for individual UXO types, in the generalized Cauchy density formula for the exponent $m^{class}$ LBL use the exponent estimated for the overall distribution of UXO responses $m^{uxo}$. Given empirical distributions $f^{class\_k}(v_j)$ for classes class_k, and a priori expectations of relative frequencies $\alpha^2_{class\_k}$ for the different classes, the probability that a response is from an object in class_q is:

$$p^{(class\_q)}(v_j) = \frac{\alpha^2_{class\_q} f^{(class\_q)}(v_j)}{\sum_k \alpha^2_{class\_k} f^{(class\_k)}(v_j)}$$

Here, scrap is included as one of the classes in the denominator. For want of prior expectations as to the expected relative frequency of different UXO types, the different $\alpha^2_{class\_k}$ are taken to be equal for all the classes except for scrap, and the sum of $\alpha^2_{class\_k}$ over UXO classes is equal to the $\alpha^2_{uxo}$ above.

l. Training Data. The empirical densities for UXO and scrap classes are formed based on training data. For the UXO class training data will include polarizability responses collected over UXO at the local test facility and the APG calibration grid. Both sets contain responses from 14 different munitions types (from 20 mm projectile to 155 mm projectile) buried at various orientations and depths. These responses are considered reliable from 80 µs to 1460 µs. These will be supplemented with an approximately equal number of additional UXO polarizability responses previously collected using the cart-mounted system (BUD). Adding them to the training data will allow for better estimates of the densities of polarizability responses. For the scrap response class, responses from the APG calibration grid will be supplemented with BUD scrap responses from previous surveys at Camp Sibert, AL, and San Luis Obispo, CA. BUD responses are considered reliable from 140 µs to 1400 µs. To extend them to the window of hand-held prototype responses, least squares predictions of responses and suitable noise will be based on responses from original BUD time window, with prediction coefficients based on hand-held responses.

### 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)

Overview of Quality Assurance (QA): LBL will perform a discrimination survey of the calibration grid, and the blind test grid. The calibration grid is 44×24 m area with cells in 11×6 layout (A-K and 1-6). Each cell is 4×4 m with plastic markers at each corner. In addition to these markers the APG group will mark all 66 centers with plastic flags. LBL will take measurements along the lines 2 m apart, with 2 m distance between the measurements on each line. Soundings will be differenced with background reference soundings taken within the previous 30 to 40 minutes at a nearby site determined by the field operator to be free from metallic objects.

The blind test grid is 40×40 m area. The individual cells are 1×1 m with an empty 1×1 m cell in between. There are 400 opportunities/flags arranged in 20×20 layout (A-T and 1-20). All 400 points will be marked with a plastic pin flag. Soundings will be collected at centers of test grid cells (400 opportunities), and at 0.15 m before and 0.15 m after cell centers along survey lines, with the system oriented in a single direction. Soundings will be differenced with background reference soundings taken within the previous 30 to 40 minutes at a nearby site determined by the field operator to be free from metallic objects. An estimate of S/N will be calculated as described above. Cells with S/N values greater than 4 will be considered occupied. When S/N values are over 400 the system will be raised 0.25 m or 0.4 m to reduce the S/N below 400 and the measurements repeated. When polarizability inversions from soundings taken at a common height disagree in appearance, provided that the central sounding has S/N larger than four, eight additional soundings will be acquired, at 0.3 m and 0.5 m offset on the arms of a cross centered on the cell center.

Overview of Quality Control (QC): Both field data and inversion results are archived. The data are retained on a portable external disk, and the inversion results are retained both on the portable external disk and CD-ROM for archiving and distribution. Data quality control will be done by E. Gasperikova, the PI.

System background calibrations, which include establishing of a reference background level, will be done several times during the day. The calibration targets will be surveyed morning and evening of each data collection day to verify system operation. Data will be digitally recorded, checked for appropriate signal strength and noise levels, and inverted to verify consistency of parameter estimation.

### 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)*<br>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)*<br>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)*<br>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)*<br>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. |

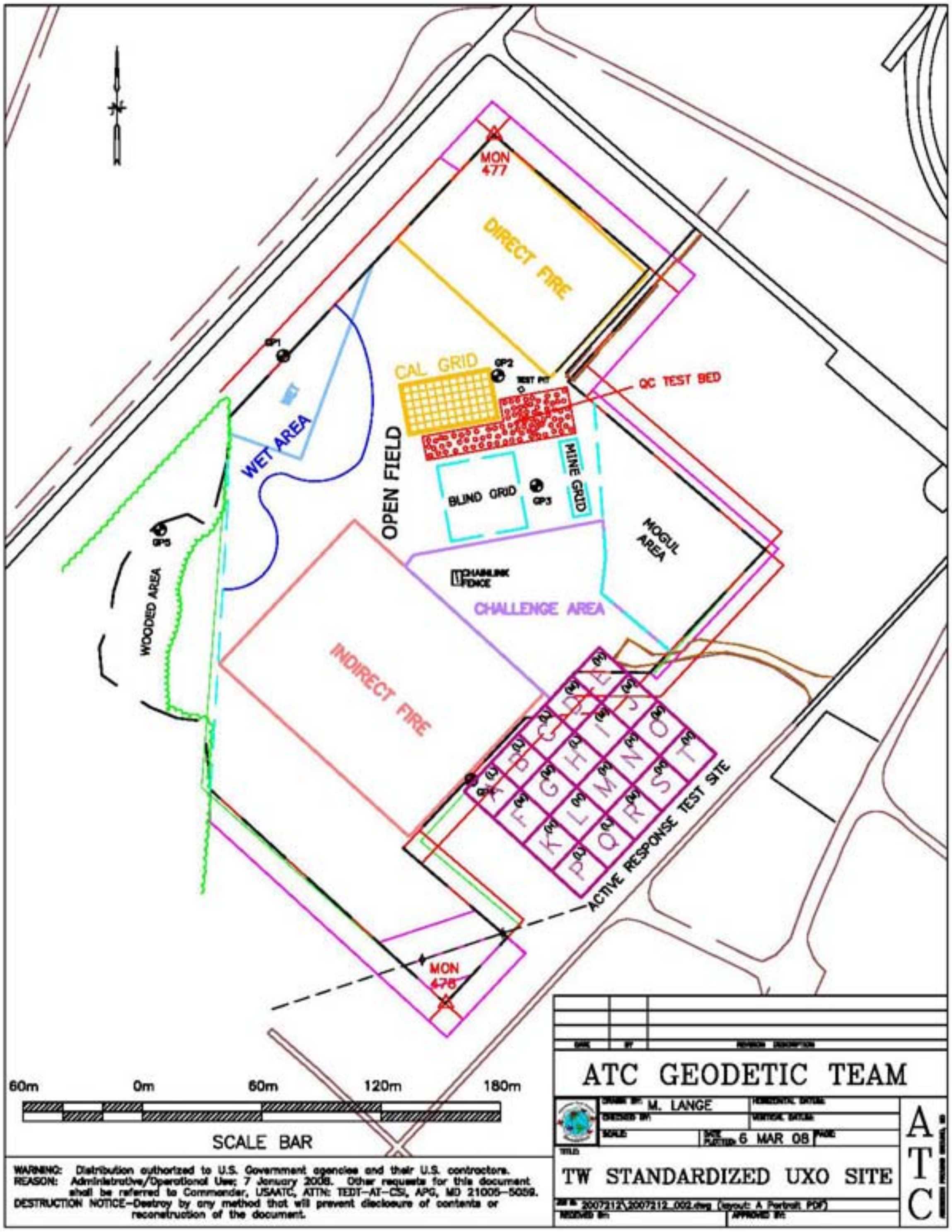



Figure 2. Test site layout.

