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14. ABSTRACT
The purpose of this Test Operations Procedure (TOP) is to provide the tester standardized testing methodologies and procedures to assess roller systems to analyze effectiveness against landmines and improvised explosive devices (IEDs) and trigger threats. Testing is performed on a primary (hard packed), secondary (compacted gravel or dirt surfaces), and/or improved, controlled lanes with buried threat targets at various depths.

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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 04-1-010 — 4 December 2017
DTIC AD No.

EFFECTIVENESS TESTING OF MECHANICAL CLEARING SYSTEMS - ROLLER SYSTEMS OPERATING IN A STRAIGHT PATH

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1. SCOPE.

a. This Test Operations Procedure (TOP) describes the systematic approach for testing and assessing the performance effectiveness of mechanical clearing mine roller systems (MRS) against buried landmines and improvised explosive devices (IED) consisting of pressure plate triggers. This document outlines the preparation, testing, data collection, and data presentation, standardizing the methodology for determining the effectiveness. Standardizing constants (e.g., target categories and configurations, burial depths, etc.) allow for direct comparison of systems, from legacy systems (fielded) to new designs not having standards, to not having any comparison possibility if testing at different dates. The purpose of this TOP is not considered to be an operational test, but rather an analysis of the MRS effectiveness to defeat a route emplaced threat. This document will point to applicable military standards and International Test Operations Procedures (ITOPs) for additional clarification of specific test activities when appropriate. These procedures do not dictate how an item is to proceed through early developmental or characterization testing.

b. To meet effectiveness performance objectives, test teams must consider the following parameters:

(1) Target Sample Size - test matrix quantity of target encounters (reliability and confidence level correlates to a sample size for target encounters).

(2) Target Types (e.g., landmines and IED pressure plate triggers).

(3) Target Depths (e.g., surface, subsurface - minimal coverage, buried).

(4) Road Types:

(a) Primary roads - all weather, hard surface highways (e.g., asphalt, etc.)

(b) Secondary roads - all weather, loose surface highways (e.g., compacted gravel, compacted dirt, etc.)

1.1 Terms and Conditions.

This procedure specifically applies to effectiveness testing in a straight, near flat controlled test lane. Effectiveness provides an important measure of how well a system under test (SUT) defeats the threat: MRS activation of pressure/deflection type threats. Effectiveness, depicted as a percentage, represents the number of targets the SUT is able to defeat, on "first strike" (single pass), out of a total number of encounters, over a set burial depth; thus providing an indication of the SUT effectiveness against current, threat-representative targets. Target selection for testing should be established by the test sponsor(s) and/or evaluation team. If the tester has available targets, they need to be in agreement with the test sponsor and/or evaluation team to ensure it meets or correlates to the SUT threat criteria. If the tester uses targets not on the established threat list, these targets should be fully characterized and documented in the test plan and/or report. Additional effectiveness testing terms and definitions are outlined as follows:

a. Run - A single pass within a bounded straight path that includes selected targets.

b. Engagement:

(1) Full Engagement - Target is 50% or greater within the bounds of the coverage area of the MRS or prime mover (PM). The centerline of the target will be marked on the target to analyze this criterion.

(2) Partial Engagement - Target encounter that does not meet full engagement requirements (e.g., 49% or less).

c. Data Point - Engagement of a functional target by either the SUT or PM (Note: PM engagement data point is not an effectiveness scoring element, but serves to determine if the SUT fully coverages the area traveled by PM; the PM data point support critical non-activation assessment).

d. Miss:

(1) Target within the MRS coverage area, but because of wheel and roller gap(s), target was not engaged. This data point is scored the same as non-activated. (Note: If within SUT coverage area and SUT wheel gap spans the target, it would be considered an engagement, a valid data point for effectiveness assessment.)

(2) Target not within the SUT or PM coverage area. A missed target is one that is not used in effectiveness assessment and is considered a No Test for that target data point. To be considered missed, target is not engaged because it is outside the MRS path; therefore, an invalid engagement - no test.

e. Target Defeat, MRS assessment:

(1) Activation - Target was engaged and the trigger mechanism was initiated (closed the circuit).

(2) Non-Activation - Functional target was engaged but trigger mechanism was not initiated.

(3) Critical Non-Activation - A target was engaged and the trigger mechanism was not initiated by MRS but was initiated by PM. (Note: monitoring for PM target critical activation does not increase or decrease the effectiveness assessment of the SUT, but may indicate shortfall or design deficiency of the SUT in the integration to a specific PM, or a safety flag as inadequate coverage of path.)

f. No Test - No data point (comments shall be placed into the remarks section of the data sheet). Possible reasons include:

(1) Target device was not functional (e.g., landmine fuze not properly reset or armed, wire not connected, etc.).

(2) Loss of power to data collecting instruments.

(3) Partial engagement (engagement of less than 50% of target body). If engagement is less than 50%, indications may be that the engagement component of the SUT does not engage the fuzing activation mechanism of the target (e.g., landmine fuze element, etc.).

(4) Miss. Target not within engagement parameters (footprint) of SUT. Footprint is referring to within roller wheel bank(s) (roller tires) and/or PM.

g. Secondary Effects - Target activated by means other than its intended functionality (such as activation during test team unearthing). Comments shall be placed into the remarks section of the data sheet.

1.2 Limitations.

These procedures define burial procedures, data acquisition requirements (specific to target threat categories), and calibration and quality checks of the data acquisition system. It is expected that identified test targets and testing methodology are designed and equipped to provide a comparable output signal or indication that provides a valid, verifiable score of when they were activated or not, and by which component (e.g., MRS or PM). Any specialized test target representatives must be supplied with supporting manuals or instructions for proper calibration and operational use as test equipment. The data produced in accordance with (IAW) this TOP are only valid for current soil conditions for a given time and location during a particular test phase, the MRS/PM integration combination, and target(s) used for a particular test event. Varying factors (e.g., targets, depths, soil, and soil moisture, SUT speed, etc.) may result in irregular conclusions.

1.3 Standardization of Testing Methodology and Threats.

a. With the onset of IEDs, MRS testing have had to expand target sets from the typical conventional buried landmine to include IEDs pressure triggers (e.g., pressure plates, etc.).

b. Testing cannot introduce all new and ever changing IED configurations and variable conditions. Therefore, a representative set of threat targets are used as a standardized baseline to assess MRS effectiveness for its ability to defeat a category of threat types for effectiveness assessment or comparative analyses between mechanical clearing systems. Testing over a flat, level surface, in a straight line provides a comparable and repeatable baseline for advance analysis for expanded assessments.

NOTE: The use of standardized targets, instrumentation, and testing procedures establishes a methodology required to provide a realistic and repeatable assessment. Throughout testing, the use of coded identifiers for systems under test, targets, depths, and other testing parameters permits the testers to maintain data, summaries, and interim reports as unclassified. However, at some point, the testers must identify all the specific elements associated with testing particulars which could render effectiveness data classified; caution must be observed when documenting individual elements and their associated test parameters and the combination of these data elements may raise the classification level as outlined in Appendix G. Examples of these elements, may include the following, but are not limited to:

(1) Listing the performance/effectiveness results for each specific SUT.

(2) Detailed information on the targets.

(3) Depths used for testing for each target configuration.

(4) How each system performed against each target configuration (e.g., specific SUT effectiveness against a specific pressure plate improvised explosive device (PPIED) threat type at a specific burial depth).

2. FACILITIES AND INSTRUMENTATION.

For testing MRSs, the evaluation agency may consider testing over a range of climates in a variety of soil types and conditions, which may require the use of test facilities in different environments to cover all possible tests. A range of targets, which represent the identified threat, should be available to help support testing. Photographic and video equipment are necessary for recording pictures and films of the test items, testing procedures, and test execution. All instrumentation used for testing must be calibrated using devices maintained IAW established standards.

2.1 Test Facilities and Conditions.

The test facility shall provide suitable test lane(s) of sufficient size, conditions, and ground support maintainability to provide repeatable data IAW this TOP. In addition, the facility should be able to provide adequate maintenance support for the MRS and PMs, or have the SUT Field Service Representative(s) on site to perform any needed maintenance actions.

2.2 Test Assets.

The following test assets are required to complete MRS effectiveness testing IAW this TOP:

a. MRS test assets (customer supplied) for effectiveness assessment.

b. Test targets consist of measureable and repeatable mechanical, electrical, or energetic elements for data acquisition scoring (see Appendices C and D). If the tester has a supply of viable targets or if they are test sponsors assets, they must be presented to the U.S Army Test and Evaluation Command (ATEC) System Team (AST) for concurrence to be representative targets for an effectiveness assessment.

c. PM(s) of the same variant, condition, and configuration loaded to the same weight (e.g., combat load) and at the same specified adjusted tire pressure for each MRS tested. A single PM can be used at the discretion of the Test Sponsor and/or evaluation team.

d. Examples of tools, equipment, and supplies for the following execution phases:

(1) Lane Preparation for secondary dirt roadways (e.g., ground drag, soil tiller (down to about 4 inches), compactor, watering mechanism, etc.).

(2) Lane Readiness (e.g., shovels, rakes, picks, rope, location marker stakes, etc.).

(3) Test Execution (e.g., white marking boards, permanent and dry eraser markers, radios, etc.).

2.3 Instrumentation and Support Equipment.

The following instrumentation are recommended to conduct MRS effectiveness testing IAW this TOP.

a. Photographic and video equipment.

b. Data acquisition equipment (per target manual or instructions).

c. Vehicle speed measurement equipment/devices (measurement error must not exceed ± 0.1 miles per hour (mph)).

d. Soil characterization tools (e.g., for measuring soil compaction, moisture, and characterization, etc.).

e. Surveying and measuring equipment (for accurate recording of the layout of the test site and location of targets before and after testing).

f. Passive or optical sensor (e.g., video, laser, infrared, etc.). to determine when the PM/MRS systems crosses over each target on the lane to show engagement event.

3. REQUIRED TEST CONDITIONS.

3.1 Prime Movers and Test Components.

Test teams must ensure the MRSs and PMs are ready for effectiveness testing by doing the following:

a. Adjust the vehicle load to desired test weight, meeting the SUT specifications for vehicle combat load, weight distribution, tire pressure, operating conditions, etc.

b. Ensure that the PMs and the MRSs are operating properly and within recognized specifications for each MRS in its test configuration. The MRS must be operating at the correct range of ground down-force, equal wheel loading, proper mechanical and electrical interface between MRS and PM, etc.

3.2 Test Lane.

Test teams must ensure test lanes meet size required for the intended target layout and size of MRS SUT, as well as, for secondary gravel roads, eliminating the wash-board effects, excessive pot holes openings, soft patches, etc.

3.2.1 Target Layout.

Appendix A contains an example target layout pattern for effectiveness testing.

3.2.2 Specific Terrain.

The lane is to be flat and level within tolerances specified or agreed to by the Test Sponsor and/or evaluation agency. Test lane should correspond to a road surface composition configuration, such as, paved, asphalt, compacted gravel, compacted dirt, etc., because the terms primary and secondary do not identify composition of road. The Test Sponsor and/or evaluation agency shall specify and/or concur with the road, soil type, and condition for test conduct.

3.2.3 Soil Characteristics for Improved, Controlled Test Lane.

Test facility shall determine methods required to maintain lane consistency so as to provide repeatable data IAW this TOP. The following test lane soil characteristics shall be documented during effectiveness testing:

a. Soil condition (e.g., dusty, muddy, rocky, frozen, packed, tilled, soft, hard, etc.).

b. Surface material (e.g., gravel, sand, loam, clay, etc.).

c. Vegetation (e.g., none, grass, etc.).

d. Soil moisture content. (Maintaining consistency from the beginning to the end of each test phase.) The Test Sponsor and/or evaluation agency must agree to a specific range of soil moisture content for test execution.

e. Soil density. (Maintaining consistency from the beginning to the end of each test phase.) The Test Sponsor and/or evaluation agency must agree to a specific range of soil compaction for test execution.

3.2.4 Meteorological Conditions.

Ambient, outdoor conditions shall be recorded (e.g., temperature, humidity, wind, rain, etc.).

3.3 Instrumentation Readiness.

Test team must prepare instrumentation readiness before effectiveness testing is conducted by doing the following:

a. Ensure all sensors, targets, and other instrumentation devices are calibrated and in proper working order.

b. Verify soil characterization equipment is available and in proper working condition.

c. Confirm data acquisition systems are programmed properly and when connected to specialized test equipment (e.g., targets), have secure continuity, proper data storage and output format, and at the correct scale/units.

d. Check video to verify field of view adequacy to capture required imagery, and verify extra camera batteries are available and/or recording media.

3.4 Sample Size.

a. A test team must determine how many encounters (sample size) are required before developing the test matrix. Capability and requirements documents may or may not provide all the information needed; therefore, several key pieces of information are required before a sample size can be determined. Consider the following questions:

(1) What test categories are required (target types, target depths, road types, etc.)?

(2) Is there a success rate requirement and if so what type of statistic is needed (percentage or reliability)?

(3) How many unsuccessful encounters are acceptable?

(4) Has the customer/evaluator provided a test matrix with sample sizes for all the test categories?

b. The reliability success rate is often confused with point percent success rate as it is stated as a percent reliability. The binomial distribution, along with the lower confidence level, are used to calculate percent reliability. A binomial distribution is used as the success rate of the MRS having only two independent outcomes: activated or non-activated. Encounter size examples are presented in Appendix H and shows sample sizes for the number of encounters using SUT reliability requirements associated with various confidence levels. These can be used in planning an effectiveness execution scope, but a statistician should calculate the required sample size of encounters required for the particular MRS under test.

4. TEST PROCEDURES.

This section discusses how to conduct the MRS effectiveness tests including inspections, preparation of instrumentation, preparation of test facility (lanes) and targets, pre-test data collection, test conduct, and post-test data collection. Sample procedure checklists and data sheets are contained in Appendix B.

4.1 Pre-Test Inspections.

a. The test team performs pre-test inspections of the MRS, the test equipment, and any related equipment utilized in the test IAW ITOP 04-2-526[1**] (paragraph 4.1). Photograph the system(s) configuration over 360 degrees around the SUT PM and its ancillary components for documentation and component referencing.

b. The test team performs the following:

(1) Install ballast weights inside the PM to increase overall weight to specific combat load; distribute the ballast weights throughout the PM vehicle as required. (The combat load is the weight determined that the PM would be equipped to during tactical deployment.)

** Superscript numbers correspond to Appendix J, References.

(2) Measure and record the weight of the overall SUT(s), in static and operational protection modes (e.g., down force, dead weight, retracted, fully extended, etc.) with the assembly attached to the vehicle, and with only the assembly resting on the scale.

4.2 Preparation of Instrumentation.

The test team will prepare all instrumentation and support equipment following procedures prescribed by this TOP, or other standardized procedures (e.g., ITOPs, Standard Operating Procedures (SOPs), etc.). Various type of instrumentation can be used to provide the required data elements; examples of recommended types of instrumentation for effectiveness testing are as follows:

a. Laser "break" beam. Install the laser apparatus and reflector on stakes at each target location (Figure 1). Targets are located between a pair of stakes along the lane. The test team uses the lasers as indicators in the plotted data to identify when the MRS and PM wheels pass over the targets. The target activation and laser signals are both digital pulse indicators that can be synchronized and merged together into a single graphical plotted chart. This will show if the PM, or SUT, activated the target; these plotted signals are discussed on paragraph 5.2. The laser signals can also be used to calculate the SUT speed at various intervals. Figures 1 and 2 show examples of a laser sensor array setup.

