Double-Blind Field Evaluation of the MOLE Programmable Detection System

Dale Murray
Entry Control and Contraband Detection Department
Sandia National Laboratories
Albuquerque, New Mexico 87185-0782
dwmurra@sandia.gov
505-845-8952

Abstract

Sandia National Laboratories participated in a double-blind field test on January 29, 2002, at the Rocky Mountain office of the National Law Enforcement and Corrections Technology Center (NLECTC) in Denver, Colorado to test the explosives detection capability of the MOLE Programmable System manufactured by Global Technical Ltd. of Kent, UK. The target material used was approximately 20 grams of C4 explosive placed in a plastic bag with a twist top and enclosed in a plastic 35-mm film canister. Based on statistical analysis of the double-blind test results, the MOLE performs no better than a random selection process. To assure that no contamination occurred that might have affected test results, the boxes used during the test were tested for the presence of explosives using an ion mobility spectrometer.

Sandia National Laboratories is the technology partner for the National Law Enforcement and Corrections Technology Center – Rocky Mountain (NLECTC-RM), a program funded by the U.S. Department of Justice, National Institute of Justice. Analyses of test results do not represent product approval or endorsement by the National Institute of Justice, U.S. Department of Justice; NLECTC-RM; or Sandia National Laboratories. The

National Institute of Justice is a component of the Office of Justice Programs, which also includes the Bureau of Justice Assistance, Bureau of Justice Statistics, Office of Juvenile Justice and Delinquency Prevention, and Office for Victims of Crime.

Introduction

The MOLE programmable system manufactured by Global Technical Ltd. of Kent, UK is advertised as a detection system that is capable of detecting a number of substances either one at a time or several substances simultaneously.

Product Description

To program the product for detecting one or more substances, the operator inserts the appropriate programming cards into a cardholder that is clipped to the operator's belt. The programming holder is attached to the search handle by a short cable with standard phono-jacks on each end. The search handle is a small black plastic handle with a radio-type antenna mounted in a free turning pivot. See Figure 1. When the antenna is fully extended, it can be balanced to protrude in front of the operator but is free to swing to either side with the slightest tilt of the operator's hand.

Figure 1. MOLE Programmable Cardholder, Card for Explosives, and Search Handle

Search Process

To initiate the search process, the operator generates static electricity by either standing stationary and taking a couple of deep breaths (according to the operator) or slowly walking forward. The product is advertised to operate using static electricity only and requires no batteries or other power sources. A positive indication is said to occur when the antenna pivots across the operator's body and points toward the target material.

Field Test Preparation

The MOLE was brought to the attention of the Rocky Mountain office of the National Law Enforcement and Corrections Technology Center (NLECTC). An offer to demonstrate the product was subsequently made by Mr. Robert Balais of Communications West, LTD. of Boulder, Colorado. Paul Reining of NLECTC contacted Sandia National Laboratories in Albuquerque, New Mexico to request assistance in conducting a field test of the MOLE. Dale Murray of Sandia's Department 5848 (Entry Control and Contraband Detection) was assigned to help design and conduct the field test. Because the MOLE's detection capability is subject to human interaction and interpretation, Sandia suggested that the test should be "double blind." This is a typical test approach used when the outcome of each trial is dependent on human influences or interpretation. The field test of the MOLE was scheduled to occur in Denver at the NLECTC offices on January 29, 2002.

Test Design

The test plan was designed to be simple to implement but scientifically and statistically rigorous. In order to provide a simple implementation, four cardboard boxes were labeled by both numbers and letters to represent "heads" and "tails" of a coin toss. Box 1 was labeled HH for heads-heads. Box 2 was labeled HT for heads-tails. Box 3 was labeled TH for tails-heads. Box 4 was labeled TT for tails-tails. With this arrangement, the location of a target substance could be determined in a random fashion by two coin tosses. This assured that the location of the target material for each trial would be truly random and would be determined immediately before each trial.

Also typical in a double-blind test, a series of baseline trials would be conducted to establish the acceptability of the test conditions by all participants before the actual testing commences. Five baseline trials would be sufficient for this test plan.

For any double-blind test, those administering the test must be fully separated from those being tested so that the testers cannot subconsciously provide nonverbal cues that could indicate where the target material is located. For this test, the participants would be divided into two groups. The first group would perform the coin tosses to determine the location of the target for each trial and then would place the target in the random location and record that location. The second group would be the search group, which would include the MOLE operator. The operator would then use the MOLE to identify a location where he believed the target to be. The selected location by both number and heads-tails label would be recorded. By keeping the two groups separate and isolated during the placement and search phases, the results of the test would be unknown to everyone until the end of the testing. It was determined prior to the test that only Mr. Reining and Mr. Murray would handle the target. This aspect of the testing was not discussed with any other participants.