### 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 |

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

## 2.3 ATC SURVEY COMMENTS

None.

## SECTION 3. FIELD DATA

### 3.1 DATE OF FIELD ACTIVITIES (21 through 26 and 28 through 30 June, and 1 Jul 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 | Number of Hours |
|---|---|
| Calibration lanes | 11.67 |
| Blind grid | 53.25 |
| Open field | NA |
| Woods | NA |
| Mogul | NA |
| Mine grid | NA |

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, 10 | Average Temperature, °F | Total Daily Precipitation, in. |
|---|---|---|
| 21 June | 85.5 | 0.00 |
| 22 June | 86.2 | 0.35 |
| 23 June | 89.1 | 0.00 |
| 24 June | 90.9 | 0.00 |
| 25 June | 83.1 | 0.00 |
| 26 June | 85.5 | 0.00 |
| 28 June | 86.8 | 0.10 |
| 29 June | 85.9 | 0.00 |
| 30 June | 73.9 | 0.00 |
| 1 July | 73.4 | 0.00 |

### 3.3.2 Field Conditions

LBL surveyed the calibration grid and blind grid areas. The field was mainly dry due to conditions prior to and during testing.

### 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 three-person crew took 5 hours and 25 minutes to perform the initial setup and mobilization. A total of 6 hour 55 minutes of equipment preparation was accrued, and end of day equipment breakdown totaled 1 hour and 5 minutes.

### 3.4.2 Calibration

LBL spent a total of 11 hours and 40 minutes in the calibration lanes, of which 8 hours and 5 minutes was spent collecting data. A number of calibration events occurred while surveying the Blind Grid. These events totaled 45 minutes.

### 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 2 hours and 45 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. LBL spent 4 hours and 35 minutes for breaks and lunches.

**3.4.3.2 Equipment failure or repair.** One equipment failure occurred during this survey. A fuse had blown. LBL troubleshot this problem for 8 hours and 15 minutes no additional problems occurred.

**3.4.3.3 Weather.** No weather delays occurred during the survey.

### 3.4.4 Data Collection

**TABLE 5. TOTAL TIME**
**LBL, SPENT PER AREA**

| Area | Time, hr/min |
|---|---|
| Blind grid | 28 hours, 15 minutes |
| Open field | NA |
| Legacy | NA |
| Direct fire | NA |
| Indirect fire | NA |
| Challenge | NA |
| Wooded | NA |
| Mine Grid | NA |
| Moguls | NA |

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

### 3.4.5 Demobilization

The LBL survey crew conducted a demonstration of the calibration grid and blind grid. Demobilization occurred on 1 July 2010. On that day, it took the crew 3 hours and 30 minutes to break down and pack up their equipment.

## 3.5 PROCESSING TIME

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

## 3.6 DEMONSTRATOR'S FIELD PERSONNEL

Erika Gasperikova, Karl Kappler, Vamsi Vytla, Alessandro Ratti, and Matthew Stettler.

## 3.7 DEMONSTRATOR'S FIELD SURVEYING METHOD

LBL collected the data on a point to point basis. All calibration and blind grid points were surveyed in prior to testing.

## 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.

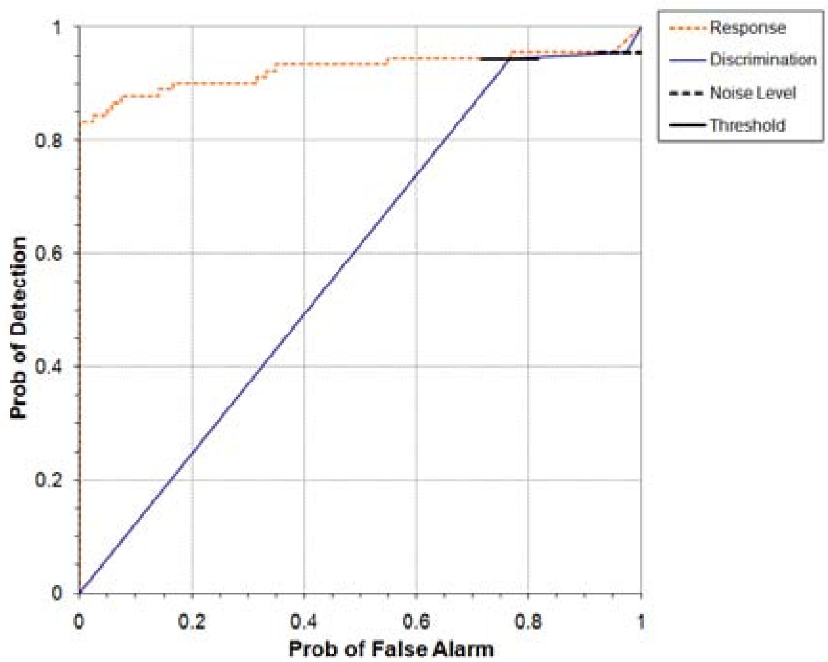



Figure 3. EM/handheld blind grid probability of detection for response and discrimination stages versus their respective probability of false positive.

Not reported

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

Not reported

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

Not reported

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

Not reported

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

Not reported

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

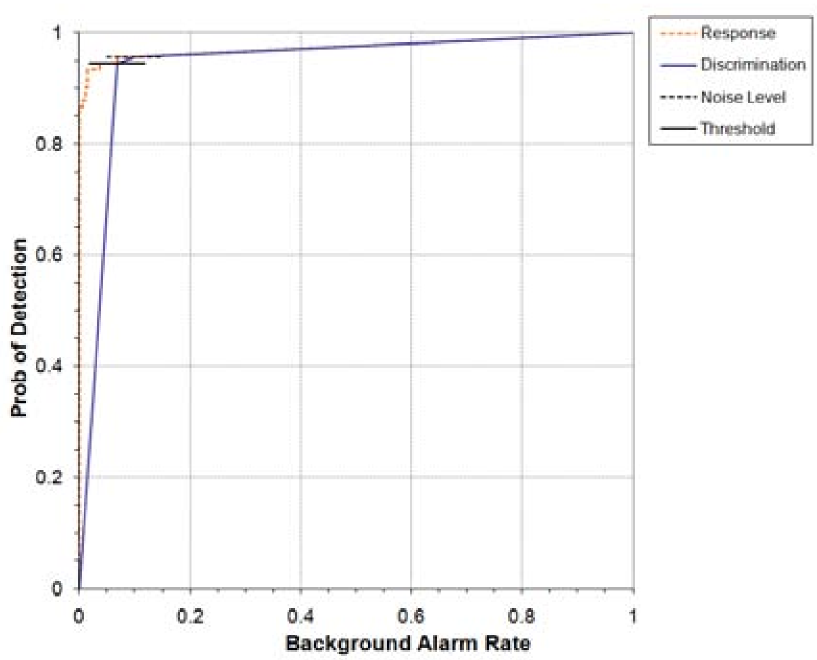



Figure 9. EM/handheld blind grid probability of detection for response and discrimination stages versus their respective probability of background alarm.