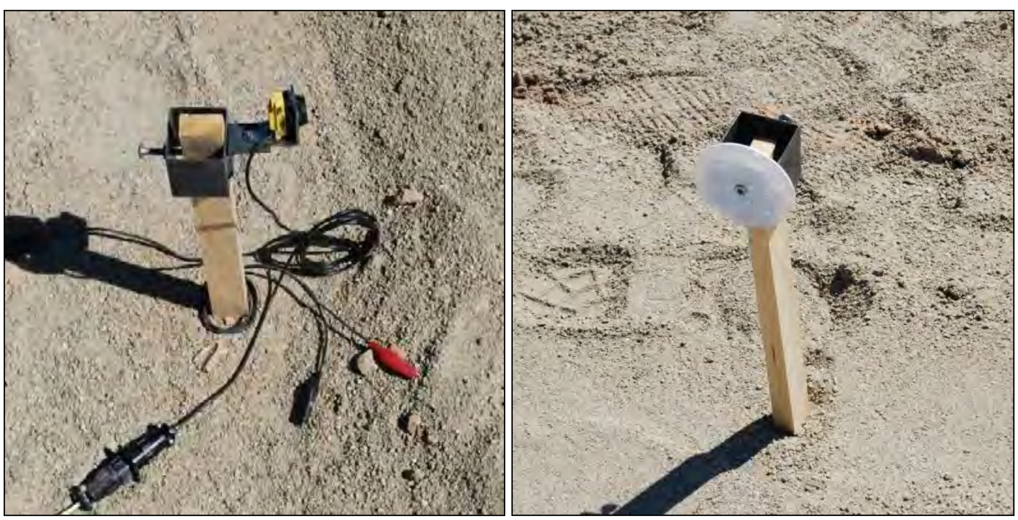


Figure 1. Laser sensor (left) and reflector (right).

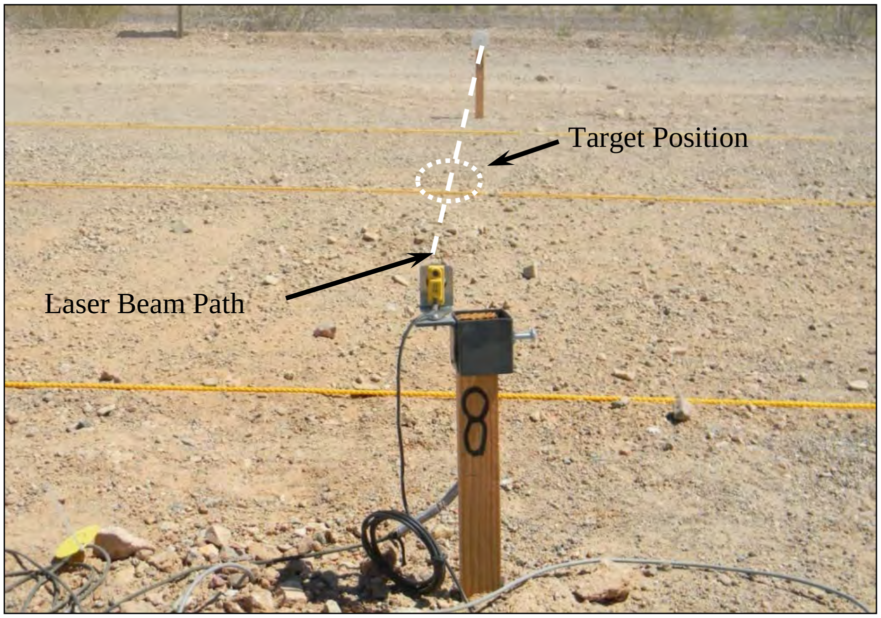


Figure 2. Laser sensor to indicate passage of systems over the target.

NOTE: Test teams can also use a video array to monitor SUT passage over targets. Precise activation of encounter and target activation must be synchronized and time stamped to permit determination of SUT component activation of target (e.g., PM or MRS).

b. Velocity Radar. Set up the instrumentation to determine speed (e.g., radar guns, laser break beams, video arrays, etc.) per the device Operator Manual (OM) and/or test plan. For Doppler radar, install at the end of the lane to monitor the velocity of the SUT as it travels through the entire test lane. Figure 3 shows a Doppler radar mounted on a tripod at the end of a test lane. The Doppler speed data reflects an average velocity (mph) over the entire lane. Having the velocity plotted over the entire run allows the tester to valid that the effectiveness run being executed was at the proper speed; if parts or the entire run were not at a valid speed, it can be identified as a No Test run and not counted. This run would have to be repeated.

Figure 3. Example of Doppler radar used for velocity measurements.

c. Global Positioning System (GPS) Speed Indicator. Use a GPS speed indicator display in the interior of the vehicle cab to provide the operator an accurate velocity speed while driving the PM (Figure 4). Most PM's speedometer may not be adequate for the operator to execute exact speeds needed for this controlled assessment. Typically, combat vehicle's speedometer dial display typically shows increments of 20 mph (e.g., 20, 40, 60 mph, etc.) or similar. The operator should use this GPS velocity indicator which is more accurate at smaller increments (e.g., 1 to 5 mph increments) to maintain the required test speed.

NOTE: Effectiveness testing must maintain controlled speed parameters for standardization and comparative assessment. Testing speeds may not represent user operational modes.

Figure 4. Operator display of a GPS velocity indicator.

d. Target Data Acquisition. Characterize threat target data acquisition instrumentation as outlined in paragraph 4.3.2 and in Appendices C and D.

4.3 Facility and Threat Target Preparation.

4.3.1 Preparation of Test Lanes.

Prepare test lane(s) by burying targets in manner and layout as defined by this TOP and concurred by the Test Sponsor and evaluation agency.

a. Prior to target burial, the test lane and ground surface should be prepared.

(1) Primary Road (paved, asphalt, etc.). Cleared, loose debris removed, pot-holes filled, etc.

(2) Secondary Road (compacted gravel or soil). Watering, compact, graded to remove wash-board irregularities, repair pot holes and soft spots repaired, etc.

(3) Off-Route (prepared ground). The test team conditions the ground (e.g., till, grade, water, compact, etc.) as requested by the Test Officer and/or testing parameters using methods developed by test facility to maintain consistency, and to monitor required compaction and ground testing parameters.

NOTE: The MRS effectiveness testing cannot maintain compaction consistency on secondary dirt lanes without lane maintenance. Therefore, the Test Team must perform MRS test on prepared ground. Native soil characteristics may not meet testing parameters for compaction. To maintain the lane uniformity throughout testing, the test team must prepare the lane by loosening the ground via a custom drag or disk to a depth of about 4 to 6 inches, spray water over the entire surface allowing the moisture to penetrate throughout, and compact the loose, moist soil using a road compactor. This should be performed after each run to maintain consistency throughout testing and prior to the burial of the next set of targets. Figure 5 shows examples of dragging/ripping equipment, watering system, and the type of road compactor that could be used.

Drag/Rip Watering Compacting

Figure 5. Example of equipment used to prepare the off-road lane.

b. Set up target data acquisition instrumentation at the test site (example shown in Appendices C and D). Identify and mark the path that each PM driver must follow; install visual boundaries like rope or chalk to identify the lane boundaries (see Figure 6). This permits the driver to stay within the target array for maximizing target engagements.

NOTE: Effectiveness testing is dependent on the number of target encounters; therefore, optimizing each run to engage all possible targets is essential.

Figure 6. Example of test lane boundary (yellow rope and target marker stakes).

c. Identify and mark the target locations IAW procedures as defined by Appendix A (random distribution) and as directed by the Test Officer with concurrence from Test Sponsor and/or evaluation agency. A string line and target markers are used (see Figure 7) to locate target positions when buried to assist in scoring after the overpass by the MRS/PM. Figure 8 shows examples of target positioned marked by a tag that locates the center of the target, as well as, the edges of the fuzing mechanism. The marker should use a code to identify the target buried at that location. The smaller ribbon clips identifies the edges of the fuze location to determine SUT or PM tire engagement over the target.

Figure 7. Example of lane with target markers.

Figure 8. Example of target markers for buried targets (center with number (target identification), and ribbon on fuze edges).

NOTE: Ribbon on target fuze edge indicator provides enhanced visual for photographic documentation as shown in Figure 8.

d. Target Burial. The test team should standardize the target burial procedures by using specifications outlined in this TOP for roller burial configurations.

(1) Roller Target Burial Requirements (non-destructive): To maintain a consistent fixed depth, test team should emplace targets on a rigid base and connect the instrumented electronic/mechanical targets via trench to the data acquisition instrumentation cables. Testers using a rigid base for a fixed depth (shallow or deep) saves time and maintains depth accuracy when targets must be removed after each run. The tester would use the fixed depth configuration for a series of runs, then lower or raise the depth per the required run series test matrix, as required. This configuration becomes important when targets have to be removed/replaced after each run for replacement or refurbishment. An example of a rigid base configuration consisting of gravel, plywood, and sand is shown in Figure 9.

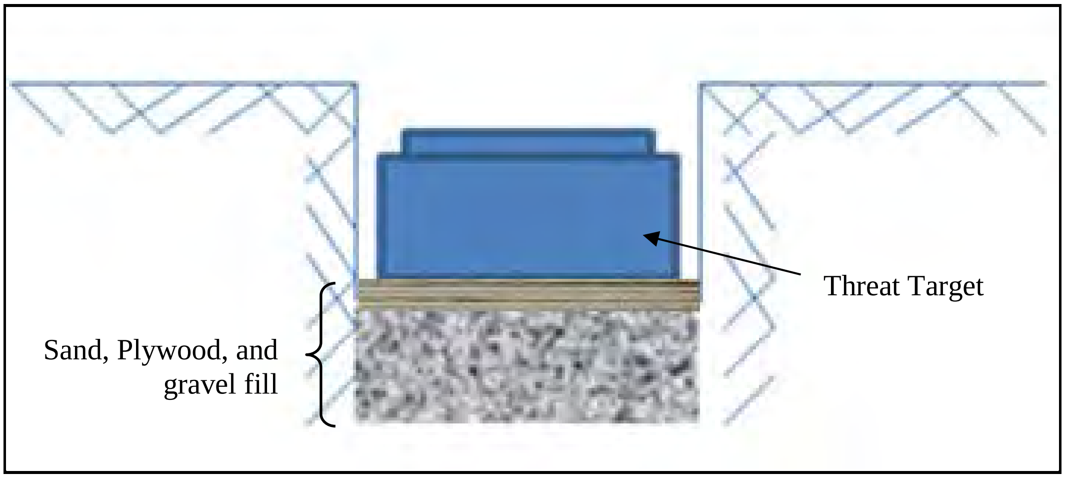


Figure 9. Example of a target hole base configuration.

(a) Dig holes to meet the correct test matrix burial depth, to include the target height and overburden of soil material (overburden is the amount of soil over top of target, also commonly referred to burial depth). The gravel, plywood, and sand shoring shown in Figure 9 support the requirement to maintain a consistent depth during testing (targets repeatedly being recovered and reburied). Each hole for each target should have common specifications. An example of the hole configuration is as follows:

1 Approximately 4-inches larger on each side of the largest targets for that category (e.g., 18-inches diameter for round targets; 12-inches by 24-inches for rectangular PPIED targets, etc.).

2 Compacted gravel fill with a minimum 6-inch depth (adjusted to ensure target has correct burial depth to meet matrix specifications).

3 3/4-inch plywood cut to the shape of hole based on target configuration to provide a rigid base for target to rest on.

4 1/2-inch sand cushion for target placement.

(b) Figure 10 shows examples of finished holes with plywood shoring and target in place. Not shown is the gravel base as shown in Figure 9.

Figure 10. Roller typical target emplacement configuration (on plywood and gravel base).

(c) Bury the cables for instrumented targets at an approximately 30 degree angle downstream of the direction of travel (see Figure 11). This prevents the roller system from oscillating (e.g., bouncing over) over the wire trench and possibly the target while being engaged, or potentially dipping into the cable trench when encountering the target. Having the cable trough downstream of target makes the lane direction, having SUT engage target before any affects from backfilled cable trench. The wiring from the target to a data acquisition system should be of equal wire thickness and adjusted lengths as determined by Test Officer and/or instrumentation technician to ensure data acquisition system compatibility of signal strength from each position and cable run. Portions of wires shall be buried as determined by the test technician to protect the data cables from damage during roller overpass. Voltage signals generated from each target should be checked to the data logger and storage media prior to burial of the target and wire. For this process, the testers should use in inspection sheet to document checkout similar to the Target Pre-Run Inspection Sheet (Table B-6) shown in Appendix B.

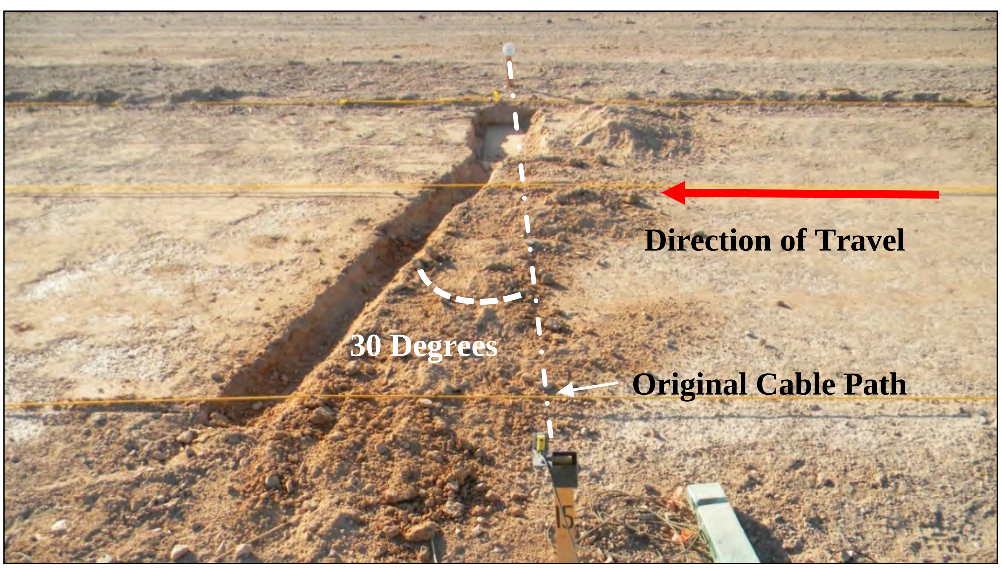


Figure 11. Roller testing, cable trench at 30 degree angle to direction of travel.

4.3.2 Effectiveness Threat Targets.

Effectiveness testing requires target consistency and repeatability to validate effectiveness scoring. A controlled target configuration must be used for the duration of the scored matrix runs. For MRS testing, two target categories must be considered: landmines and PPIED, and possibly at varying standardized testing depths (e.g., 0.5-inch and 2-inch overburden). Other types target configurations may be used, but must be validated by the intelligence community, and concurred with by test sponsor and evaluator. Appendix C has information and operational features of targets that have been successfully used in support of effectiveness testing.

a. Instrumented Landmine (electronic sensors)(reusable). Examples of reusable Surrogate Mine (SUM) landmines are shown in Figure 12.

Figure 12. Antitank surrogate mines electro-mechanical instrumented tools.

b. PPIED Trigger (electronic circuit)(single use). Examples of single use PPIED triggers are shown in Figure 13.