Test Parameters

The test was conducted on the second floor of the building occupied by NLECTC. This floor is a rectangular area with a hall around the perimeter of the floor. The outside of the hall has mostly offices and the interior has mostly conference and classrooms. Placing a box in each corner of the hall would provide sufficient separation of the boxes so that if the product operated as advertised it would be a simple matter to identify the location of the target. In addition to the distance separating the boxes, there was ample angular access to the boxes so that a triangulation could be made. The triangulation technique is mentioned in the product literature and is performed by taking at least two readings on a suspected location and the exact location of the target is determined by the intersection of the two directional readings. Aircraft and ships use this technique to determine their location. Accurate triangulation can be made easily with readings that are separated by as little as twenty degrees and the test setup allowed the operator at least 90 degrees access to each box location.

To isolate one test group while the other group fulfilled its task, the idle group waited in Paul Reining' s office on the second floor. The heavy wooden door, in combination with the block construction of the walls, provided sufficient soundproofing to prevent the idle group from observing or hearing the other group perform its task. In addition to the heavy construction of the office, a desktop radio was played to ensure that none of the other group' s activities was heard. After each group had performed its function, a knock on the door signaled that it was time for the groups to exchange places. Twenty trials were chosen to be a reasonable number to provide enough data to clearly show the results.

Mr. Reining provided the target material. He carefully placed approximately 20 grams of C4 into a plastic bag with clean tongs. After the C4 was in the bag, the top of the bag was twisted and secured with a twist tie. Then the bag was placed in a clean, plastic, 35-mm film canister and the top was placed securely on the canister. Mr. Reining took extreme care to ensure that no contamination was spread to the outside of the canister.

Conducting the Test

Mr. Robert Balais arrived at 10 A.M. with Patrick Cardozo of Newcourt Systems Inc. of Toronto, Canada. Paul Reining asked Jennifer Dunne, an employee of NLECTC, to assist in the tests. The entire group went to a conference room in an adjacent building to discuss their activities. Mr. Balais conducted a short demonstration of the operation of the MOLE by searching for a shotgun shell and a small caliber bullet that he had brought with him. He stood stationary and took a couple of deep breaths and the antenna moved to point to the ammunition that was in plain view on the conference room table. He stated that his performance with the MOLE had been better than 95% accurate in locating and identifying substances. Following the demonstration, the group discussed how to conduct the test. Mr. Balais agreed that placing the boxes in the corners of the hall outside Paul Reining' s office would provide sufficient separation for easy identification of which box contained the target. Mr. Reining produced the target and Mr. Balais inserted the plastic explosives programming card into the MOLE and demonstrated his ability to detect the target when it was in plain view on the conference room table. The group then returned to the previous building to conduct the test.

When the test group arrived, the empty, marked boxes were placed in the corners of the hall on the floor as near the corners of the building as possible. Figure 2 shows the relative location of the boxes and Mr. Reining' s office. Next, the group conducted the five baseline trials. For the entire baseline test, the target was placed in the selected box in full view of every participant. To randomly select a target location, one person tossed a quarter coin twice, each time allowing the coin to fall to the floor. The first coin toss resulted in tails-heads, indicating Box 3. Mr. Balais then used the MOLE to point to Box 3 and indicated that the detection was easy. The second coin toss resulted in tails-heads, again selecting Box 3. Mr. Balais again quickly performed a search that he indicated selected Box 3. The third coin toss resulted in tails-tails, selecting Box 4. Mr. Balais quickly identified Box 4. The next two tosses both resulted in heads-tails, indicating Box 2 and both times Mr. Balais indicated that he detected Box 2. During the baseline test, Mr. Balais stated that we did not have to let him know where the target was located and that he could find the target without prior knowledge of the location. He was told that we would get to that phase of the testing but it was important to perform the baseline to make sure that the test parameters were acceptable to all. The baseline testing is very important in any test of this nature to reveal any problems in the test setup and procedures prior to beginning the actual test. If any problems with the test setup existed they would be revealed during the baseline phase and could be addressed at that time. After the baseline was complete, Mr. Balais stated that the test parameters were acceptable and fair and indicated he had no problems locating the targets. Mr. Balais located the target 100% of the time during the baseline test when all participants knew the target location. Baseline test results are shown in Table 1.