Not reported

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

Not reported

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

Not reported

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

Not reported

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

Not reported

Figure 14. EM/handheld 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. All results in Table 6a through 6f have been rounded to protect the GT. However, lower confidence limits were calculated using actual results.

## TABLE 6a. BLIND GRID TEST AREA RESULTS

| | Response Stage | | | | Discrimination Stage | | | |
|---|---|---|---|---|---|---|---|---|
| [a]Munitions 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** |
| | 0.98 | 0.96 | 1.00 | 1.00 | 0.97 | 0.94 | 1.00 | 1.00 |
| | 0.96 | 0.90 | 0.97 | 1.00 | 0.94 | 0.87 | 0.97 | 1.00 |
| | 0.91 | 0.79 | 0.88 | 0.93 | 0.90 | 0.75 | 0.88 | 0.93 |
| | | | | [b]*By Depth* | | | | |
| **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 | 1.00 | 1.00 | 1.00 | 1.00 |
| **8D to 12D** | 0.56 | 0.50 | 0.00 | 1.00 | 0.44 | 0.33 | 0.00 | 1.00 |
| Clutter Scores | $P_{cd}$ | | | | $P_{fp}$ | | | |
| | | | | *By Mass* | | | | |
| [b]*By Depth* | **All Mass** | **0 to 0.25 kg** | **>0.25 to 1 kg** | **>1 to 10 kg** | **All Mass** | **0 to 0.25 kg** | **>0.25 to 1 kg** | **>1 to 10 kg** |
| **All Depth** | 0.99 | | | | 0.82 | | | |
| | 0.98 | 0.95 | 1.00 | 1.00 | 0.77 | 0.71 | 0.79 | 1.00 |
| | 0.95 | | | | 0.71 | | | |
| **0 to 0.15 m** | 0.98 | 0.96 | 1.00 | 1.00 | 0.77 | 0.74 | 0.78 | 1.00 |
| **0.15 to 0.3 m** | 0.94 | 0.80 | 1.00 | 1.00 | 0.75 | 0.40 | 0.86 | 1.00 |
| **0.3 to 0.6 m** | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | | | | Background Alarm Rates | | | | |
| | **$P_{ba}^{res}$:** 0.10 | | | | **$P_{ba}^{disc}$:** 0.07 | | | |

[a]The two numbers to the right of the all types munitions result are an upper and lower 90 percent confidence level 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 reported)

| | Response Stage | | | | Discrimination Stage | | | |
|---|---|---|---|---|---|---|---|---|
| [a]Munitions Scores | **$P_d^{res}$: *by type*** | | | | **$P_d^{disc}$: *by type*** | | | |
| | **All Types** | **105-mm** | **37-mm** | **25-mm** | **All Types** | **105-mm** | **37-mm** | **25-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* | | | | | | | | |
| [b]*By Depth* | **All Mass** | **0 to 0.25 kg** | **>0.25 to 1 kg** | **>1 to 10 kg** | **All Mass** | **0 to 0.25 kg** | **>0.25 to 1 kg** | **>1 to 10 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]Note: The two numbers to the right of the all types munitions result are an upper and lower 90 percent confidence level 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 (not reported)

| | Response Stage | | | | Discrimination Stage | | | |
|---|---|---|---|---|---|---|---|---|
| [a]Munitions 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* | | | | | | | | |
| [b]*By Depth* | **All Mass** | **0 to 0.25 kg** | **>0.25 to 1 kg** | **>1 to 10 kg** | **All Mass** | **0 to 0.25 kg** | **>0.25 to 1 kg** | **>1 to 10 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]Note: The two numbers to the right of the all types munitions result are an upper and lower 90 percent confidence level 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 reported)

| | Response Stage | | | | | Discrimination Stage | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| [a]Munitions 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* | | | | | | | | | | |
| [b]*By Depth* | **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]Note: The two numbers to the right of the all types munitions result are an upper and lower 90 percent confidence level for an assumed binomial distribution.

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

## TABLE 6e. WOODED TEST AREA RESULTS (not reported)

| | Response Stage | | | | Discrimination Stage | | | |
|---|---|---|---|---|---|---|---|---|
| [a]Munitions 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* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| [b]*By Depth* | **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]Note: The two numbers to the right of the all types munitions result are an upper and lower 90 percent confidence level for an assumed binomial distribution.

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

## TABLE 6f. MOGUL TEST AREA RESULTS (not reported)

| | Response Stage | | | | Discrimination Stage | | | |
|---|---|---|---|---|---|---|---|---|
| [a]Munitions 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* | | | | | | | | | |
| [b]*By Depth* | **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]Note: The two numbers to the right of the all types munitions result are an upper and lower 90 percent confidence level 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: one at the point where no decrease in $P_d$ is suffered (i.e., the efficiency is by definition equal to one) and the other at the operator selected threshold. These values are presented in Tables 7a through 7f.

**TABLE 7a. BLIND GRID EFFICIENCY AND REJECTION RATES**

| | Efficiency (E) | False Positive Rejection Rate | Background Alarm Rejection Rate |
|---|---|---|---|
| At Operating Point | 0.99 | 0.21 | 0.32 |
| With No Loss of $P_d$ | 1.00 | 0.00 | 0.00 |

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

| | 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 (not reported)**

| | Efficiency (E) | False Positive Rejection Rate | Background Alarm Rejection Rate |
|---|---|---|---|
| At Operating Point | -- | -- | -- |
| With No Loss of $P_d$ | -- | -- | -- |

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

| | 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 reported)**

| | 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 reported)

| | 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 (tables 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 |
|---|---|
| 25mm | 100% |
| 37mm | 100% |
| 60mm | 100% |
| 81mm | 13% |
| 105mm | 67% |
| 105 artillery | 20% |
| Overall | 67% |

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

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

**TABLE 8c. OPEN FIELD INDIRECT FIRE CORRECT TYPE CLASSIFICATION OF TARGETS CORRECTLY DISCRIMINATED AS MUNITIONS (not reported)**

| Size | Percentage |
|---|---|
| 60mm | -- |
| 81mm | -- |
| 105mm | -- |
| Overall | -- |

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

| Size | Percentage |
|---|---|
| Small | -- |
| Medium | -- |
| Large | -- |
| Overall | -- |

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

| Size | Percentage |
|---|---|
| Small | -- |
| Medium | -- |
| Large | -- |
| Overall | -- |

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

| Size | Percentage |
|---|---|
| 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 | N/A | N/A |
| Easting | N/A | N/A |
| Depth | 0.02 | 0.10 |

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

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

**TABLE 9c. OPEN FIELD INDIRECT FIRE MEAN LOCATION ERROR AND STANDARD DEVIATION (not reported)**

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

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

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

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

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

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

| | 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.