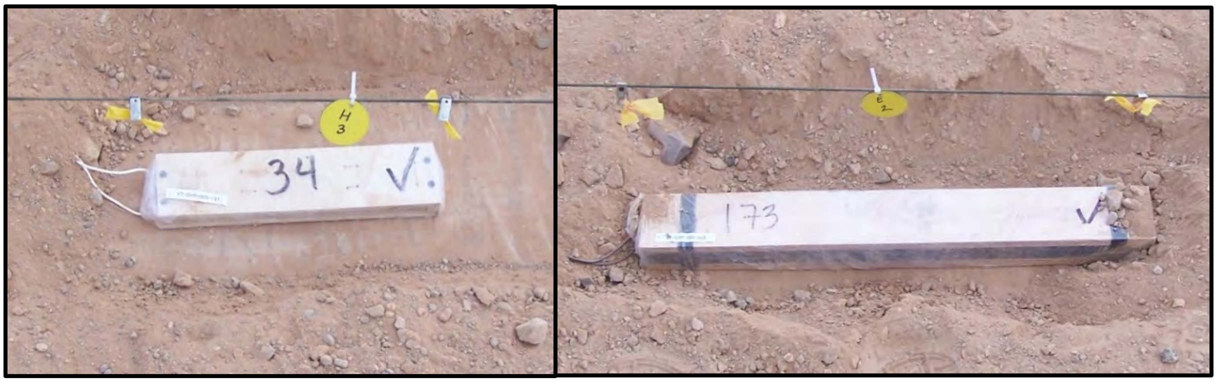


Figure 13. Examples of the pressure plate trigger devices.

c. Functioning Surrogate Landmines (energetic (smoke) or mechanical). An example of a surrogate landmine is shown in Figure 14.

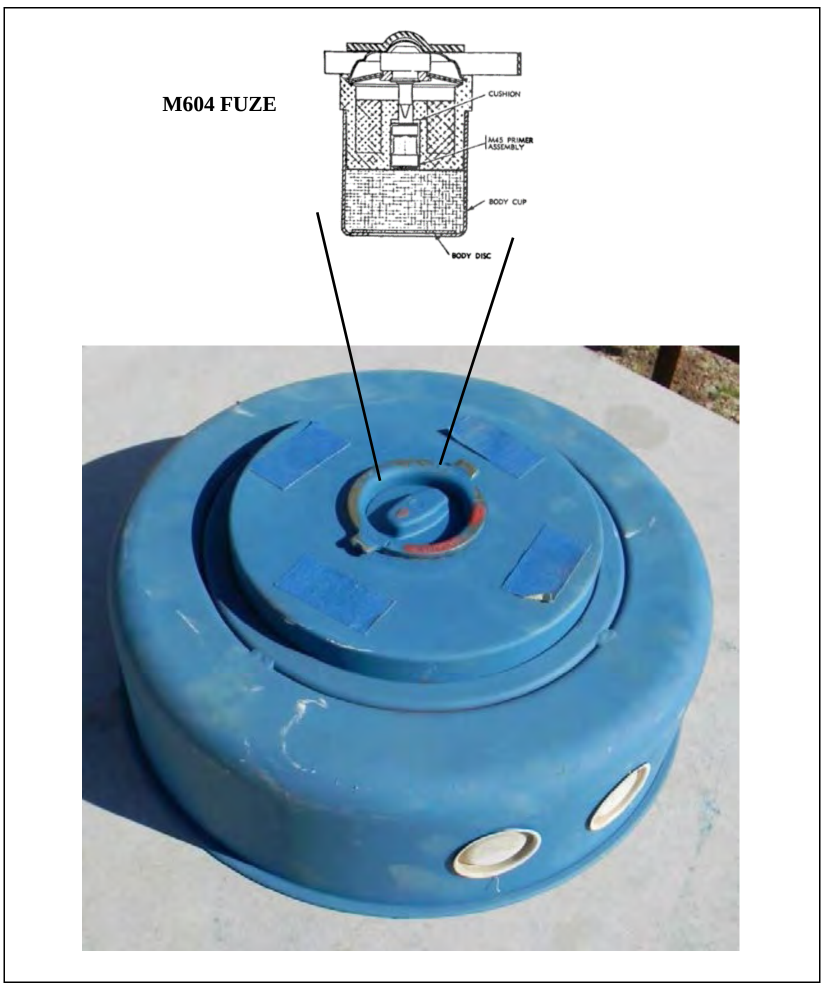


Figure 14. Mine, Practice, M20 (Smoke Charge) with M604 Fuze.

d. Other. Trainer Aids that use lights, powder, and/or acoustic indicators are also used in effectiveness testing as long as they are an equivalent replication of actual threat targets.

4.4 Pre- and Post-Test Data Collection.

a. Preparation of data collection forms.

(1) The test team must develop the following example data sheets to manage and collect the required data elements throughout the effectiveness test:

(a) Test matrix tracking sheet.

(b) Target functional check sheet (pre-run).

(c) Test Officer data sheet (post-run with post target functional checks).

(d) Scoring data sheet.

(2) Examples of field data collection forms are provided in Appendix B. Personnel should modify the example forms as necessary following execution of a recommended Pilot Test if it's determined additional data elements are required, and/or if ways to streamline the manual data collection process are identified (e.g., adding in optional choices versus having to hand write repeated data, etc.).

b. Identify and record soil characteristics.

(1) Document soil description IAW American Society for Testing and Materials (ASTM) D2488 - 09a[2] (particle identification).

(2) Soil moisture content (IAW ASTM D2216 - 10[3]); a measurement shall be taken from at least 5 locations equally spaced along the length of the test lane. Otherwise, daily pre-test and post-test samples shall be taken for later analysis and documentation. Moisture measurements should be taken periodically throughout the day, and possibly more frequently if water and ground work conditioning is implemented between runs.

(3) Soil density (IAW ASTM D6938 - 17[4]); a measurement shall be taken from at least 5 locations equally spaced along the length of the test lane. Density measurements should be taken periodically throughout the day, and possibly more frequently as ground work conditioning is implemented between runs.

c. Observe and record ambient weather conditions: air and ground temperature, wind direction, humidity, and rain.

4.5 Test Conduct.

The procedures in this TOP use a first-strike method (initial impact). After each test run, the targets will be recovered. If applicable, the data will be recorded, and the targets reconditioned or replaced, and reburied per the directions of the Test Officer. Specific, controlled test speeds shall be specified in the test plan. Multiple SUTs (PM, PM/MRS, etc.) shall alternate throughout the conduct of the test. The following describes test conduct to evaluate one, two, or more MRSs during a common event.

4.5.1 Test Run Readiness.

a. Prepare test lane as described in paragraph 4.3 and Figure 15.

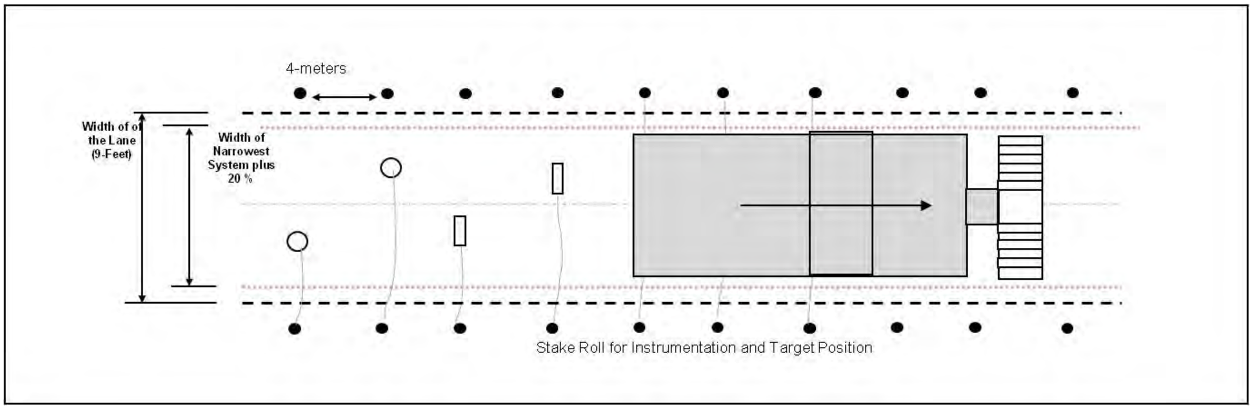


Figure 15. Lane example of roller target types: mines and pressure plate-triggers.

b. Dig holes and wire trenches IAW procedures outlined in this TOP and depths identified by the SUT test plan. The test plan should identify threat target burial depth for the MRS SUT, and if it does not, these depths must be obtained from test sponsor and/or evaluation team. After the holes have been prepared in the pattern provided in Appendix A, place the threat target in each hole.

c. Targets.

(1) Electronic Circuit Targets.

(a) Conduct pre-arm/target functionality/reset procedures on each target by following a procedure specified in the target instructions.

(b) Take documentation photographs of each target inside burial hole and include a target position measurement referenced to a set datum line as shown in Figure 16.

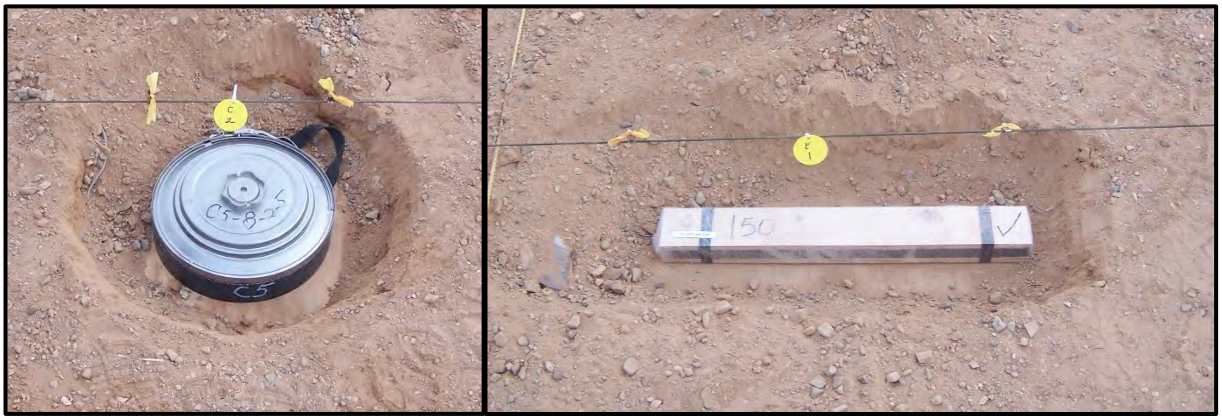


Figure 16. Example of documenting target identification (ID) and position markers.

(c) Walk the lane from target to target as shown in Figure 17 filling in a pre-run inspection data sheet documenting target type, lane location, target serial number, and target burial depth.

Figure 17. Documenting target information prior to burial.

(2) Energetic and Mechanical Threat Surrogate Targets.

(a) Prepare target body for test IAW procedures specified by the target Technical Manual (TM) and place in its designated hole.

(b) Take documentation photographs of each target within burial hole and include a target position measurement referenced to a set datum line (Figure 18).

Figure 18. Typical target emplacement in test lane.

(c) Fill in data sheet identifying type, serial number, and burial depth for each target.

(d) For energetic targets, tester should clear area of unnecessary personnel and have only certified Explosive Ordnance Technicians place and arm energetic fuze in target IAW procedures specified by the target TM.

(3) Finalize target burial as defined by the Test Sponsor and/or evaluation team; bury each target after being photographed and documented. After burial of targets, lightly rake or dust soil over targets to provide overpass witness media (soil over target) to record target engagement location (Figure 19).

Figure 19. Typical lane raking and preparation for run.

4.5.2 Effectiveness Run Execution.

a. Drive the first SUT (PM/MRS) through the test lane at the prescribed speed specified in the test plan and/or test matrix.

b. Record test data manually and electronically.

(1) For the manual test data collection, use example data sheets shown in Appendix B.

(2) For the electronic test data collection, save data to an appropriately named file.

c. If energetic targets are utilized, have Explosive Tech personnel perform or assist with inspection for hazards and/or indications of a functioned M604 Fuze, prior to target scoring personnel accessing target positions to document findings.

d. Take documentation photographs of each non-activated and missed target locations.

e. As a supplement for photographs, record the overpass coverage information (MRS and PM tire tracks) from the witness media on top of target in tabular form on the data sheet (Appendix B), using one side of the lane as reference (datum line) for measuring each MRS and PM tire tracks.

4.5.3 Post-Run Lane Inspection Assessment.

The test team should perform the following for each test position and configuration for post-run lane scoring analysis.

4.5.3.1 Engagement Status.

The post-run scoring team must determine for each target position if the SUT engaged the target. This is evident by the SUT footprint (wheel bank and/or PM) over the target area (witness media). The target markers and edge indicators provide the outline of the target. Personnel will initially score the engagement as follows:

a. Full Engagement (>50% of target): SUT footprint over center of target.

(1) Activation.

(2) Non-activation - photograph required.

b. Partial Engagement (<50% of target): SUT footprint over part of the target.

(1) Activation.

(2) Non-activation - photograph required.

c. Missed (scored as No Test): SUT footprint misses (engagement of less than 50% or more) - photograph required.

4.5.3.2 Photograph Documentation.

The test team will photograph targets for each non-activated full or partial engagement and missed targets to document coverage of the SUT engagement “footprint” over the target position. (NOTE: Photographs of targets that were successfully activated are not required except as characteristics photographic documentation.) For post-run, scoring personnel should use a marker board in each photograph view to show the buried target’s virtual location, as well as the tire/roller wheels over the target. Figure 20 shows an example of the target position markers and post-run information board containing the tire locations of the SUT for better enhancement of SUT footprint on target location for post analysis photographs.

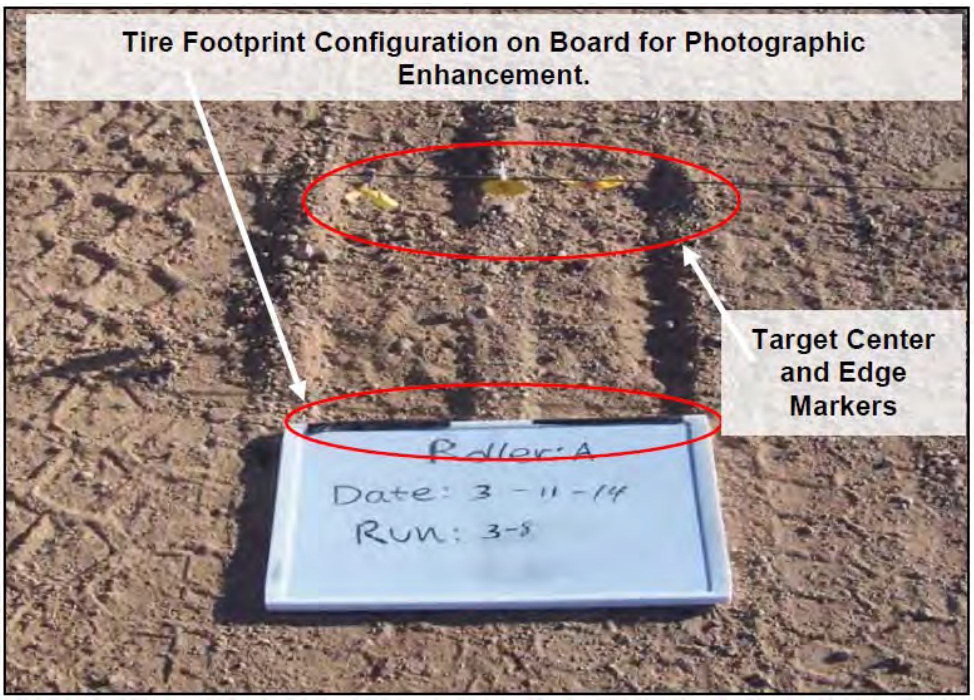


Figure 20. Example of post-run photograph of the target markers/information board with roller/prime mover wheel indicators over target position.