Table 1. Baseline Trial Results

Baseline Trial Number	Actual Location of Target by Box Number and Coin Toss	Location Selected by MOLE Operator When Given Target Location
1	3 (TH)	3 (TH) *
2	3 (TH)	3 (TH) *
3	4 (TT)	4 (TH) *
4	2 (HT)	2 (HT) *
5	2 (HT)	2 (HT) *

*** Indicates Correct Location**

The participants then divided into the two groups and proceeded to the double-blind phase of the testing. The placement group consisted of Dale Murray and Jennifer Dunne while Robert Balais, Paul Reining, and Patrick Cardozo formed the search group. The double blind trials were conducted in exactly the same manner as the baseline trials. (This is important to ensure that the testing was following an established acceptable test procedure.) The only deviation from the baseline was that the search group was inside Mr. Reining' s office while the coin toss and placement of the target took place and the placement group waited inside Mr. Reining' s office while the actual search took place. The double-blind phase required approximately 1½ hours to complete. At the end of the testing, the entire group gathered in a conference room to score the tests.

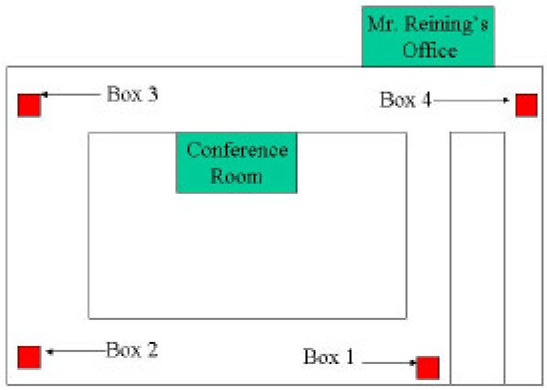

Figure 2. Floor Plan of Double-Blind Field Test

Test Results

Mr. Reining was given the two data sheets and he compared the locations selected by Mr. Balais to the actual locations where the target was placed. By random selection alone, it is expected that of the twenty trials, approximately five selections would be the correct location. (The probability of the target being in any one of the boxes is 0.25.) If the product worked as advertised, then the number of correctly identified boxes would be statistically more significant, at least 12 to 13 correct "hits" or a little better than half. (See the section called Probability of Random Chance.) Mr. Balais correctly identified six boxes, or 33.3%, in contrast to the claimed accuracy of 95%. The results of the actual locations of the target and the boxes selected by Mr. Balais are presented in Table 2.

Table 2. Trial Numbers, Randomly Selected Target Placement Locations, and Locations Selected by the MOLE Operator

Trial Number	Actual Location of Target by Box number and Coin Toss	Location Selected by MOLE Operator * Indicates Correct Location
1	3 (TH)	4 (TT)
2	4 (TT)	1 (HH)
3	3 (TH)	4 (TT)
4	1 (HH)	1 (HH) *
5	4 (TT)	2 (HT)
6	1 (HH)	3 (TH)
7	4 (TT)	4 (TT) *
8	2 (HT)	1 (HH)
9	1 (HH)	1 (HH) *
10	1 (HH)	3 (TT)
11	3 (TH)	2 (HT)
12	4 (TT)	4 (TT) *
13	3 (TH)	2 (HT)
14	2 (HT)	1 (HH)
15	1 (HH)	2 (HT)
16	4 (TT)	4 (TT) *
17	4 (TT)	4 (TT) *
18	2 (HT)	1 (HH)
19	2 (HT)	1 (HH)
20	2 (HT)	1 (HH)

These results are consistent with the search process being simple random selection. The product performed no better than random chance.

Probability of Random Chance

The following data analysis is used to determine the number of correct selections that would be required in order to show that the product was likely performing better than random chance. Sandia created a table (Table 3) that lists some (0 through 13) of the possible outcomes of a twenty trial test and the probabilities for each possible outcome of a random selection process. For example, the probability of a person getting none, or zero, matches, is very unlikely, only occurring 0.32% of the time. However, randomly selecting correct boxes between 3 and 7 times during a twenty trial test would occur 81% of the time (the sum of the probabilities for 3, 4, 5, 6, and 7 correct selections). Mr. Balais' s results of only selecting six correct boxes are consistent with random chance.