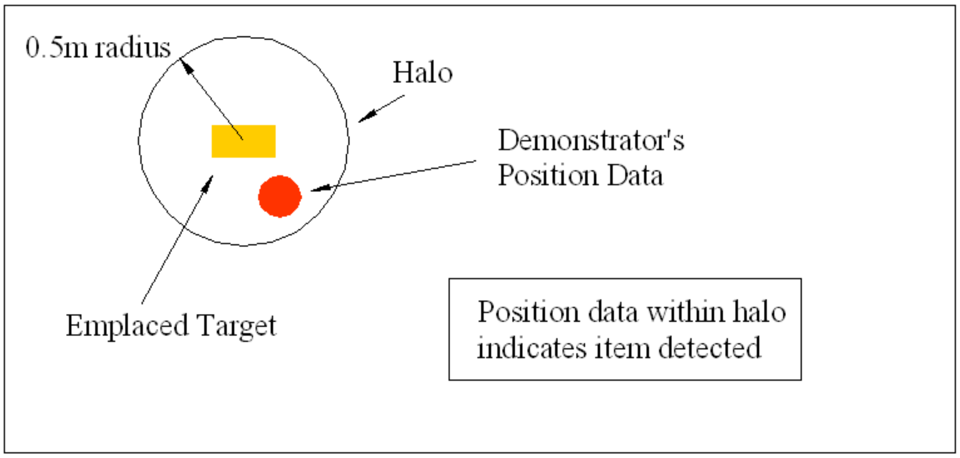
(2) Groups Identified (ID): the number of groups that have two or more GT items matched divided by the total number of groups. Demonstrators will be credited with identifying that a group is present if multiple items within the composite halo are matched to anomalies in their list.

(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.

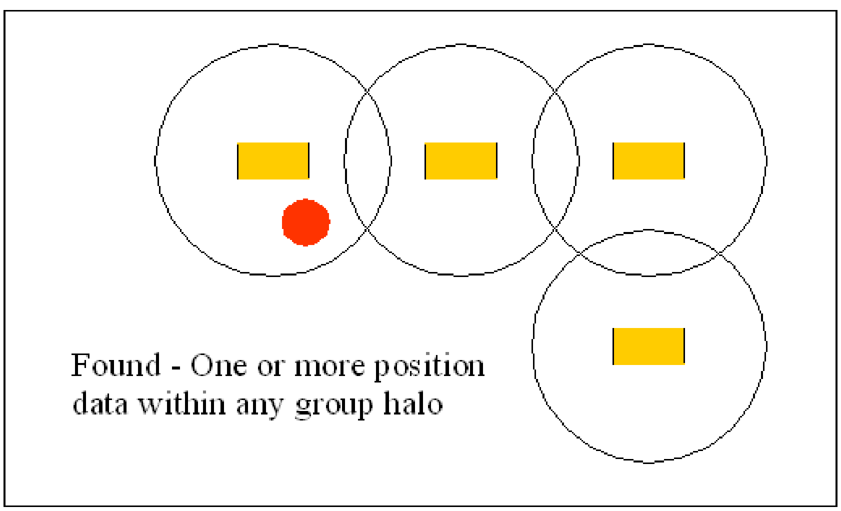
e. Location error will not be reported for groups.

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.

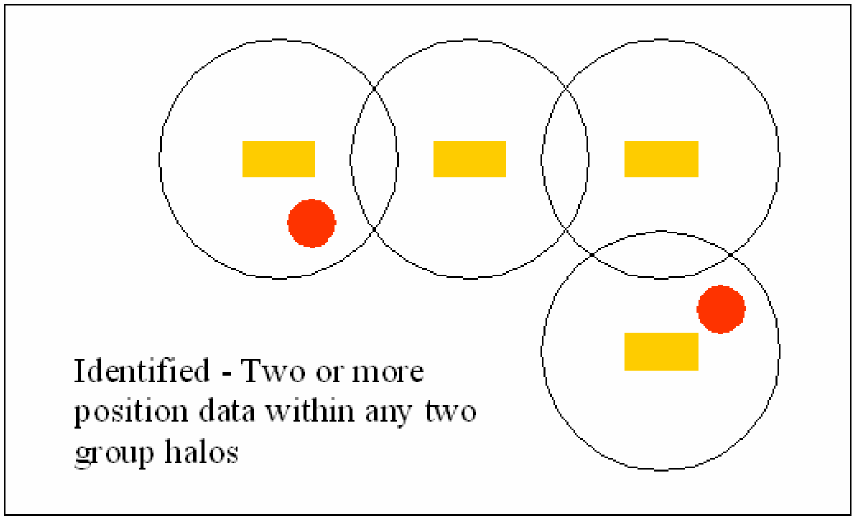
g. Excess alarms within a halo will be disregarded.



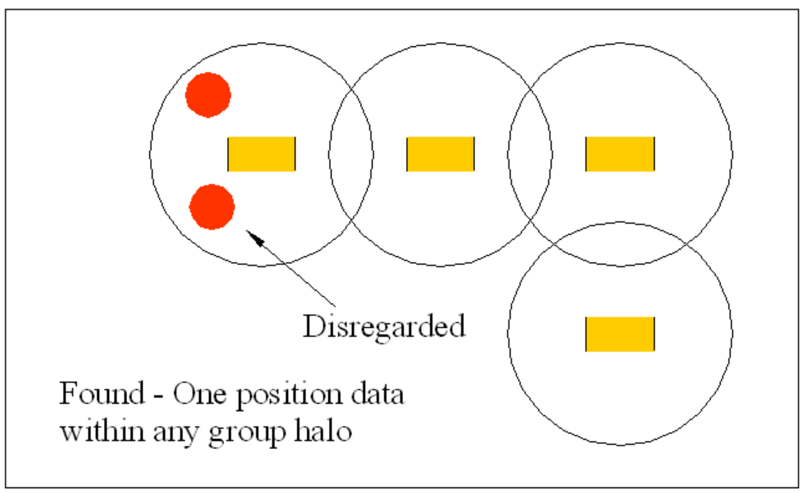

A-1. Example of detected item.



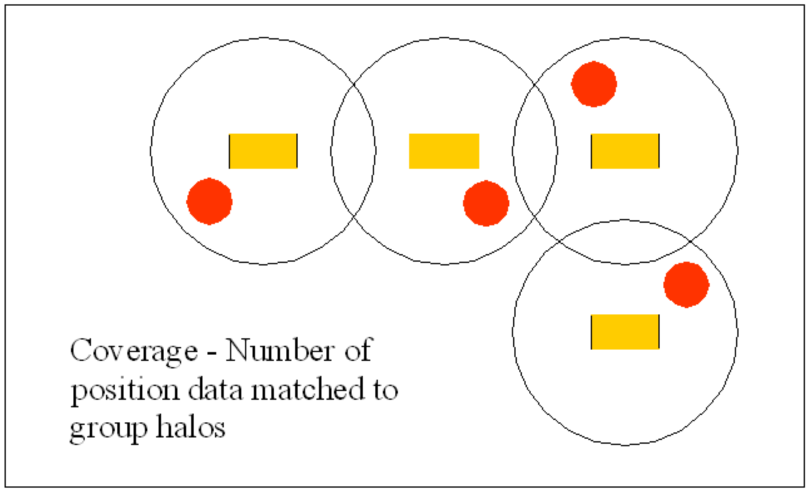

A-2. Example of group found (found).