4.5.3.3 Post-Run Target Functionality Verification.

a. The Lane Scoring Team performs post-run target inspections of each target on the lane to verify it was engaged and activated by verification of at least one of several activation indicators depending on the target type/configuration (e.g., electronic, visual, acoustic (energetic components), etc.). A post-run target inspection scoring decision tree sheet for each target engagement is provided in Appendix B.

(1) If the SUT engaged a target, and activation data were verified by the data acquisition system, nothing more is required for that target position; inspection personnel go to the next target position.

(2) If the test team determined the target location was fully or partially engaged (evidenced of the SUT tire footprint), and no activation indicators were recorded, the target must be checked to determine the target functionality to validate a score.

(a) Non-Activation. If target(s) are not activated, the target(s) still must have the ability to be functional after the run to justify a non-activated engagement score. The Lane Scoring Team must attempt to activate each target manually (e.g., by stepping on, if possible and safe), in an attempt to register an activation on the data acquisition system. If target is manually activated, personnel will score target position as non-activated.

(b) If target cannot be activated to validate functionality and no other damage or discrepancies were noted, personnel will score as a “No-Test”, unless mechanical measurements can be determined once target components have been recovered for measurements.

NOTE: The tester must validate the quality of the data by confirming that the target is within operational parameters before engagement run and still operational when checked in post-run assessment.

b. Electronic Data Check. During a post-check, if applicable for the target type, personnel will activate target to register a voltage indication on the data acquisition instrumentation or indicator. This confirms continuity and target functionality, and validates activated or non-activated scoring for that target position.

c. Functioning Surrogate Landmines Mechanical Fuzing Mechanism Check.

(1) Mechanical Plungers. Test team must measure the plungers for movement to determine activation or not (see Appendix D for range of deflection movement for scoring).

(2) Energetics. The Lane Scoring Team must determine the target activation status by the following: Mine (with M604 Fuze and M45 Primer). Explosive Ordnance Technicians will recover the mine from a buried or exposed position to remove and inspect the M604 Fuze for the activation of the M45 Primer. If the M45 Primer is not expended, this target is scored as Non-Activated. (NOTE: After the inspection, the test team may re-use a non-expended M45 Primer or install a new primer into the M604 Fuze well for reburial to support follow-on runs.)

(3) Trainer Aid. If not activated, personnel must manually attempt to activate the target to function training aid. If the training aid functions, this target is scored as Non-Activated. If the training aid cannot be functioned, this target position is scored as a No Test.

d. Excavate, recover, recondition, and/or replace individual targets per the test target qualification protocols and/or direction of the Test Officer.

e. If required, re-condition the lane (e.g., watering, dragging, and/or compacting) to re-establish the test lane to a pre-run condition.

(1) Check for soil compaction and moisture content.

(2) After lane reconditioning, emplace the lane with a new set of targets.

f. Reset test lane by repeating paragraphs 4.5.1 through 4.5.3.3.e, verifying target placement, soil, and surface conditions are within parameters specified by the Test Sponsor, evaluation agency, and test requirements.

g. If applicable, drive the next SUT through the test lane at the designated speed outlined in the test matrix.

h. Repeat paragraphs 4.5.1 through 4.5.3.3.e for speed specified by the test plan, alternating the PM/MRS combination used for each run set, until the required number of data points are collected (per the test plan or matrix requirement).

i. Repeat the test process specified in paragraphs 4.5.1 through 4.5.3.3.h for each MRS condition (e.g. floating (static), down-force (pressurized systems), extended, retracted, etc.) until a data set is obtained to characterize the effectiveness capabilities of the SUT MRS configuration.

4.6 Baseline Test Conduct of Legacy Systems.

The test team will perform a baseline analysis to determine if the MRS SUT performs as well as, or better than, a legacy MRS. For comparative analysis, the test will be conducted on the same test lane in similar soil conditions as the MRS SUT. Follow the test process specified in paragraphs 4.5.1 through 4.5.3.3.e.

5. DATA REQUIRED.

5.1 Data Collection Overview.

a. Overall Test Data. Document the following (example data sheets in Appendix B):

(1) Administrative data including test officer and data collector ID, test ID number, test date, MRS ID numbers, PM ID numbers, and driver ID.

(2) Test lane description, target layout in test lane, target IDs, and associated test lane ID number.

(3) Ambient weather conditions during testing.

(4) Soil characterization data (collected in Paragraph 4.4.b) (e.g., compaction, soil moisture, etc.).

(5) Average vehicle speed through lane.

b. Pre-Run Target Inspection. The test team collects data during the target inspection prior to each run; see example data forms in Appendix B.

c. Post-Run Lane/Target Results from Lane Inspection (Preliminary Score): The test team collects data during the lane/target inspection after each run; see example data forms in Appendix B. This would also include the preliminary scoring classifying the engagement (e.g., activation or non-activation, full/partial, missed, etc.). They would also document the initial determination on data forms with the following engagement assessment: full or partial engagement or missed, and confirmation target was fully operational.

NOTE: A target could not be considered a Missed Target if it was within the roller wheel coverage region to include roller bank gap; missed targets between wheel gaps, etc., but could be considered in the overall covered area for scoring.

d. Distinguish whether the MRS or PM activated the target.

e. Target/sensor output signals (e.g., force, deflection, voltage, etc.), if measured.

f. Video data of target passes. As applicable based on data acquisition and scoring methodology utilized.

g. Photographic and tabular information of PM/MRS wheel coverage referenced to a datum line.

h. The assessment scoring team would provide the final scoring as follows:

(1) Engagement - Activation / Non Activation.

(2) Partial Engagement (less than 50% coverage over target) - Activation / Non Activation.

(3) Critical Activation (target activated by PM platform).

(4) Missed (outside the footprint of the MRS/PM).

(5) No Test.

NOTE: Scoring personnel should score a missed target as a No Test for scoring analysis, and should not include it as a data point in the scoring effectiveness summary. Tactical route clearance would be the path cleared and the route identified that would be followed by follow-on mounted or dismounted traffic; targets outside this cleared path are not considered as an encounter.

5.2 <u>Electronic Data Plots - Scoring Elements</u>.

a. The scoring team must validate the electronic data captured by the data acquisition system to create the graphical plots to record effectiveness engagement of the SUT against each target. The validated plots provide the specific scoring signature elements essential to analyze and assess effectiveness. Components of the plots are as follow:

(1) Time of day of the run.

(2) Captured data signals of the target circuits (voltage output of target).

(3) Laser motion traces as the SUT engages and when the PM passes over the targets.

b. Electronic Scoring SUM Targets. The data acquisition system registers voltage levels based on mechanical movements of the trigger mechanisms within the SUM. Each target has a specific threshold (voltage or linear displacement), based on the mechanical design of the threat target (see Appendices C and D for linear displacement voltages for example SUM targets). The electronic SUMs use a potentiometer that provides voltage levels based on a linear displacement deflection, whereas, the PPIED trigger provides a closed circuit voltage.

c. Figures 21 and 22 show plot samples of the combined events outlining typical target engagement scenarios; each plot indicates when the SUT engages the target registered by voltage output of target, and laser indicator or SUT. The test team and scoring analyst must generate plots for every target engaged, and score each one for effectiveness assessments.

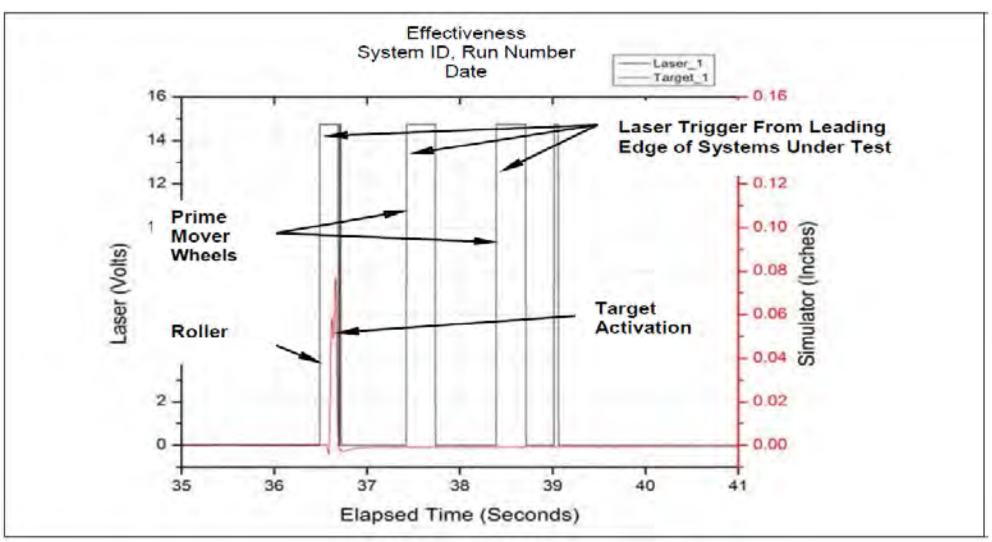


Figure 21. Example of a data plot showing a SUT with lead attachment, activating the target and the laser traces as it encounters the target.

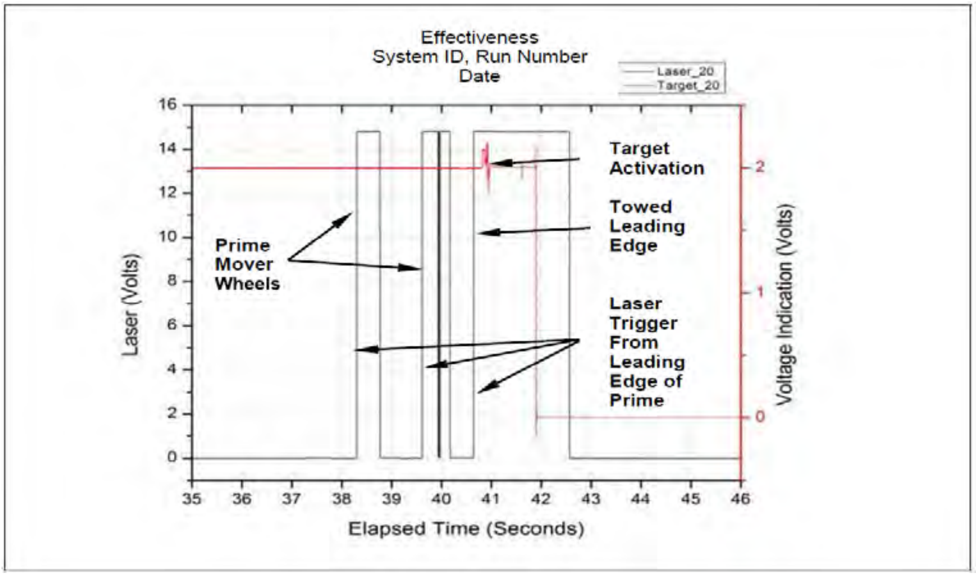


Figure 22. Example of a data plot showing a SUT with towed attachment, activating the target and the laser traces as it encounters the target.

6. PRESENTATION OF DATA.

a. The test team enters the collected data (from field data and scoring sheets) into spreadsheets and/or databases, digitizing the data to develop graphical charts and tabular data tables. After all effectiveness testing is completed, graphical and tabular presentations may be prepared to allow for singular and/or comparative analysis. Data analysis will result in the generation of tables and graphs that may include, but are not limited to the following:

(1) Overall System Effectiveness (for each MRS).

(2) Wheel Bank Analysis by System (MRS footprint).

(3) System Effectiveness by Road Type.

(4) Target Analysis by Each Roller SUT.

(5) Target Analysis by Target Type and Depth

NOTE: If testing is conducted in multiple soil types, these comparative tables and graphs should be created for each soil type as well. If the overall system effectiveness and wheel bank analysis by system tables are roll ups of multiple target types, this data are presented as point estimates with no associated confidence interval.

b. Scored Plots. The data analyst generates target encounter plots for each valid engaged target for all runs, for all systems. There may be thousands of these plots generated for every system engaging every target, which increases when operating in different road types and for the various target burial depths; these graphical images represent and is a record of each target scored event. Management of this data set is vital and critical for effectiveness analysis.

Roller Plots. The test team must have a record of each engagement documenting the target engagement to justify the engagement score. Examples of recordable engagements are presented in Figures 23 and 24.

NOTE: Figure 23 shows when the roller and/or prime mover wheels apply down force onto the SUM target, and that voltage received by the data acquisition system is plotted showing engagement. Figure 24 shows additional integration of instrumentation data of when the roller and/or prime mover wheels apply down force onto the SUM; when, and the amount of voltage received by the data acquisition system and the laser traces that indicated passage of roller and prime mover plotted showing engagement.

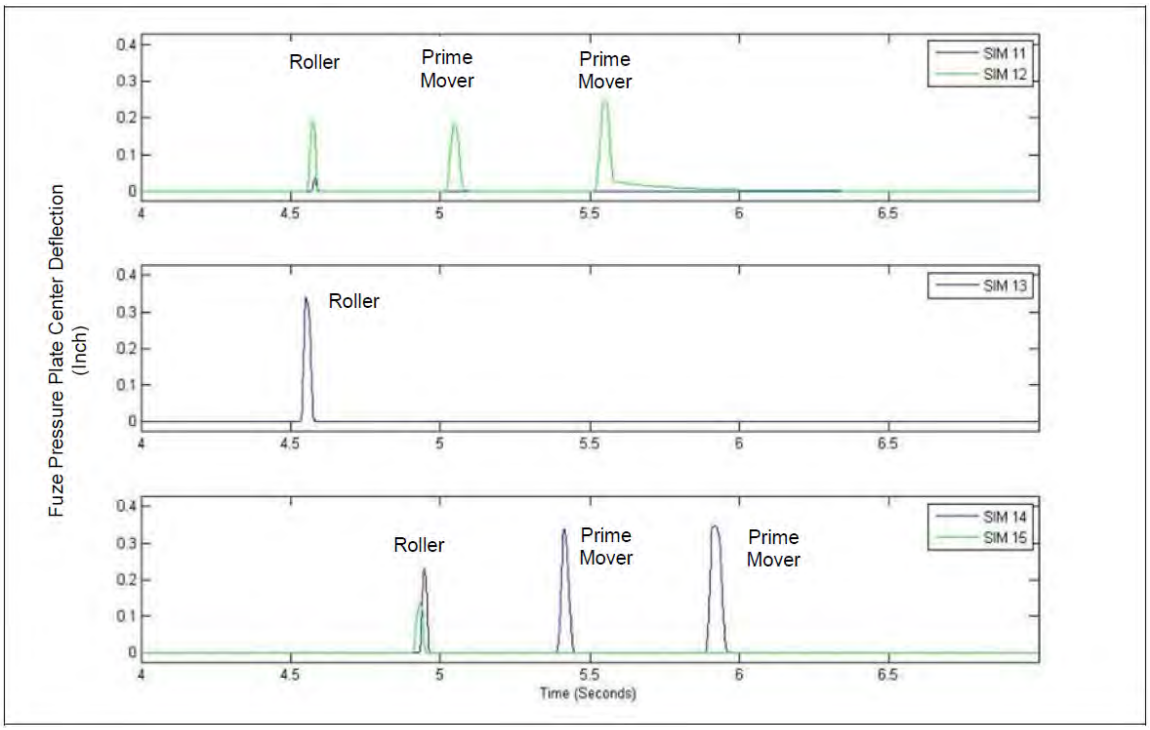


Figure 23. Example chart showing pressure plate deflections of different targets.