Table 3. Probabilities of Possible Results, based on Random Chance

Number of correct selections (based on 20 trials)	Probability of this Result Occurring (Assuming random selection)
0	0.0032 (0.32%)
1	0.0211 (2.11%)
2	0.0669 (6.69%)
3	0.1339 (13.4%)
4	0.1897 (19.0%)
5	0.2023 (20.2%)
6	0.1686 (16.9%)
7	0.1124 (11.2%)
8	0.0609 6.09%)
9	0.0270 (2.70%)
10	0.0099 (0.99%)
11	0.0030 (0.30%)
12	0.0008 (0.08%)
13	0.0002 (0.02%)

The table of random probabilities shows that the three most likely results are 5, 4, and 6 correct selections (starting from the highest probability), closely followed by 3 and then 7. The probability of the results being 13 is only about two chances in 10,000 and so any result of 13 or higher would have indicated a strong possibility that the performance of the MOLE was better than random chance.

Post-Test Discussion

Following the evaluation of the test results, the participants discussed the results. Mr. Balais started by stating he could not explain the low performance of the product in the testing. He also stated that he intended to discuss the results with the factory. Later he suggested that perhaps the exterior of the target container (film canister) was contaminated with the target material and that this contamination had spread to the boxes. He said that this could explain why he had detected empty boxes that were close by when the target was actually in a box farther away. Sandia and NLECTC personnel agreed to examine the boxes by ion mobility spectrometry (IMS) for traces of contamination. Mr. Balais asked if he could scan the empty boxes. He was told that he could do so but the results would not be considered as part of the test. He proceeded to scan each of the four boxes and indicated that the MOLE had positive "hits" on all boxes. He then stated that he thought contamination had skewed the results of the tests.

It was suggested that if the boxes were contaminated then it would be likely that the hands of participants would be contaminated. Mr. Balais first scanned Mr. Reining's hands and indicated a positive "hit". He then scanned the hands of Mr. Cardozo, who had handled neither the target nor the boxes and indicated he got a negative response from the MOLE. He then scanned the hands of Mr. Murray and stated he obtained a positive response. He then scanned the hands of Ms. Dunne and stated he had obtained a positive response. Mr. Balais then stated that only he and Mr. Cardozo had not handled the materials. He was informed that this was not the case and that during the testing, Ms. Dunne had never handled any of the materials. He then asked to again scan Ms. Dunne's hands and this time he stated that the MOLE gave a negative response, but could not explain the previous positive response.

Follow-Up Tests

After the discussions ended, the flattened boxes were wrapped in clear plastic wrap and returned to Sandia for analysis. At Sandia on January 30, 2002, the boxes were unwrapped and the entire interior and exterior surfaces of each box were carefully wiped with a sampling paper that was analyzed by a Barringer Saber 2000 IMS explosives detector. The results for all surfaces were negative. Since this instrument is highly sensitive and capable of detecting less than a single fingerprint of explosive material, this effectively rules out any possibility that contamination occurred during the test.

Summary

Sandia National Laboratories participated in a double-blind field test on January 29, 2002, at the Rocky Mountain office of the National Law Enforcement and Corrections Technology Center (NLECTC) in Denver, Colorado to test the explosives detection capability of the MOLE Programmable System manufactured by Global Technical Ltd. of Kent, UK. The target material used was approximately 20 grams of C4 explosives placed in a plastic bag with a twist top and enclosed in a plastic 35-mm film canister.

Based on statistical analysis of the double-blind test results, the MOLE performs no better than a random selection process. To assure that no contamination occurred that might have affected test results, the boxes used during the test were tested for the presence of explosives contamination using an ion mobility spectrometer. The results of the ion mobility spectrometer test indicate there was no contamination.

Additional Information

In October 1995, Sandia National Laboratories examined a product that appeared physically nearly identical to the MOLE. This product was the Quadro Tracker, which was manufactured by the Quadro Corporation of Harleyville, South Carolina. The visible physical differences between the two products appeared to be the product labels and the handle-programming chip. On the Quadro Tracker the programming chip was inter-changeable and could be inserted into the handle where on the MOLE, the programming chip is permanently fixed into the handle, which can be seen in Figure 3 as the raised area under the label. Additional information on the Quadro Tracker can be located by performing a search on the World Wide Web using the key words Quadro and Tracker.

Figure 3. MOLE handle showing permanently attached "Programming Chip"

Acknowledgements

I would like to add special thanks to Paul Reining and Jennifer Dunne of NLECTC-Rocky Mountain. NLECTC-RM is supported by Cooperative Agreement #96-MU-MU-K012 awarded by the U.S. Department of Justice, National Institute of Justice.

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

Sandia National Laboratories is designated a satellite facility of the National Institute of Justice's (NIJ) Office of Science and Technology to work in partnership with the NLECTC-Rocky Mountain.