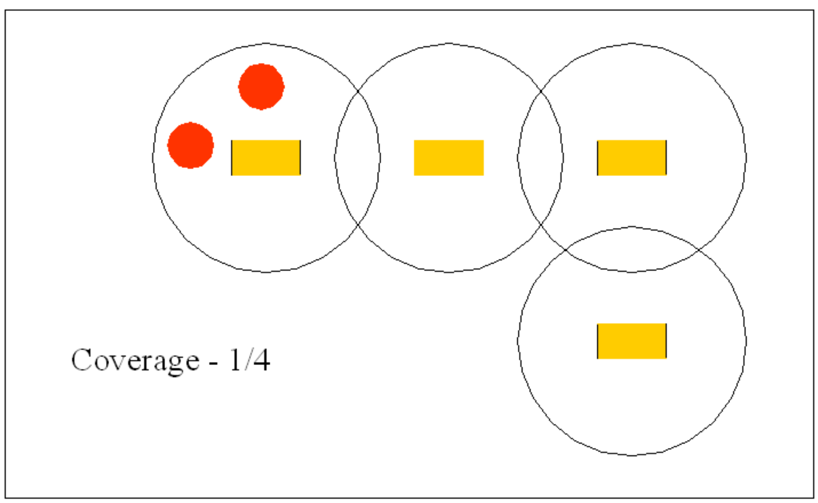

A-3. Example of group identified (ID).



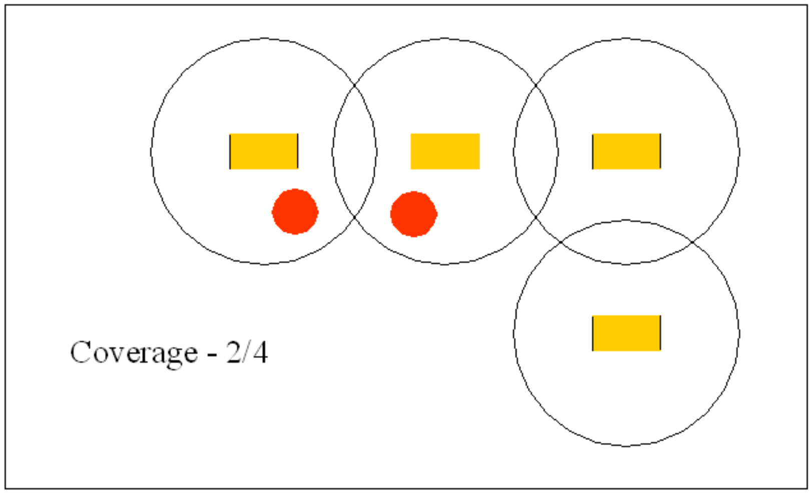

A-4. Example of excess alarms disregarded.



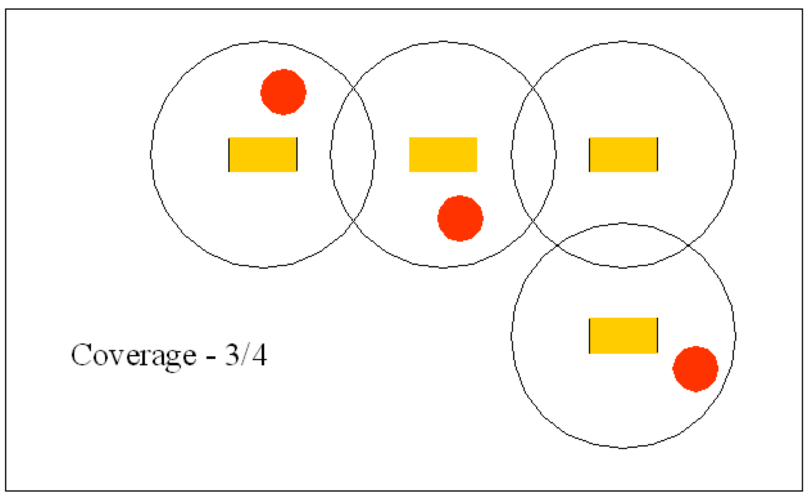

A-5. Example of a group.



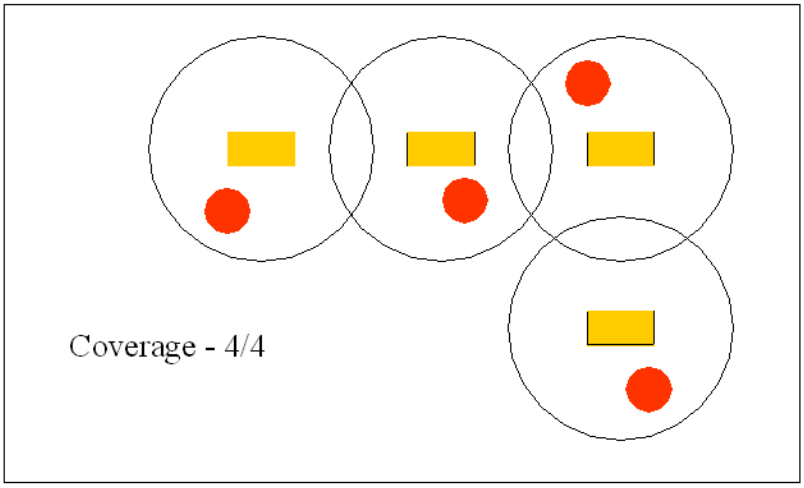

A-6. Example of group (1/4 = 0.25).




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 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 $P_d$ 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 is shown in Figure A-10. Note that the "res" and "disc" superscripts have been suppressed from all the variables for clarity.

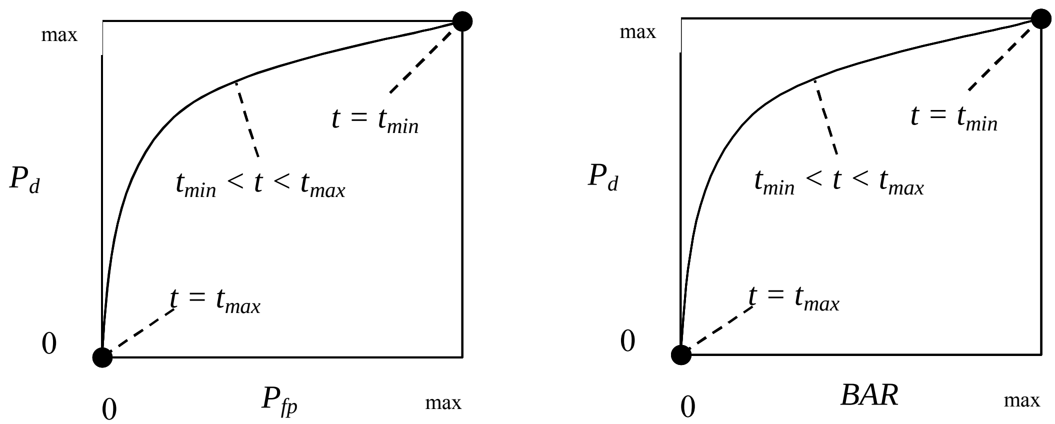



Figure A-10. ROC curves for open field testing. Each curve applies to both the response and discrimination stages.