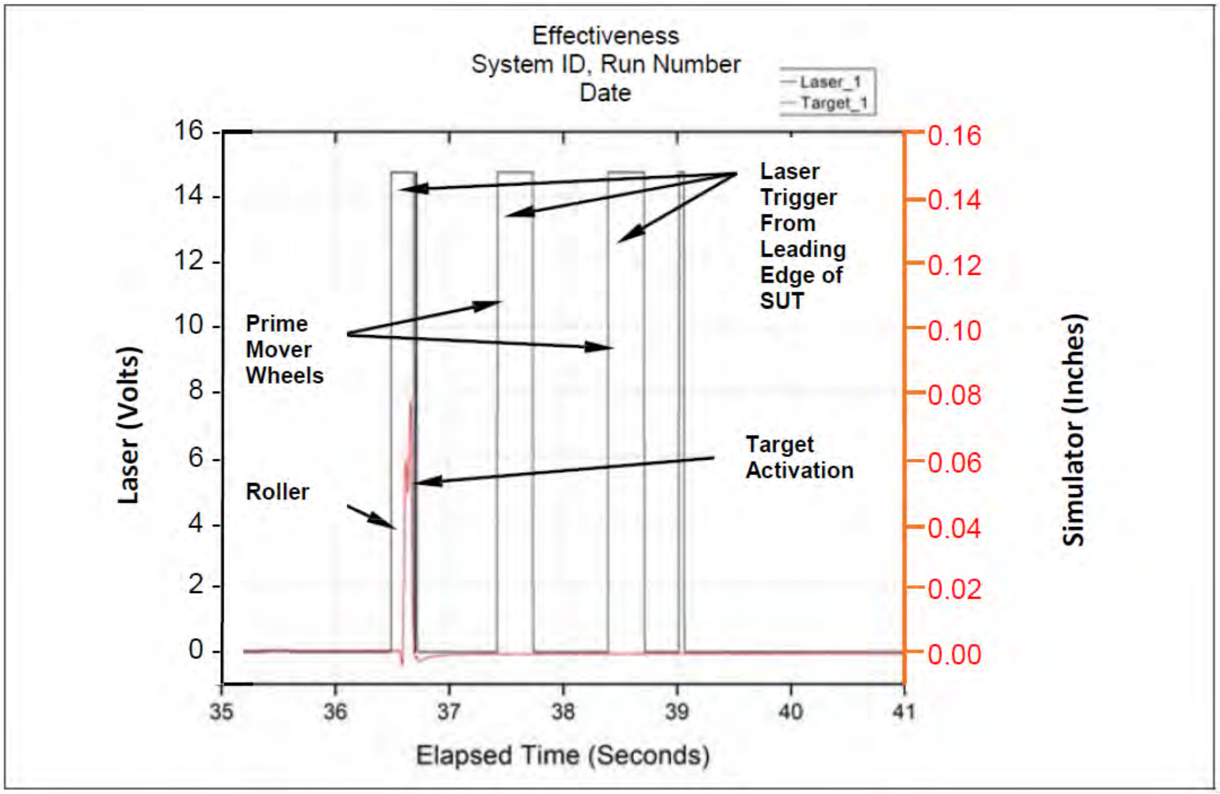


Figure 24. Example of a data plot showing when a SUT with lead attachment, activated the target and the laser traces as it encountered the target.

c. Effectiveness Summary Tables. The data analyst generates effectiveness summary tables with the scored data, verifiable by the target engagement plots. The analyst produces summarized effectiveness tables from data extracted from populated spreadsheets and/or databases. Following are examples of effectiveness summary tables.

(1) Comparative Tables. Table 1 is an example (typical format) of the comparative presentation of overall system effectiveness representative by a point estimate, and Table 2 is an example (typical format) of overall system effectiveness categorized by road type.

TABLE 1. EXAMPLE OF A ROLLER OVERALL EFFECTIVENESS SUMMARY FOR ALL ROAD TYPES, TARGETS, AND DEPTHS AND ALL TARGETS

	SYSTEM X			SYSTEM Y		
Road Type	Targets Encountered	Targets Activated	Percent Activated	Targets Encountered	Targets Activated	Percent Activated
Overall	--	--	--	--	--	--

TABLE 2. EXAMPLE OF A ROLLER OVERALL EFFECTIVENESS SUMMARY PER ROAD TYPE FOR ALL TARGETS AND DEPTHS

Road Type	SYSTEM X			SYSTEM Y		
	Targets Encountered	Targets Activated	Percent Activated	Targets Encountered	Targets Activated	Percent Activated
Primary	--	--	--	--	--	--
Secondary	--	--	--	--	--	--
Overall	--	--	--	--	--	--

(2) Data Element Specific Summary Tables. The data analyst should generate summary tables of the various data elements itemization. Following are summary table examples (typical format) of key data elements identifying coded threats:

(a) Encounter for each target type (Table 3).

TABLE 3. EXAMPLE OF ROLLER EFFECTIVENESS PER TARGET TYPE FOR ALL DEPTHS AND ROADS

Road Type	SYSTEM X			SYSTEM Y		
	Targets Encountered	Targets Activated	Percent Activated	Targets Encountered	Targets Activated	Percent Activated
PP-000	--	--	--	--	--	--
PP-001	--	--	--	--	--	--
PP-002						
PP-003						
AT-A						
AT-B						
AT-C						
AT-D						
Total						
AT = antitank PP = pressure plate						

(b) Encounter for each target type at each depth (Table 4).

TABLE 4. EXAMPLE OF ROLLER EFFECTIVENESS PER TARGET TYPE AT EACH DEPTH FOR ALL ROAD TYPES

Target Type[a]	Depth[a] (Shallow) (Deep)	SYSTEM X		SYSTEM Y		SYSTEM Z	
		Targets Activated	Percent Activated	Targets Activated	Percent Activated	Targets Activated	Percent Activated
PP-001	Shallow	--	--	--	--	--	--
	Deep	--	--	--	--	--	--
PP-002	Shallow	--	--	--	--	--	--
	Deep	--	--	--	--	--	--
AT-A	Shallow	--	--	--	--	--	--
	Deep	--	--	--	--	--	--
AT-B	Shallow	--	--	--	--	--	--
	Deep	--	--	--	--	--	--
Total	Shallow	--	--	--	--	--	--

[a] Specific identification of target type and depths makes data classified to the SECRET level as outlined in security guidance shown in Appendix G.

(3) Segregated Data Element Summary Tables: Segregated data summary tables will show data highlights of a specific data element; a second or multiple tables are developed to show variable comparisons for a specific element (e.g., shallow vs deep, primary vs secondary, System X vs System Y, Speed Effectiveness, etc.). Tables 5 and 6, and Figure 25 are examples of data segregated tables.

TABLE 5. EXAMPLE OF ROLLER EFFECTIVENESS PER TARGET TYPE FOR EACH ROAD TYPE

Road Type	Target Type	SYSTEM X			SYSTEM Y		
		Targets Encountered	Targets Activated	Percent Activated	Targets Encountered	Targets Activated	Percent Activated
Primary	PP-001	--	--	--	--	--	--
	PP-002	--	--	--	--	--	--
	AT-A	--	--	--	--	--	--
	AT-B	--	--	--	--	--	--
Secondary	PP-001	--	--	--	--	--	--
	PP-002	--	--	--	--	--	--
	AT-A	--	--	--	--	--	--
	AT-B	--	--	--	--	--	--
Total	--	--	--	--	--	--	--

TABLE 6. EXAMPLE OF OVERALL SYSTEM EFFECTIVENESS

Speed (mph)	SYSTEM X		SYSTEM Y	
	Effectiveness (percent)	Number of Data Points (Encounters)	Effectiveness (percent)	Number of Data Points (Encounters)
5	75.0	60	51.2	60
10	66.7	60	52.8	60
15	58.3	60	43.1	60
20	45.8	60	25.8	60
25	45.8	60	23.6	60

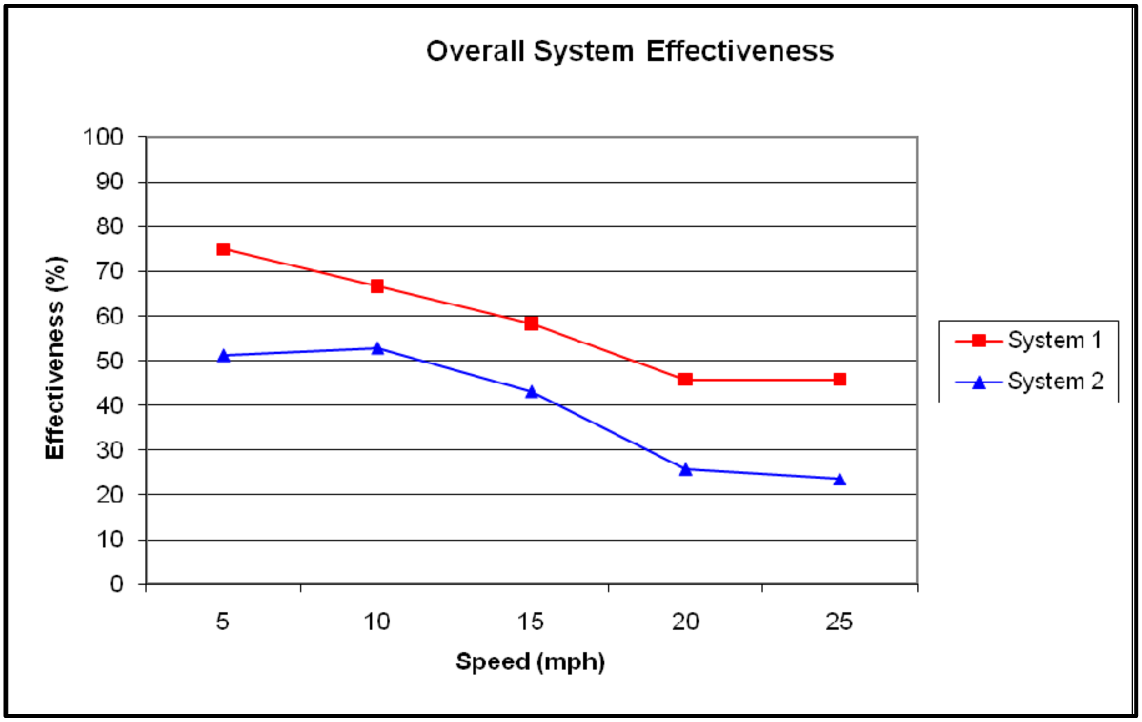


Figure 25. Example of a plot for overall system effectiveness.

d. Narrative Descriptions. The technical writer must narratively summarize the data and provide a narrative analysis with the introduction of the tables and plots to support their analysis. Examples of narrative descriptions are as follows:

Effectiveness Summary Example: "Table 27 shows the overall effectiveness of each SUT. Roller C was the most effective overall at 80.7%. Table 28 is effectiveness summary broken down by depth for each road type and all targets and depths.

Example: "Critical Activation results are summarized in tables 31 and 32. System A had the least overall Critical Activation events with an overall average of all configurations to be at 3.7 percent."

"NOTE: Critical Activation is when target is activated by Prime Mover."

6.1 Confidence Intervals.

a. If there is a need to determine confidence levels, a narrative example is provided in Appendix G.

6.2 Other Data Tables.

Additional graphical and tabular presentations of data collected may include:

a. Soil characterization information for each test lane (example Table 7).

TABLE 7. EXAMPLE OF SOIL CHARACTERIZATION COMPACTION DATA

TEST LANE ID	SOIL TYPE	AVERAGE SOIL STRENGTH READING[a] (pounds per square inch))	AVERAGE SOIL MOISTURE (percent)	COMMENTS
1	Sand	50	65	Using shovel, sides caved in.
2	Sandy Loam	49	64	Using shovel, sides stayed intact.

[a] Soil compaction measurements (density)

b. Time history of data used to determine target activation such as force/deflection seen at each target, if appropriate (example Figure 26).

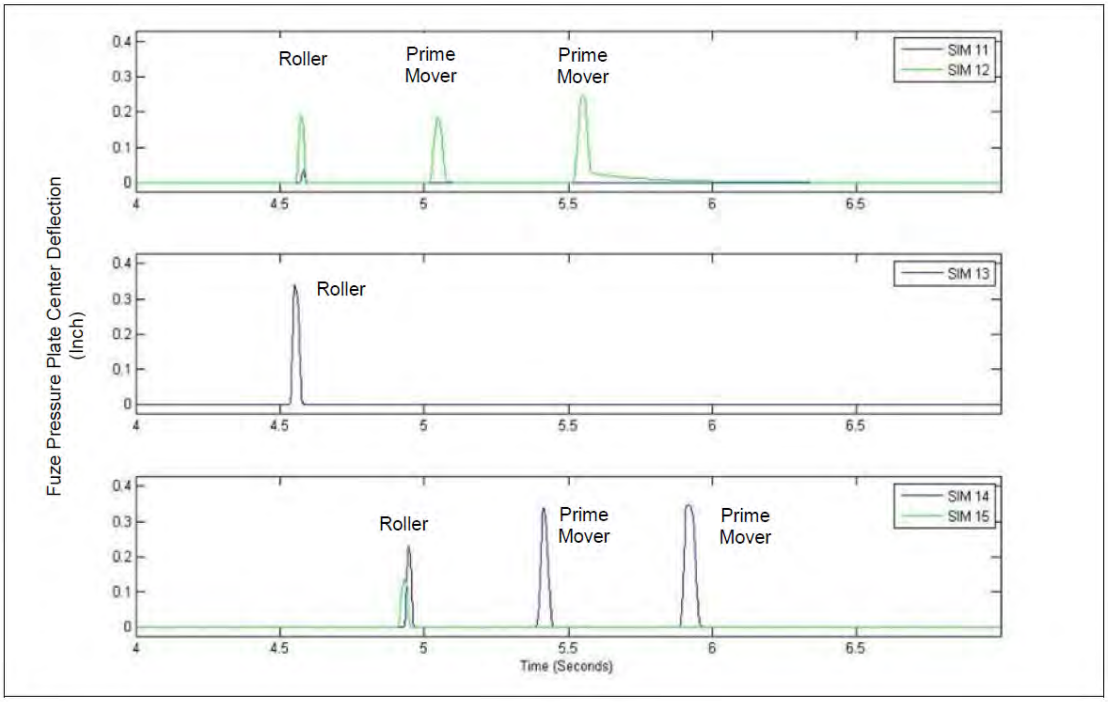


Figure 26. Example chart showing pressure plate deflections of different targets at specific time intervals along the test lane.

c. Photographs of wheel coverage (example Figure 27).