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 .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, 2010 | Time EST[a] | Avg Temp, °F | Total Precip, in. |
|---|---|---|---|
| 21 Jun | 7:00 | 77.5 | 0.00 |
| | 8:00 | 80.4 | 0.00 |
| | 9:00 | 82.9 | 0.00 |
| | 10:00 | 84.6 | 0.00 |
| | 11:00 | 85.5 | 0.00 |
| | 12:00 | 86.2 | 0.00 |
| | 13:00 | 86.0 | 0.00 |
| | 14:00 | 88.3 | 0.00 |
| | 15:00 | 89.2 | 0.00 |
| | 16:00 | 89.4 | 0.00 |
| | 17:00 | 90.5 | 0.00 |
| 22 Jun | 7:00 | 76.5 | 0.00 |
| | 8:00 | 79.2 | 0.00 |
| | 9:00 | 82.2 | 0.00 |
| | 10:00 | 84.9 | 0.00 |
| | 11:00 | 87.4 | 0.00 |
| | 12:00 | 89.2 | 0.00 |
| | 13:00 | 90.1 | 0.00 |
| | 14:00 | 90.9 | 0.00 |
| | 15:00 | 89.2 | 0.00 |
| | 16:00 | 89.4 | 0.00 |
| | 17:00 | 89.6 | 0.00 |
| 23 Jun | 7:00 | 77.4 | 0.00 |
| | 8:00 | 81.7 | 0.00 |
| | 9:00 | 84.9 | 0.00 |
| | 10:00 | 87.8 | 0.00 |
| | 11:00 | 90.3 | 0.00 |
| | 12:00 | 91.9 | 0.00 |
| | 13:00 | 93.0 | 0.00 |
| | 14:00 | 93.4 | 0.00 |
| | 15:00 | 93.4 | 0.00 |
| | 16:00 | 94.5 | 0.00 |
| | 17:00 | 92.3 | 0.00 |

[a]Eastern Standard Time

| Date, 2010 | Time EST[a] | Avg Temp, °F | Total Precip, in. |
|---|---|---|---|
| 24 Jun | 7:00 | 82.8 | 0.00 |
| | 8:00 | 85.6 | 0.00 |
| | 9:00 | 88.2 | 0.00 |
| | 10:00 | 92.3 | 0.00 |
| | 11:00 | 94.1 | 0.00 |
| | 12:00 | 95.4 | 0.00 |
| | 13:00 | 95.9 | 0.00 |
| | 14:00 | 96.1 | 0.00 |
| | 15:00 | 94.5 | 0.00 |
| | 16:00 | 87.4 | 0.00 |
| | 17:00 | 87.6 | 0.00 |
| 25 Jun | 7:00 | 76.6 | 0.00 |
| | 8:00 | 78.1 | 0.00 |
| | 9:00 | 80.1 | 0.00 |
| | 10:00 | 82.2 | 0.00 |
| | 11:00 | 83.8 | 0.00 |
| | 12:00 | 84.9 | 0.00 |
| | 13:00 | 85.6 | 0.00 |
| | 14:00 | 85.3 | 0.00 |
| | 15:00 | 85.3 | 0.00 |
| | 16:00 | 86.7 | 0.00 |
| | 17:00 | 85.8 | 0.00 |
| 26 Jun | 7:00 | 72.7 | 0.00 |
| | 8:00 | 78.8 | 0.00 |
| | 9:00 | 82.9 | 0.00 |
| | 10:00 | 84.9 | 0.00 |
| | 11:00 | 86.7 | 0.00 |
| | 12:00 | 88.3 | 0.00 |
| | 13:00 | 89.1 | 0.00 |
| | 14:00 | 89.2 | 0.00 |
| | 15:00 | 89.6 | 0.00 |
| | 16:00 | 89.4 | 0.00 |
| | 17:00 | 89.1 | 0.00 |

| Date, 2010 | Time EST[a] | Avg Temp, °F | Total Precip, in. |
|---|---|---|---|
| 28 Jun | 7:00 | 84.4 | 0.00 |
| | 8:00 | 86.9 | 0.00 |
| | 9:00 | 89.4 | 0.00 |
| | 10:00 | 92.1 | 0.00 |
| | 11:00 | 92.3 | 0.00 |
| | 12:00 | 91.8 | 0.00 |
| | 13:00 | 92.8 | 0.00 |
| | 14:00 | 87.8 | 0.06 |
| | 15:00 | 79.5 | 0.03 |
| | 16:00 | 77.0 | 0.01 |
| | 17:00 | 81.0 | 0.00 |
| 29 Jun | 7:00 | 77.4 | 0.00 |
| | 8:00 | 81.0 | 0.00 |
| | 9:00 | 83.8 | 0.00 |
| | 10:00 | 86.5 | 0.00 |
| | 11:00 | 87.6 | 0.00 |
| | 12:00 | 88.5 | 0.00 |
| | 13:00 | 89.2 | 0.00 |
| | 14:00 | 88.7 | 0.00 |
| | 15:00 | 87.6 | 0.00 |
| | 16:00 | 87.1 | 0.00 |
| | 17:00 | 87.3 | 0.00 |
| 30 Jun | 7:00 | 66.2 | 0.00 |
| | 8:00 | 68.0 | 0.00 |
| | 9:00 | 69.6 | 0.00 |
| | 10:00 | 71.2 | 0.00 |
| | 11:00 | 72.7 | 0.00 |
| | 12:00 | 73.6 | 0.00 |
| | 13:00 | 76.3 | 0.00 |
| | 14:00 | 76.8 | 0.00 |
| | 15:00 | 78.4 | 0.00 |
| | 16:00 | 79.9 | 0.00 |
| | 17:00 | 79.7 | 0.00 |

| Date, 2010 | Time EST[a] | Avg Temp, °F | Total Precip, in. |
|---|---|---|---|
| 1 Jul | 7:00 | 64.8 | 0.00 |
| | 8:00 | 67.5 | 0.00 |
| | 9:00 | 70.0 | 0.00 |
| | 10:00 | 71.8 | 0.00 |
| | 11:00 | 73.4 | 0.00 |
| | 12:00 | 74.7 | 0.00 |
| | 13:00 | 75.9 | 0.00 |
| | 14:00 | 76.6 | 0.00 |
| | 15:00 | 77.2 | 0.00 |
| | 16:00 | 78.1 | 0.00 |
| | 17:00 | 77.5 | 0.00 |