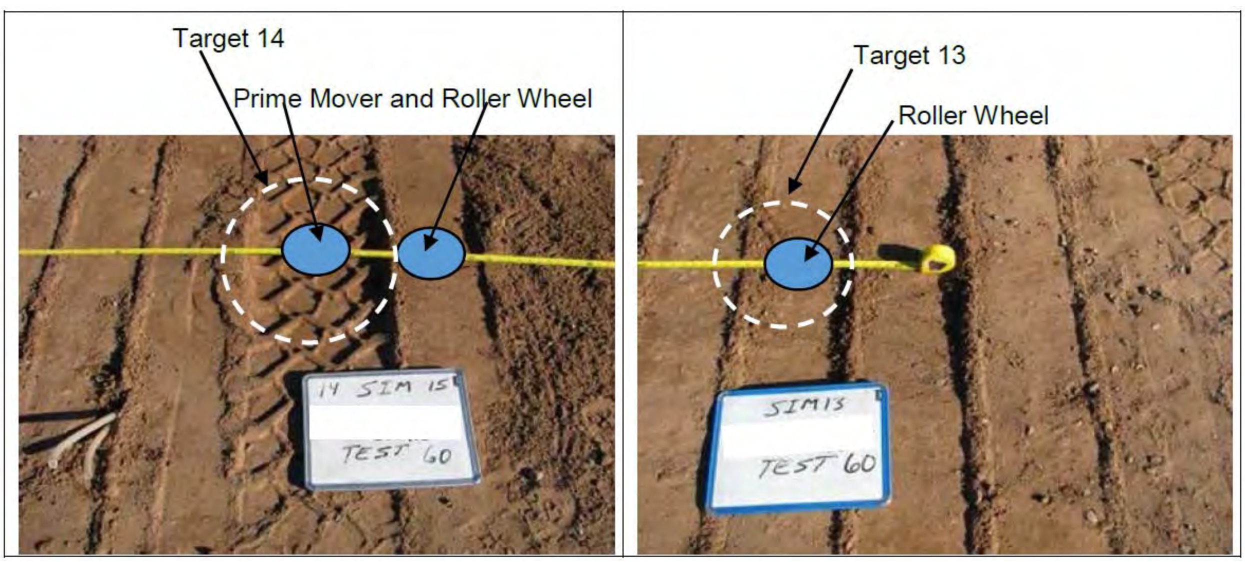
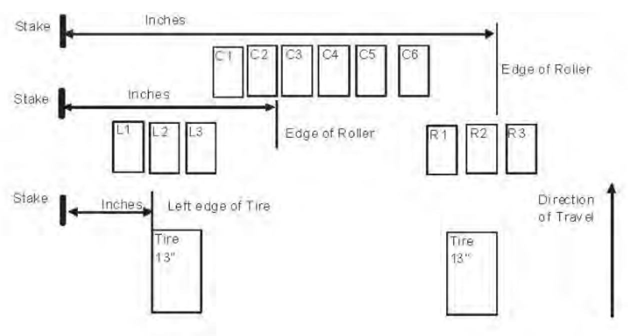


Figure 27. Example of photo documentation of coverage over targets.

d. Tabular information of wheel coverage analysis (example Table 8). Test team will take measurements from a datum (constant edge) to remain consistent for all SUTs.

TABLE 8. DATA DOCUMENTATION OF MRS TARGET COVERAGE



LEGEND:
C – Center Roller Bank
L – Left Roller Bank
R – Right Roller Bank

Run	Target A		Target B		Target C		Target D		Target E	
	Roller Section	Inch to Roller	Roller Section	Inch to Roller	Roller Section	Inch to Roller	Roller Section	Inch to Roller	Roller Section	Inch to Roller
Test #	Roller #	left edge	Roller #	left edge	Roller #	left edge	Roller #	left edge	Roller #	left edge
1	L1	133	Tire	142	C3/C4	179/189	Tire	218	R3	233
2	L1	131	Tire	142	C3/C4	177/187	Tire	218	R3	234
3	L1	133	Tire	144	C3/C4	179/189	Tire	221	R3	234
4	L1	137	Tire	146.5	C3	183.5	Tire	223	R3	237
5	L1	134.5	Tire	145	C3	181	Tire	222	R3	234*

* Comment: Roller Wheel may have been airborne (jumped over target).

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APPENDIX A. TEST LANE DESIGN AND CONFIGURATION.

A.1. EFFECTIVENESS TEST LANES.

a. One effectiveness test lane should be used for comparable simultaneous MRS testing. A run set consists of a single pass of each system at a given speed. The run order will be defined in the test plan. At the commencement of each test run set, the Test Officer shall evaluate the condition of the lane for uniform soil and surface consistency. If conditions warrant, reconditioning of the lane shall be performed only at the conclusion of a test run set.

b. The basic premises for conducting a comparative effectiveness test are the following:

(1) Targets should be buried in a consistent pattern throughout the test.

(2) Effectiveness testing is conducted to determine if the MRS will activate a target. It is necessary to determine activation/non-activation of a target by either the MRS and/or the PM.

(3) Near straight and level lanes should be used to minimize variables.

(4) With a fixed number of targets per run, variability (e.g., adding into matrix multiple depths, road type, etc.) of data increases as the number of runs increases. Consideration should be given to increasing the number of targets per run, thereby minimizing the number of runs needed to fulfill data collection requirements.

(5) Increasing the number of data points over a common target will increase reliability and confidence levels of the data.

(6) Effectiveness testing should be a first strike (initial impact) type test. Targets shall be reset/replaced in accordance with their TM after each run.

(7) Effectiveness testing should be conducted on the same soil and soil condition for each MRS tested.

(8) Effectiveness testing should be conducted over a range of prescribed speeds.

A.2. TEST LANE LAYOUT FOR ROLLER EVALUATION.

a. The following is a suggested test lane layout procedure:

(1) Choose a test lane that is at least 20% wider than the track width of the widest PM/MRS combination being tested.

APPENDIX A. TEST LANE DESIGN AND CONFIGURATION.

(2) Allow a few extra threat targets as backups when determining the target layout pattern. This will allow the replacement of a target if it becomes damaged or non-usable maintaining planned matrix encounters.

(3) To reduce burden on burial team and for ease of instrumentation, it is recommended that target be grouped by type.

b. The following is an example target layout derivation for one PM, two roller SUTs, and two target types.

c. Determine the following parameters.

(1) WMRS = Width of MRS.

(2) WPM = Width of Prime Mover (left tire center to right tire center).

(3) LW = Lane Width (120% of widest MRS) (side track).

(4) PW = Path Width (Width of widest MRS).

(5) BG = Bank Gap (narrowest distance between inboard MRS wheel tread). BG = 0 for a full width MRS.

(6) N = Total number of targets per run.

(7) n = Longitudinal location ID (down-track).

(8) NT = Total number of targets by type per run.

(9) di = Width of activation mechanism for each target type.

(10) TL = Longitudinal target down-track spacing shall be a minimum of 8 feet. If test lane length is insufficient to accommodate the number of targets required, 4 feet target spacing may be utilized if targets are alternately spaced around the centerline of the lane. For targets utilizing energetics (M604 smoke fuzes), a spacing of 33 feet is required for visual separation of individual events.

(11) L = Lane Length (N*TL).

(12) i = Target Type.

(13) p = Target Position.

APPENDIX A. TEST LANE DESIGN AND CONFIGURATION.

(14) Example: Using the following hypothetical roller SUT (MRS) systems:

WMRS1 = 127 inches WMRS2 = 108 inches.
WPM = 88 inches.
BGMRS1 = 10 inches. BGMRS2 = 0 inches (full width).
N = 12
NT1 = 5
NT2 = 7
d1 = 7 inches
d2 = 24 inches.

d. Develop a table to show the number of target types and determine spacing (see Table A-1).

TABLE A-1. EXAMPLE SHOWING TARGET INVENTORY FOR LANE

DATA POINT	TARGET TYPE 1	TARGET TYPE 2
Number of targets per run (NT_i)	5	7
Width of activation mechanism (d_i)[a]	7 inches	24 inches

[a] Width of mine fuze or length of pressure plate.

e. The longitudinal position for each target (Xn) in Table A-2 =

$$n*TL \quad \textit{(Equation A-1)}$$

f. The lateral position for each target (Yn) in the table below =

$$\{-1\}n * \text{Integer Value of } (((BG/2+di/2+(p-1)(PW-6-2di-BG))/(2(NTi-1))) \quad \textit{(Equation A-2)}$$

Note: The above equation alternates target layout about the centerline of the lane. Distance “Y” is measured from lane centerline to center of target.

(1) If BG=10 inches, Table A-2 is used.

(2) If BG=0 inch, Table A-3 is used.

APPENDIX A. TEST LANE DESIGN AND CONFIGURATION.

TABLE A-2. SPACING OF TARGETS WITH ROLLER CENTER WHEEL GAP OF 10 INCHES

LONGITUDINAL LOCATION ID (n)	X (inch)	Y (inch)	TARGET TYPE POSITION (p)
1	48	-8	1
2	96	20	2
3	144	-32	3
4	192	44	4
5	240	-57	5
6	288	17	1
7	336	-22	2
8	384	27	3
9	432	-32	4
10	480	38	5
11	528	-43	6
12	576	48	7
Note: Length of Lane for Targets (additional length will be required at each end): 4 foot spacing between targets = 4-feet X 12 targets = 48-feet (14.6 meters) 8 foot spacing between targets = 8-feet X 12 targets = 96 feet (29.2 meters)			

APPENDIX A. TEST LANE DESIGN AND CONFIGURATION.

TABLE A-3. SPACING OF TARGETS WITH ROLLER CENTER WHEEL GAP OF 0 INCHES.

LONGITUDINAL LOCATION ID (n)	X (inch)	Y (inch)	TARGET TYPE POSITION (p)
1	48	-3	1
2	96	16	2
3	144	-30	3
4	192	43	4
5	240	-57	5
6	288	12	1
7	336	-18	2
8	384	24	3
9	432	-30	4
10	480	36	5
11	528	-42	6
12	576	48	7
Note: Length of Lane for Targets (additional length will be required at each end): 4 foot spacing between targets = 4-feet X 12 targets = 48-feet (14.6 meters) 8 foot spacing between targets = 8-feet X 12 targets = 96 feet (29.2 meters)			

g. The example in Figure A-1 shows 12 targets: five type 1 targets, and seven type 2 targets. The equations outlined in paragraph A.2 show how to determine lane width, layout of the target pattern, and required lane length.

APPENDIX A. TEST LANE DESIGN AND CONFIGURATION.

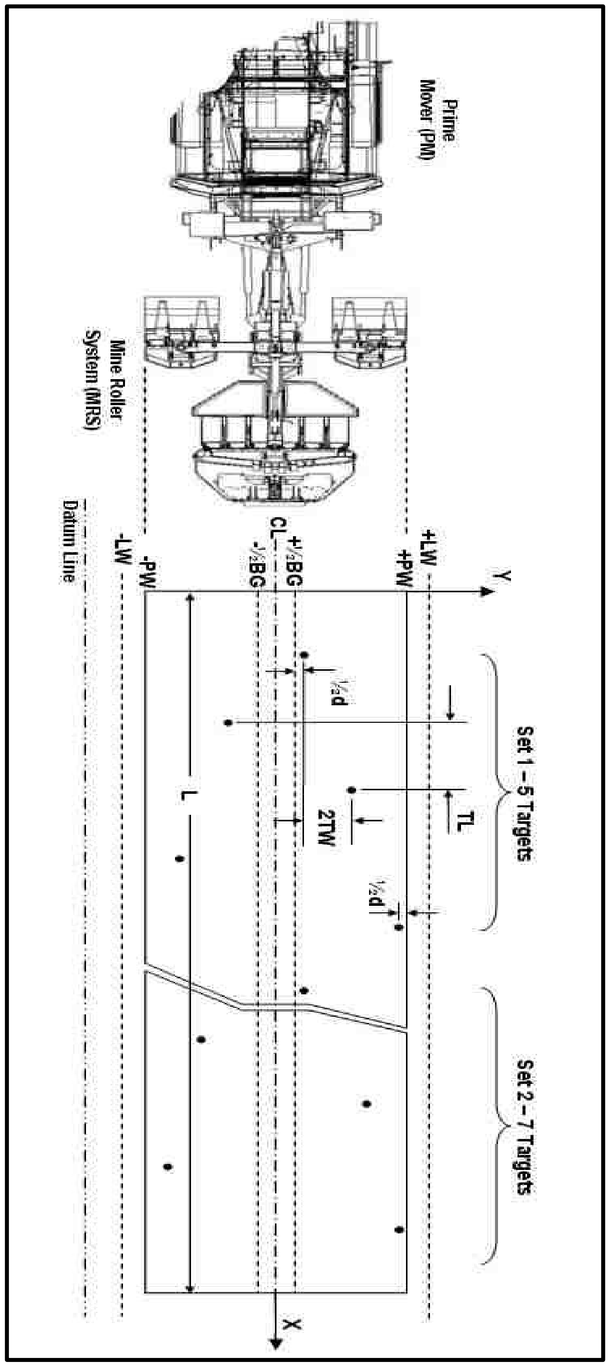

Figure A-1. Example test lane layout for roller evaluation.

APPENDIX A. TEST LANE DESIGN AND CONFIGURATION.

A.3. TEST LANE CONSIDERATION FOR EFFECTIVENESS EVALUATION.

a. When testing track width systems, the same test lane layout is used; targets outside the coverage area of the MRS are not counted against the system effectiveness. Additional runs may be required to get the required number of data points (encounters), unless additional targets are emplaced to account for those outside the coverage area.

b. The testing agency should make a detailed map of the layout once the targets are in place and measure X and Y distances referenced to a datum line. The targets should be numbered for data tracking, so that the tester knows which targets are activated and which ones are not activated. In addition to the map of the layout, the tester should also make a table showing reference distances and target numbers for further test data information. An example of a map/schematic is shown in Figure A-2.

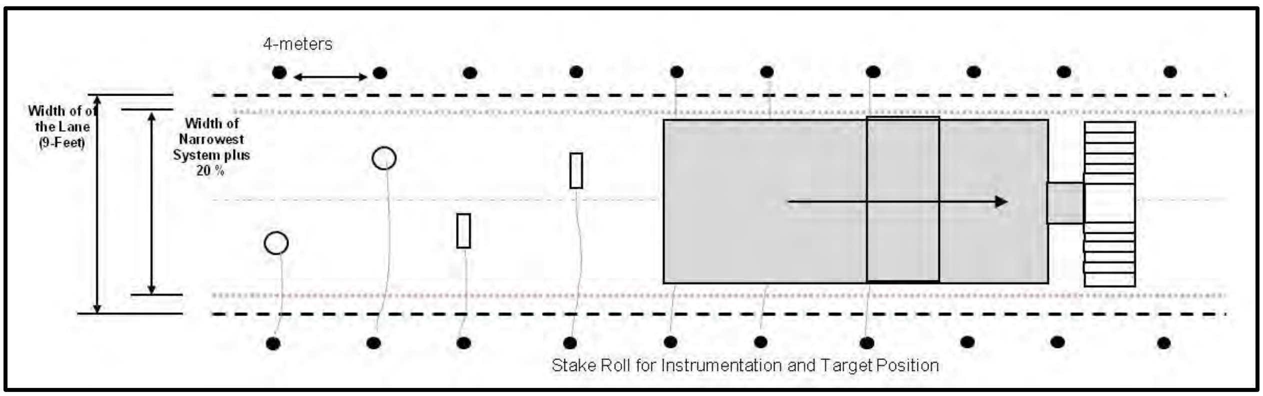

Figure A-2. Lane schematic for both primary and secondary lane containing roller target types: instrumented mines and pressure plates with wire.

c. The test team will prepare test lanes for both primary (asphalt pavement) and secondary (compacted gravel or dirt) courses. They will mark the test lanes with ropes to define the lane boundaries. This is essential to provide the driver a concentrated, focused path over target emplacements. This assists in maintaining effective and efficient target encounters, since effectiveness assessment is based on the number of target encounters, not number of runs. The overall lane length is the number of targets times defined spacing with an additional 50 meters at each end to allow the systems to achieve desired operational test speed, and at the end, to allow the SUT to come to a gradual stop after the last target.

d. The following is an example of preparing a test lane for effectiveness testing.

APPENDIX A. TEST LANE DESIGN AND CONFIGURATION.

(1) The test team prepares a primary (asphalt) road for the test. Figure A-3 shows an example of the effectiveness primary lane ready for a test run. They will document asphalt material thickness, material over buried targets, (e.g., asphalt, dirt, grave, etc.), and any deteriorated conditions (e.g., pot holes, cracks, etc.). Typically, all that is required for asphalt primary roads is for the test team to sweep any loose rocks, dirt, and/or debris, to include watering if too dusty. Target hole locations should be backfilled to the level of the asphalt or road surface.

Figure A-3. Primary road test lane ready for a run.

(2) The test team prepares the secondary (gravel) road for the first phase of the test. Figure A-4 shows an example of the typical effectiveness secondary lane ready for a test run.

APPENDIX A. TEST LANE DESIGN AND CONFIGURATION.