[a]Eastern Standard Time

# APPENDIX C. SOIL MOISTURE

| Date: 21 Jun 10 | | | |
|---|---|---|---|
| **Probe Location** | **Layer, in.** | **AM Reading, %** | **PM 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 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Calibration lanes | 0 to 6 | 13.4 | 14.1 |
| | 6 to 12 | 23.6 | 23.4 |
| | 12 to 24 | 26.2 | 23.7 |
| | 24 to 36 | 30.7 | 28.4 |
| | 36 to 48 | 38.7 | 37.2 |
| Blind grid/moguls | 0 to 6 | 10.4 | -- |
| | 6 to 12 | 21.1 | -- |
| | 12 to 24 | 23.8 | -- |
| | 24 to 36 | 26.0 | -- |
| | 36 to 48 | 32.5 | -- |

| Date: 22 Jun 10 | | | |
|---|---|---|---|
| **Probe Location** | **Layer, in.** | **AM Reading, %** | **PM 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 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Calibration lanes | 0 to 6 | 13.9 | 13.8 |
| | 6 to 12 | 23.1 | 23.1 |
| | 12 to 24 | 23.4 | 23.5 |
| | 24 to 36 | 28.2 | 28.1 |
| | 36 to 48 | 37.0 | 36.8 |
| Blind grid/moguls | 0 to 6 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |

| **Date:** 23 Jun 10 | | | |
|---|---|---|---|
| **Probe Location** | **Layer, in.** | **AM Reading, %** | **PM 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 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Calibration lanes | 0 to 6 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Blind grid/moguls | 0 to 6 | 11.7 | 11.5 |
| | 6 to 12 | 22.7 | 22.6 |
| | 12 to 24 | 27.5 | 27.3 |
| | 24 to 36 | 29.6 | 29.7 |
| | 36 to 48 | 36.4 | 36.3 |

| **Date:** 24 Jun 10 | | | |
|---|---|---|---|
| **Probe Location** | **Layer, in.** | **AM Reading, %** | **PM 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 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Calibration lanes | 0 to 6 | 14.7 | -- |
| | 6 to 12 | 23.9 | -- |
| | 12 to 24 | 23.8 | -- |
| | 24 to 36 | 28.7 | -- |
| | 36 to 48 | 37.6 | -- |
| Blind grid/moguls | 0 to 6 | 11.2 | 11.1 |
| | 6 to 12 | 22.4 | 22.4 |
| | 12 to 24 | 27.2 | 27.1 |
| | 24 to 36 | 29.6 | 29.5 |
| | 36 to 48 | 36.2 | 36.2 |

| **Date:** 25 Jun 10 | | | |
|---|---|---|---|
| **Probe Location** | **Layer, in.** | **AM Reading, %** | **PM 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 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Calibration lanes | 0 to 6 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Blind grid/moguls | 0 to 6 | 10.9 | -- |
| | 6 to 12 | 22.3 | -- |
| | 12 to 24 | 26.9 | -- |
| | 24 to 36 | 29.4 | -- |
| | 36 to 48 | 36.0 | -- |

| Date: 26 Jun 10 | | | |
|---|---|---|---|
| **Probe Location** | **Layer, in.** | **AM Reading, %** | **PM 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 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Calibration lanes | 0 to 6 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Blind grid/moguls | 0 to 6 | 10.7 | -- |
| | 6 to 12 | 22.2 | -- |
| | 12 to 24 | 26.6 | -- |
| | 24 to 36 | 29.2 | -- |
| | 36 to 48 | 35.8 | -- |

| **Date:** 28 Jun 10 | | | |
|---|---|---|---|
| **Probe Location** | **Layer, in.** | **AM Reading, %** | **PM 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 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Calibration lanes | 0 to 6 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Blind grid/moguls | 0 to 6 | 10.4 | 10.3 |
| | 6 to 12 | 21.9 | 21.9 |
| | 12 to 24 | 26.3 | 26.2 |
| | 24 to 36 | 28.8 | 28.6 |
| | 36 to 48 | 35.4 | 35.3 |

| Date: 29 Jun 10 | | | |
|---|---|---|---|
| **Probe Location** | **Layer, in.** | **AM Reading, %** | **PM 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 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Calibration lanes | 0 to 6 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Blind grid/moguls | 0 to 6 | 10.7 | 10.6 |
| | 6 to 12 | 22.7 | 22.5 |
| | 12 to 24 | 26.9 | 26.8 |
| | 24 to 36 | 29.3 | 29.2 |
| | 36 to 48 | 35.7 | 35.5 |

| **Date:** 30 Jun 10 | | | |
|---|---|---|---|
| **Probe Location** | **Layer, in.** | **AM Reading, %** | **PM 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 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Calibration lanes | 0 to 6 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Blind grid/moguls | 0 to 6 | 10.4 | 10.2 |
| | 6 to 12 | 22.7 | 22.6 |
| | 12 to 24 | 26.7 | 26.6 |
| | 24 to 36 | 28.9 | 28.9 |
| | 36 to 48 | 35.3 | 35.2 |

| Date: 01 Jul 10 | | | |
|---|---|---|---|
| **Probe Location** | **Layer, in.** | **AM Reading, %** | **PM 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 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Calibration lanes | 0 to 6 | -- | -- |
| | 6 to 12 | -- | -- |
| | 12 to 24 | -- | -- |
| | 24 to 36 | -- | -- |
| | 36 to 48 | -- | -- |
| Blind grid/moguls | 0 to 6 | 10.1 | 10.0 |
| | 6 to 12 | 22.4 | 22.3 |
| | 12 to 24 | 26.5 | 26.3 |
| | 24 to 36 | 28.7 | 28.6 |
| | 36 to 48 | 35.1 | 34.9 |

# APPENDIX D. DAILY ACTIVITY LOGS

| Date, 2010 | No. of People | Area Tested | Status Start Time | Status Stop Time | Duration min. | Operational Status | Operational Status - Comments | Pattern | Field Conditions | |
|---|---|---|---|---|---|---|---|---|---|---|
| 21 Jun | 4 | CALIBRATION LANES | 930 | 1455 | 325 | INITIAL SET-UP | INITIAL MOBILIZATION | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 1455 | 1600 | 65 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 1600 | 1605 | 5 | CALIBRATION | CALIBRATION | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 1605 | 1620 | 15 | DAILY START, STOP | EQUIPMENT BREAKDOWN | POINT | SUNNY DRY | HOT |
| 22 Jun | 4 | CALIBRATION LANES | 800 | 815 | 15 | DAILY START, STOP | SET UP EQUIPMENT | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 815 | 825 | 10 | CALIBRATION | CALIBRATION | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 825 | 1050 | 145 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 1050 | 1110 | 20 | DOWNTIME DUE TO EQUIP MAINT/CHECK | CHANGE BATTERIES | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 1110 | 1120 | 10 | CALIBRATION | CALIBRATION | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 1120 | 1225 | 65 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 1225 | 1245 | 20 | BREAK/LUNCH | BREAK/LUNCH | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 1245 | 1340 | 55 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 1340 | 1350 | 10 | DOWNTIME DUE TO EQUIP MAINT/CHECK | DOWNLOAD DATA | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 1350 | 1445 | 55 | BREAK/LUNCH | BREAK/LUNCH | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 1445 | 1525 | 40 | DAILY START, STOP | SET UP EQUIPMENT | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 1525 | 1600 | 35 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 1600 | 1615 | 15 | DAILY START, STOP | EQUIPMENT BREAKDOWN | POINT | SUNNY DRY | HOT |
| 23 Jun | 4 | BLIND TEST GRID | 750 | 1030 | 160 | DAILY START, STOP | SET UP EQUIPMENT | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1030 | 1105 | 35 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1105 | 1115 | 10 | DOWNTIME DUE TO EQUIP MAINT/CHECK | DOWNLOAD DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1115 | 1200 | 45 | BREAK/LUNCH | BREAK/LUNCH | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1200 | 1310 | 70 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1310 | 1430 | 80 | BREAK/LUNCH | BREAK/LUNCH | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1430 | 1450 | 20 | DAILY START, STOP | SET UP EQUIPMENT | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1450 | 1625 | 95 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1625 | 1645 | 20 | DAILY START, STOP | EQUIPMENT BREAKDOWN | POINT | SUNNY DRY | HOT |