Figure A-4. Secondary road test lane ready for a run.

e. The test team identifies target positions required for each test phase, similar to the examples as follows:

Roller: 12 SUM AT mines, 12 PPIED triggers.

f. The test team must dig target holes per test phase. The test team should complete the following for a roller test phase:

(1) Dig holes to meet the correct test matrix burial depth, to include the target height and overburden (to make target position location level with the top of road surface) to maintain a consistent depth during testing for targets repeatedly being recovered and reburied. Each hole for each target should have the following specifications:

(a) Primary Holes: about 2-inches wider around all edges of target whether its round, square, or rectangle.

(b) Compacted gravel base with a minimum 6-inch depth (adjusted to ensure target has correct burial depth to meet matrix specifications).

(c) 3/4-inch plywood board to provide a rigid base for target to rest on.

(d) 1/2-inch sand cushion between target and plywood board.

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APPENDIX B. EXAMPLE CHECKLISTS AND DATA SHEETS.

TABLE B-1. SYSTEM PHYSICAL MEASUREMENT DATA SHEET (SAMPLE)

Attributes/Parameters **Date of Measurements:________________**	**Vehicle Name/Roller Name:______________** **Serial Number: ________**
Physical Measurements (Inches)	
Roller Length	
Roller Width	
Roller Height	
Roller Ground Clearance	
Standoff/Gap Measurements (Inches)	
SOD First Wheel Bank	
SOD to Second Wheel Bank	
SOD Third Wheel Bank	
SOD from Bumper to First Wheel Bank	
SOD from Bumper to Rear Wheel Bank	
Bank Gap	
Roller Wheel Gap	
Roller Patch	
Pitch (Wheel + Gap)	
Wheel Diameter	
Wheel Type	
Number of Wheels	
Percent Coverage	
Ratio	
Weight Measurements (Pounds)	
Total Vehicle Weight	
Axle Weight of Vehicle w/o Roller	
Front Axel Weight, Bracket Installed, No Roller	
Front Axle Weight Forward w/ Roller	
Front Axle Weight Backward w/ Roller	
Tongue Weight Forward	
Tongue Weight Backward	
Towing Weight	
Total Roller Weight	
Total Bracket Weight	

APPENDIX B. EXAMPLE CHECKLISTS AND DATA SHEETS.

TABLE B-2. EFFECTIVENESS TESTING INPUT DATA/SETUP CHECKLIST (SAMPLE)

Trial ID No. ____________________________ Trial Date: ________________________

Test Officer (TO):________________________

Data Recorder (if other than TO): ___________________________

1. Inspections per ITOP 04-2-526, Paragraph 4.1 Complete: Yes No

2. Preparation of Instrumentation:

   a. Test Targets prepared for Burial IAW TM: Yes No

   b. Vehicle Speed Reading Device Setup IAW OM: Yes No

   c. Data Acquisition Equipment Setup: Yes No

   d. Cameras Positioned to Provide Visual Results: Yes No

   e. All instrumentation functional: Data Acquisition Equipment ____ Test Targets ____

      Vehicle Speed Reading Device ____ Cameras ____

      Soil Strength Reading Device _______

   f. All instrumentation calibrated: Data Acquisition Equipment ______ Test Targets ____

      Vehicle Speed Reading Device _____

      Soil Strength Reading Device _____

3. Preparation of Test Lanes:

   a. Record Test Lane Setup:

Lane ID:				
Position	**Target ID**	**Depth**	**Target Orientation**	**Layout Comments (e.g., Target Spacing)**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				

APPENDIX B. EXAMPLE CHECKLISTS AND DATA SHEETS.

TABLE B-2. EFFECTIVENESS TESTING INPUT DATA/SETUP CHECKLIST (CONTINUED)

b. Map of Test Lane Setup Prepared: Yes ______ No ______
c. Targets Buried with Soil Raked Over Targets: Yes ______ No ______
d. Test Lane Marked to Indicate Driver Path: Yes ______ No ______

4. Pre-test Data Collection:

a. Cone Index or Soil Strength Readings Taken: Yes ______ No ______
b. Soil Samples Collected for Soil Moisture Analysis: Yes ______ No ______
c. Photos Taken of the Soil on White Background: Yes ______ No ______
d. Qualitatively evaluate the soil: Sand Gravel Clay Hardpack Other
e. What tools had to be used to dig to the deepest depth?
Pickax Trenching shovel Pick Flat shovel Other
f. Upon completion of digging, did the sides of the hole cave in (i.e., loose sand)? Yes No
g. Weather (General): Sunny Partly Cloudy Cloudy Rain T-Storm

—Note time of rain showers (if any) on the bottom of the Target Actuation Data Sheet

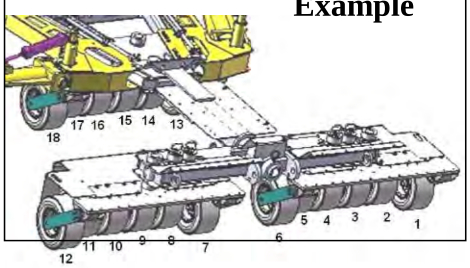
Air Temperature: Expected High for Trial Date: Expected Low for Trial Date:

Wind speed/direction: Relative Humidity: Ground Temperature:

h. Ground Pressure/Wheel Loading Conducted: Yes No

Use the tire numbers indicated in the figure below for input on the data sheet. For identifying tire numbers, count from left to right and from front to back from the driver's perspective in the same manner as shown in the example.

Example



5. Required Test Conditions:

a. PM loaded to GVW or combat weight: Yes No if No, what weight: ____________
b. Maintenance and Service Operations Performed on PM: Yes No
c. Maintenance and Service Operations Performed on MRSs: Yes No
d. Normal Operating Temperatures of Fluids and Components Reached Prior to Start of Test: Yes No
e. Drivers orientated to test matrix
f. Drivers orientated to test lane and test targets
g. Drivers orientated to communication and vehicle speed requirements

APPENDIX B. EXAMPLE CHECKLISTS AND DATA SHEETS.

TABLE B-3. SOIL DATA SHEET (SAMPLE)

Trial ID No. ______________________________ Trial Date: _________________________

Test Officer (TO):_________________________

Data Recorder (if other than TO): _____________________________

1. Soil Strength Readings (Beginning of Test Day):

   a. Record Time: ____________________

   b. Record Readings:________________

Lane ID:				
Reading No.	**Location Relative to Target ID**	**Depth**	**Reading**	**Comments**

2. Soil Moisture Analysis (Beginning of Test Day):

   a. Record Time: ____________________

   b. Record Readings:________________

Lane ID:				
Sample No.	**Taken from Hole for Target ID**	**Depth**	**Soil Moisture (%)**	**Comments**

APPENDIX B. EXAMPLE CHECKLISTS AND DATA SHEETS.

TABLE B-3. SOIL DATA SHEET (CONTINUED)

3. Soil Strength Readings (End of Test Day):

a. Record Time: ____________________

b. Record Readings:________________

Lane ID:				
Reading No.	**Location Relative to Target ID**	**Depth**	**Reading**	**Comments**

4. Soil Moisture Analysis (End of Test Day):

a. Record Time: ____________________

b. Record Readings:________________

Lane ID:				
Sample No.	**Taken from Hole for Target ID**	**Depth**	**Soil Moisture (%)**	**Comments**

APPENDIX B. EXAMPLE CHECKLISTS AND DATA SHEETS.

TABLE B-4. WHEEL LOADING DATA SHEET (SAMPLE)

MINE ROLLER LOAD TEST REPORT

Date:	Test Engineer:		Test Recorder:	
Configuration	**Model**	**Reference DWG**	**Test Instruments**	**Serial No.**

Mud Guards Installed		Yes		No	Weight Kit Installed		Yes		No
Driver's Side Mudguard Number			Weight		Rhino Number		Weight		
A/Driver's Side Mudguard Number			Weight		A-Frame Number		Weight		
Outside Wheel to Outside Wheel					Outside Tread to Outside Tread				
Tongue Weight: Driver's Side		A/Driver's Side			Total Weight		Holiday		
Tongue Height: Driver's Side		A/Driver's Side			Photos Taken		Yes		No

Left Wheel Bank		Height to Table Bottom:				
Wheel No.	**Load (lb)**	**Load (lb)**	**Load (lb)**	**Avg Load (lb)**	**Torsion Spring Angle**	**Remarks**
			Total Avg		**NOTES:**	

Right Wheel Bank		Height to Table Bottom:				
Wheel No.	**Load (lb)**	**Load (lb)**	**Load (lb)**	**Avg Load (lb)**	**Torsion Spring Angle**	**Remarks**
			Total Avg		**NOTES:**	

Center Wheel Bank		Height to Table Bottom:				
Wheel No.	**Load (lb)**	**Load (lb)**	**Load (lb)**	**Avg Load (lb)**	**Torsion Spring Angle**	**Remarks**
			Total Avg		**NOTES:**	
Total Configuration Load					**Total Configuration Avg**	

APPENDIX B. EXAMPLE CHECKLISTS AND DATA SHEETS.

TABLE B-5. TARGET ACTUATION DATA SHEET FOR BI-DIRECTIONAL LANES (SAMPLE)

Target Actuation Data Sheet

Test Director:	Data Recorder:	
Trial ID:	Trial Date:	Lane ID:
MRS 1 ID:	TV 1 ID:	Driver 1 ID:
MRS 2 ID:	TV 2 ID:	Driver 2 ID:
X:	MRS 1 Tire Nos. in X° Direction:	in X°+180° Direction:
	MRS 2 Tire Nos. in X° Direction:	in X°+180° Direction:

Position	1	2	3	4	5	6	7	8	9	10
Target ID										

Run No.	Target Speed	Direction	System	Start Time	Average Speed	Record Target Positions Activated			Notes (Add'l Space Below)
						Target Activations	Activations by MRS	Activations by TV	
1	5	X							
2	5	X							
3	10	X+180							
4	10	X+180							
5	15	X							
6	15	X							
7	20	X+180							
8	20	X+180							
9	25	X							
10	25	X							
11	30	X+180							
12	30	X+180							
13	35	X							
14	35	X							
15	5	X+180							
16	5	X+180							
17	10	X							
18	10	X							
19	15	X+180							
20	15	X+180							
21	20	X							
22	20	X							
23	25	X+180							
24	25	X+180							
25	30	X							
26	30	X							
27	35	X+180							
28	35	X+180							
29	5	X							
30	5	X							
31	10	X+180							
32	10	X+180							
33	15	X							
34	15	X							
35	20	X+180							
36	20	X+180							
37	25	X							
38	25	X							
39	30	X+180							
40	30	X+180							
41	35	X							
42	35	X							
43	5	X+180							
44	5	X+180							
45	10	X							
46	10	X							
47	15	X+180							
48	15	X+180							
49	20	X							
50	20	X							

Notes:

APPENDIX B. EXAMPLE CHECKLISTS AND DATA SHEETS.

TABLE B-5. TARGET ACTUATION DATA SHEET (CONTINUED)

Run No.	Target Speed	Direction	System	Start Time	Average Speed	Record Target Positions Activated			Notes (Add'l Space Below)
						Target Activations	Activations by MRS	Activations by TV	
51	25	X+180							
52	25	X+180							
53	30	X							
54	30	X							
55	35	X+180							
56	35	X+180							
57	5	X							
58	5	X							
59	10	X+180							
60	10	X+180							
61	15	X							
62	15	X							
63	20	X+180							
64	20	X+180							
65	25	X							
66	25	X							
67	30	X+180							
68	30	X+180							
69	35	X							
70	35	X							
Notes:									

APPENDIX B. EXAMPLE CHECKLISTS AND DATA SHEETS.

TABLE B-6. ROLLER TARGET PRE-RUN INSPECTION SHEET (SAMPLE)

Target Pre-Run Inspection Sheet

Targets 1 - 30 Run Series: ___________	Date:	System: A B C	Road Type: Primary / Secondary
	Lane Inspection by:		Time Inspection completed: _________ MST

Location	Target Type	Target Serial #	Tolerance Weight	Pre-Function Check	Notes:	Target Disposition Pre-Run:	New # if Applicable	Tolerance Weight	Pre-Function Check
1				SAT / UNSAT		Used/Replaced			SAT / UNSAT
2				SAT / UNSAT		Used/Replaced			SAT / UNSAT
3				SAT / UNSAT		Used/Replaced			SAT / UNSAT
4				SAT / UNSAT		Used/Replaced			SAT / UNSAT
5				SAT / UNSAT		Used/Replaced			SAT / UNSAT
6				SAT / UNSAT		Used/Replaced			SAT / UNSAT
7				SAT / UNSAT		Used/Replaced			SAT / UNSAT
8				SAT / UNSAT		Used/Replaced			SAT / UNSAT
9				SAT / UNSAT		Used/Replaced			SAT / UNSAT
10				SAT / UNSAT		Used/Replaced			SAT / UNSAT
11				SAT / UNSAT		Used/Replaced			SAT / UNSAT
12				SAT / UNSAT		Used/Replaced			SAT / UNSAT
13				SAT / UNSAT		Used/Replaced			SAT / UNSAT
14				SAT / UNSAT		Used/Replaced			SAT / UNSAT
15				SAT / UNSAT		Used/Replaced			SAT / UNSAT
16				SAT / UNSAT		Used/Replaced			SAT / UNSAT
17				SAT / UNSAT		Used/Replaced			SAT / UNSAT
18				SAT / UNSAT		Used/Replaced			SAT / UNSAT
19				SAT / UNSAT		Used/Replaced			SAT / UNSAT
20				SAT / UNSAT		Used/Replaced			SAT / UNSAT
21				SAT / UNSAT		Used/Replaced			SAT / UNSAT
22				SAT / UNSAT		Used/Replaced			SAT / UNSAT
23				SAT / UNSAT		Used/Replaced			SAT / UNSAT
24				SAT / UNSAT		Used/Replaced			SAT / UNSAT
25				SAT / UNSAT		Used/Replaced			SAT / UNSAT
26				SAT / UNSAT		Used/Replaced			SAT / UNSAT
27				SAT / UNSAT		Used/Replaced			SAT / UNSAT
28				SAT / UNSAT		Used/Replaced			SAT / UNSAT
29				SAT / UNSAT		Used/Replaced			SAT / UNSAT
30				SAT / UNSAT		Used/Replaced			SAT / UNSAT

Comments:

APPENDIX B. EXAMPLE CHECKLISTS AND DATA SHEETS.

TABLE B-7. ROLLER TARGET POST-RUN SCORING SHEET (SAMPLE)

Roller Effectiveness Scoring Sheet

SCORING DATA SHEET ROAD TYPE: Date: △ min.