| Date, 2010 | No. of People | Area Tested | Status Start Time | Status Stop Time | Duration min. | Operational Status | Operational Status - Comments | Pattern | Field Conditions | |
|---|---|---|---|---|---|---|---|---|---|---|
| 24 Jun | 4 | BLIND TEST GRID | 755 | 845 | 50 | DAILY START, STOP | SET UP EQUIPMENT | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 845 | 850 | 5 | CALIBRATION | CALIBRATION | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 850 | 945 | 55 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 945 | 1020 | 35 | BREAK/LUNCH | BREAK/LUNCH | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 1020 | 1125 | 65 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1125 | 1140 | 15 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1140 | 1245 | 65 | BREAK/LUNCH | BREAK/LUNCH | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1245 | 1350 | 65 | DAILY START, STOP | SET UP EQUIPMENT | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1350 | 1445 | 55 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1445 | 1455 | 10 | BREAK/LUNCH | BREAK/LUNCH | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1455 | 1550 | 55 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1550 | 1610 | 20 | DAILY START, STOP | EQUIPMENT BREAKDOWN | POINT | SUNNY DRY | HOT |
| 25 Jun | 4 | BLIND TEST GRID | 745 | 815 | 30 | DAILY START, STOP | SET UP EQUIPMENT | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 815 | 820 | 5 | CALIBRATION | CALIBRATION | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 820 | 1025 | 125 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1025 | 1035 | 10 | BREAK/LUNCH | BREAK/LUNCH | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1035 | 1055 | 20 | DAILY START, STOP | SET UP EQUIPMENT | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1055 | 1150 | 55 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1150 | 1205 | 15 | DAILY START, STOP | EQUIPMENT BREAKDOWN | POINT | SUNNY DRY | HOT |
| 26 Jun | 4 | BLIND TEST GRID | 750 | 810 | 20 | DAILY START, STOP | SET UP EQUIPMENT | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 810 | 820 | 10 | CALIBRATION | CALIBRATION | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 820 | 935 | 75 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 935 | 950 | 15 | BREAK/LUNCH | BREAK/LUNCH | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 950 | 1145 | 115 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1145 | 1150 | 5 | CALIBRATION | CALIBRATION | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1150 | 1200 | 10 | DAILY START, STOP | EQUIPMENT BREAKDOWN | POINT | SUNNY DRY | HOT |
| 28 Jun | 4 | BLIND TEST GRID | 750 | 830 | 40 | DAILY START, STOP | SET UP EQUIPMENT | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 830 | 1645 | 495 | DOWNTIME DUE TO EQUIPMENT FAILURE | FUSE BLOWN, TROUBLESHOOTING FOR CAUSE | POINT | SUNNY DRY | HOT |

| Date, 2010 | No. of People | Area Tested | Status Start Time | Status Stop Time | Duration min. | Operational Status | Operational Status - Comments | Pattern | Field Conditions | |
|---|---|---|---|---|---|---|---|---|---|---|
| 29 Jun | 4 | BLIND TEST GRID | 750 | 810 | 20 | DAILY START, STOP | SET UP EQUIPMENT | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 810 | 815 | 5 | CALIBRATION | CALIBRATION | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 815 | 1150 | 215 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1150 | 1205 | 15 | DOWNTIME DUE TO EQUIP MAINT/CHECK | CHANGE BATTERIES | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1205 | 1445 | 160 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1445 | 1500 | 15 | BREAK/LUNCH | BREAK/LUNCH | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1500 | 1515 | 15 | DAILY START, STOP | EQUIPMENT BREAKDOWN | POINT | SUNNY DRY | HOT |
| 30 Jun | 4 | BLIND TEST GRID | 755 | 810 | 15 | DAILY START, STOP | SET UP EQUIPMENT | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 810 | 820 | 10 | CALIBRATION | CALIBRATION | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 820 | 950 | 90 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 950 | 1015 | 25 | DOWNTIME DUE TO EQUIP MAINT/CHECK | DOWNLOAD DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1015 | 1235 | 140 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1325 | 1300 | -25 | BREAK/LUNCH | BREAK/LUNCH | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1300 | 1345 | 45 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1345 | 1355 | 10 | DOWNTIME DUE TO EQUIP MAINT/CHECK | CHANGE BATTERIES | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1355 | 1635 | 160 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1635 | 1645 | 10 | DOWNTIME DUE TO EQUIP MAINT/CHECK | EQUIPMENT BREAKDOWN | POINT | SUNNY DRY | HOT |
| 1 Jul | 4 | BLIND TEST GRID | 755 | 810 | 15 | DAILY START, STOP | SET UP EQUIPMENT | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 810 | 820 | 10 | CALIBRATION | CALIBRATION | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 820 | 1035 | 135 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | CALIBRATION LANES | 1035 | 1130 | 55 | COLLECTING DATA | COLLECT DATA | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1130 | 1315 | 105 | DOWNTIME DUE TO EQUIP MAINT/CHECK | DATA CHECK | POINT | SUNNY DRY | HOT |
| | 4 | BLIND TEST GRID | 1315 | 1645 | 210 | DEMOBILIZATION | DEMOBILIZATION | POINT | SUNNY DRY | HOT |

## 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

| | | |
|---|---|---|
| ADST | = | Aberdeen Data Services Team |
| APG | = | Aberdeen Proving Ground |
| ATC | = | U.S. Army Aberdeen Test Center |
| ATSS | = | Aberdeen Test Support Services |
| BAR | = | background alarm rate |
| DMM | = | discarded military munitions |
| 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 |
| GT | = | ground truth |
| HDSD | = | Homeland Defense and Sustainment Division |
| HEAT | = | high-explosive antitank |
| JPG | = | Jefferson Proving Ground |
| LBL | = | Lawrence Berkeley National Laboratory |
| MM | = | military munitions |
| NA | = | not available |
| NS | = | nonstandard munition |
| POC | = | point of contact |
| QA | = | quality assurance |
| QC | = | quality control |
| ROC | = | receiver-operating characteristic |
| S | = | standard munition |
| SERDP | = | Strategic Environmental Research and Development Program |
| USAEC | = | U.S. Army Environmental Command |
| UXO | = | unexploded ordnance |
| YPG | = | U.S. Army Yuma Proving Ground |

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