Test Officers/DCs:

Run Series: System ID: A B C Time: Speed: mph

Target Location	Activated	Activated By: System or PM	Peak Level System	Peak Level PM	SYS Time (sec)	PM Time (sec)	Notes	Post Check
1	Yes / No / CA / NT	SYS / PM					0.192	P / F
2	Yes / No / CA / NT	SYS / PM					0.192	P / F
3	Yes / No / CA / NT	SYS / PM					0.192	P / F
4	Yes / No / CA / NT	SYS / PM					0.310	P / F
5	Yes / No / CA / NT	SYS / PM					0.310	P / F
6	Yes / No / CA / NT	SYS / PM					0.310	P / F
7	Yes / No / CA / NT	SYS / PM					0.270	P / F
8	Yes / No / CA / NT	SYS / PM					0.270	P / F
9	Yes / No / CA / NT	SYS / PM					0.270	P / F
10	Yes / No / CA / NT	SYS / PM					0.113	P / F
11	Yes / No / CA / NT	SYS / PM					0.113	P / F
12	Yes / No / CA / NT	SYS / PM					0.113	P / F
13	Yes / No / CA / NT	SYS / PM						P / F
14	Yes / No / CA / NT	SYS / PM						P / F
15	Yes / No / CA / NT	SYS / PM						P / F
16	Yes / No / CA / NT	SYS / PM						P / F
17	Yes / No / CA / NT	SYS / PM						P / F
18	Yes / No / CA / NT	SYS / PM						P / F
19	Yes / No / CA / NT	SYS / PM						P / F
20	Yes / No / CA / NT	SYS / PM						P / F
21	Yes / No / CA / NT	SYS / PM						P / F
22	Yes / No / CA / NT	SYS / PM						P / F
23	Yes / No / CA / NT	SYS / PM						P / F
24	Yes / No / CA / NT	SYS / PM						P / F
25	Yes / No / CA / NT	SYS / PM						P / F
26	Yes / No / CA / NT	SYS / PM						P / F
27	Yes / No / CA / NT	SYS / PM						P / F
28	Yes / No / CA / NT	SYS / PM						P / F
29	Yes / No / CA / NT	SYS / PM						P / F
30	Yes / No / CA / NT	SYS / PM						P / F

Comments: RUN SUMMARY: YES - CA - NO - NT -

1 - 12: YES - CA - NO - NT -

13 - 24: YES - CA - NO - NT -

HYDAULIC PRESSURE DURING RUN PRE: POST:

Legend-: PM-Prime Mover CA-Critical Activation NT-No Test Both1-ACT&CA Both2-CA&DESTRY P - Photos F - Function Check N - None

FORM DATE: 30 APRIL 2014

APPENDIX B. EXAMPLE CHECKLISTS AND DATA SHEETS.

TABLE B-8. ROLLER TARGET POST-RUN INSPECTION SHEET (SAMPLE)

Post Run Inspection Sheet

System Type: A B C			Targets 1-30	Run Series: ________			DATE:
Target Depth: Shallow / Deep			Driver:	Lane Inspection by:			
Outdoor Conditions During Run: Light / Dark			Roller Down Force Engaged YES NO	Speed: MPH	Time of Run: Start ______MST Stop ______MST		
Target Position	Target Visually Exposed (20m)	Target Visually Exposed (4m)	Target engaged by System Roller	Disposition of Target Post Run	Post-Functional Check on Target	Notes	Photo taken
1	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
2	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
3	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
4	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
5	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
6	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
7	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
8	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
9	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
10	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
11	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
12	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
13	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
14	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
15	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
16	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
17	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
18	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
19	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
20	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
21	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
22	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
23	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
24	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
25	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
26	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
27	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
28	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
29	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
30	Yes / No	Yes / No	Fully / Partially / Missed / NT	Destroyed / Disconnected	SAT / UNSAT / NP		YES / NO
Comments:							

Legend-

		R/S - Right Side	**NP-** Not Possible
		L/S - Left Side	**UNSAT- Unsatisfactory**
RW -	Roller Wheel	**PM - Prime Mover**	**Mounted Visual-** indicates the target was inspected from a distance of over 20 meters.
RBG -	Roller Bank Gap	**MST-** Mountain Standard Time	**Dismounted Visual-** indicates the target was inspected at the position marker.
PP -	Pressure Plate	**SAT-** Satisfactory	**MPH-** Miles Per Hour

APPENDIX B. EXAMPLE CHECKLISTS AND DATA SHEETS.

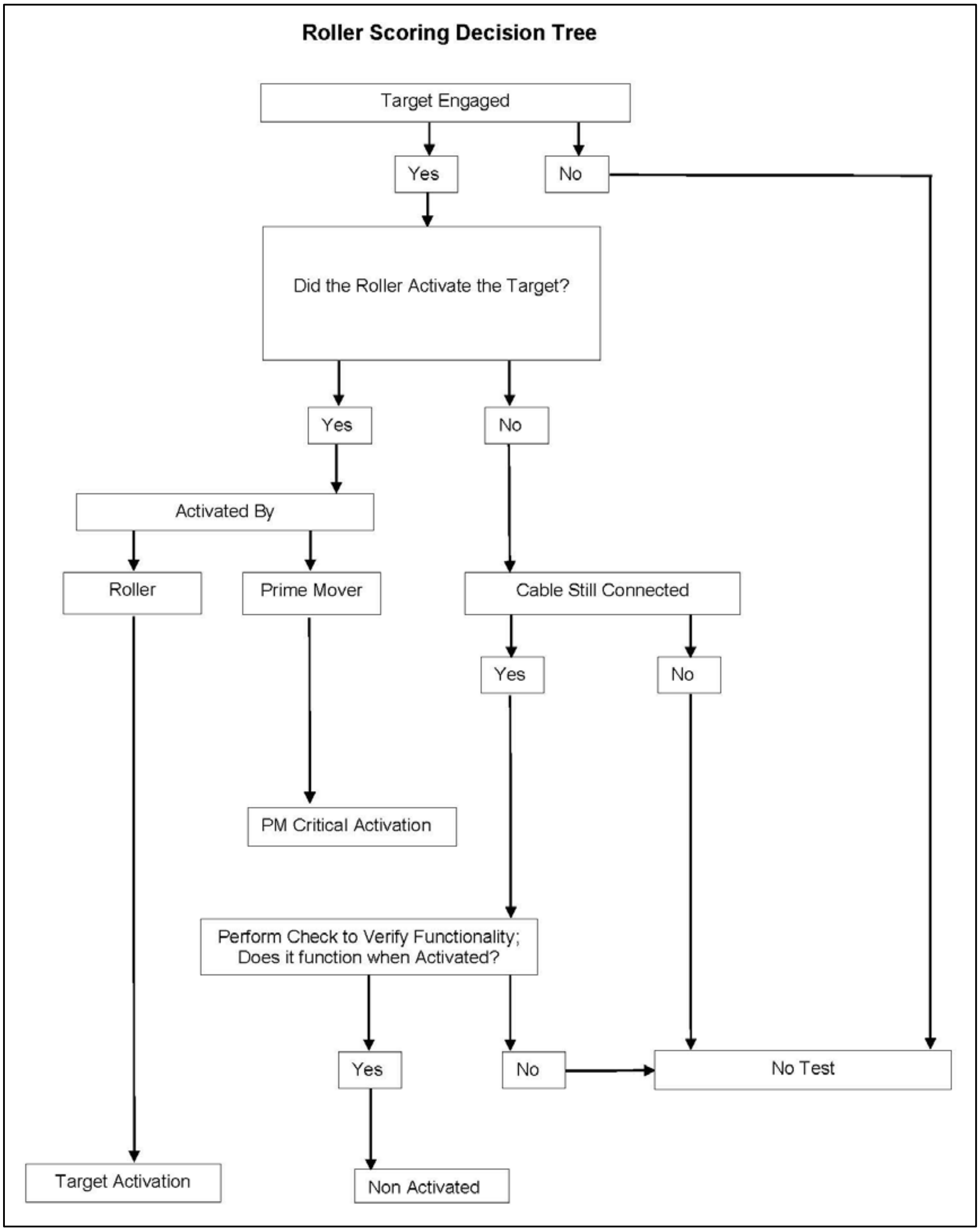


Figure B-1. Roller scoring decision tree.

APPENDIX C. ROLLER TEST TARGET DESCRIPTIONS.

C.1 The testing facility and SUT customers must determine and prepare the targets for effectiveness testing. Current threat targets and configurations should be identified by the Intelligence community, if not out lined in requirement documents. An example of some roller effectiveness targets are provided in this appendix. Roller effectiveness target assembly and operational scenarios are also provided using these samples.

> **NOTE:** The following targets were jointly developed by the U.S. Army Tank-Automotive Research Development and Engineering Center (TARDEC), Keweenaw Research Center of Michigan Technological University, and ATEC, and are used solely in support of effectiveness testing. Test teams can coordinate the use of these surrogate landmines, or develop similar tools that provide repeatable results, to include landmines with energetic smoke discharge elements (e.g., M20 practice AT mine) and/or other training devices.

C.1.1 Instrumented Landmine (Electronic Sensors).

A set of surrogate mines (SUM) are depicted in Figure C-1. Each target is designed to simulate the mechanical functionality of the actual tactical landmine (fuzing mechanism) it is replicating (e.g., down force requirement for activation, crushing of metal collars, etc.). These targets contain electronic circuitry that provides an output voltage to a data acquisition system that registers engagement down force movement of the target. The magnitude of down force movement correlates to a varying voltage output recorded by the data acquisition system. Each target type is depicted in Figure C-1.

Figure C-1. Antitank surrogate mines electro-mechanical instrumented tools.

APPENDIX C. ROLLER TEST TARGET DESCRIPTIONS.

C.1.1.1 M20 AT SUM.

M20 AT SUM: The design for M20 SUM was reverse engineered from the AT M20 Training Mine with smoke fuze. A pressure fuze potentiometer sensor (measures linear deflection) returns to normal position after the SUT overpasses the target; the target can remain in place between runs and be reused. The M20 surrogate SUM is shown in Figure C-2.

Figure C-2. M20 surrogate landmine.

a. Dimensions:

(1) 13.1-inches diameter.

(2) 5.75-inches in height (with wired adapter).

(3) 7.5-inches diameter push plate.

b. Activation Parameters: Greater than 0.310-inch center deflection at 265 - 287 pounds (lb).

c. The design for M20 SUM was reverse engineered from the M20 training mine with smoke fuze. The load and deflection properties of the M20 SUM replicate data obtained from the destructive testing of inert hardware.

d. Typically, M20 SUM resets without assistance. The M-20 SUM is a Type 7-4A Standard Test Target (STT), in accordance with ITOP 04-2-521[5].

APPENDIX C. ROLLER TEST TARGET DESCRIPTIONS.

C.1.1.2 M19 AT SUM.

The design for M19 SUM was reverse engineered from the AT M80 Training Mine with M606 Fuze. A pressure fuze potentiometer sensor (measures linear deflection) returns to normal position after the SUT overpasses the target; the target can remain in place between runs and be reused. The M19 surrogate SUM is shown in Figure C-3.

Figure C-3. M19 surrogate landmine.

a. Dimensions:

(1) 13.1-inches in length.

(2) 13.1-inches wide.

(3) 3.50-inches in height.

(4) 8.5-inches diameter push plate.

b. Activation Parameters: Greater than 0.192-inch center deflection at 375 – 450 lbs.

c. The design for the M19 SUM was reverse engineered from the M80 training mine with M606 fuze. The load and deflection properties of the M19 SUM replicate data obtained from the destructive testing of inert hardware.

d. Typically, M19 SUM resets without assistance.

APPENDIX C. ROLLER TEST TARGET DESCRIPTIONS.

NOTE: According to U.S. Army Field Manual (FM) 20-32[6], the activation load for the M19 AT Mine is 157-225 kilograms (kg) (346 - 496 lb). According to Jane's Mines and Mine Clearance[7], the operating pressure for the M19 AT Mine is 118 - 226 kg (260 - 498 lb).

e. The M19 SUM is a Type 7-4A STT, in accordance with ITOP 04-2-521.

C.1.1.3 TM-62M AT SUM.

The design for TM-62M AT SUM was reverse engineered from inert mines with the MVCh-62 Fuze. This target requires re-assembly with a new crushable element after each SUT overpass of the target. The test team must remove the target after each run and rebuild it for each continuous use. The TM-62M surrogate SUM is shown in Figure C-4.

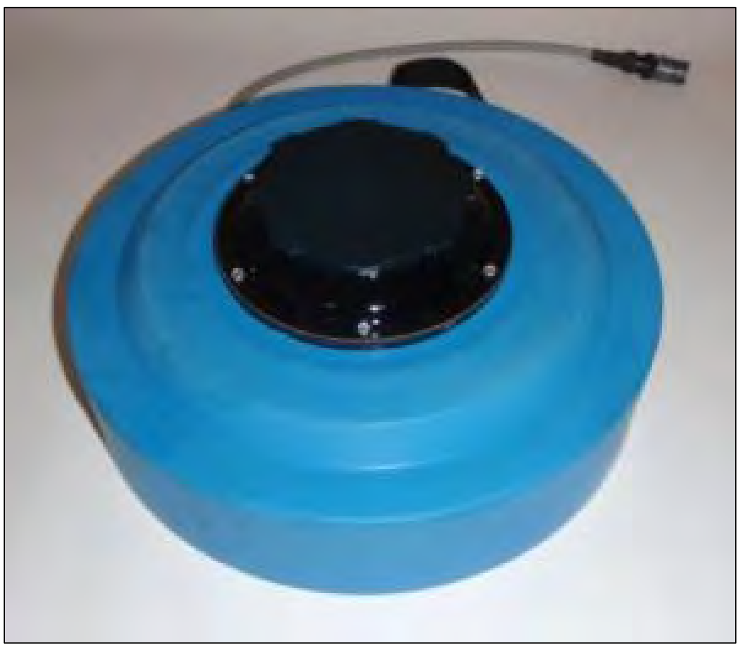


Figure C-4. TM-62M surrogate landmine.

a. Dimensions:

(1) 12.5-inches diameter.

(2) 4.5-inches in height.

(3) 4.376-inches diameter push plate.

APPENDIX C. ROLLER TEST TARGET DESCRIPTIONS.

b. Activation Parameters: Greater than 0.113-inch (plus some unknown air gap) center deflection at 700-925 lbs.

c. The design for the TM-62M SUM was reverse engineered from inert mines with MVCh- 62 fuzes. The load and deflection properties of the TM-62M SUM replicate data obtained from the destructive testing of inert hardware.

d. TM-62M SUM must have a crushable element reassembled in the SUM after it has been engaged by mine roller system or prime mover.

NOTE: According to FM 20-32, the sensitivity of the TM-62M AT Mine is 200 kg (440.9 lbs). According to Jane's Mines and Mine Clearance, the activation load for the TM-62M AT Mine is 150 - 550 kg (330 - 1212 lbs).

e. The TM-62M SUM is a Type 7-4B STT, in accordance with ITOP 04-2-521.

C.1.1.4 TM-46 AT SUM.

The design for TM-46 AT SUM was reverse engineered from inert mines with the MVM Fuze. This target requires re-assembly with a new crushable element after each SUT overpass of the target. The TM-46 surrogate SUM is shown in Figure C-5.

Figure C-5. TM-46 surrogate landmine.

APPENDIX C. ROLLER TEST TARGET DESCRIPTIONS.

a. Dimensions:

(1) 12.25-inches in diameter.

(2) 4.3-inches in height.

(3) 8.0-inches diameter pressure plate.

b. Activation Parameters: Greater than 0.27-inch center deflection at 265 - 882 lb.

c. The design for the TM-46 SUM was reverse engineered from inert mines with MVM fuzes. The load and deflection properties of the TM-46 SUM replicate data obtained from the destructive testing of inert hardware.

d. TM-46 SUM must have a crushable element reassembled in the SUM after it has been engaged by a mine roller system or prime mover.

NOTE: According to FM 20-32, the sensitivity of the TM-46 AT Mine is 180 kg (396.8 lb). According to Jane's Mines and Mine Clearance, the activation load for the TM-46 AT Mine is 120 - 400 kg (265 - 882 lb).

e. The TM-46 SUM is a Type 7-4A STT, in accordance with ITOP 04-2-521.

C.1.2 Target Wiring Detail For Electronic Data Acquisition.

All SUMs come equipped with a 16-inch wiring pigtail terminated with a circular Military Specification connector (TV01RW-11-98P) (Figure C-6). The mating connector (TV06RW- 11-98S) will be required for extension cables run between each SUM and the data acquisition system.

APPENDIX C. ROLLER TEST TARGET DESCRIPTIONS.

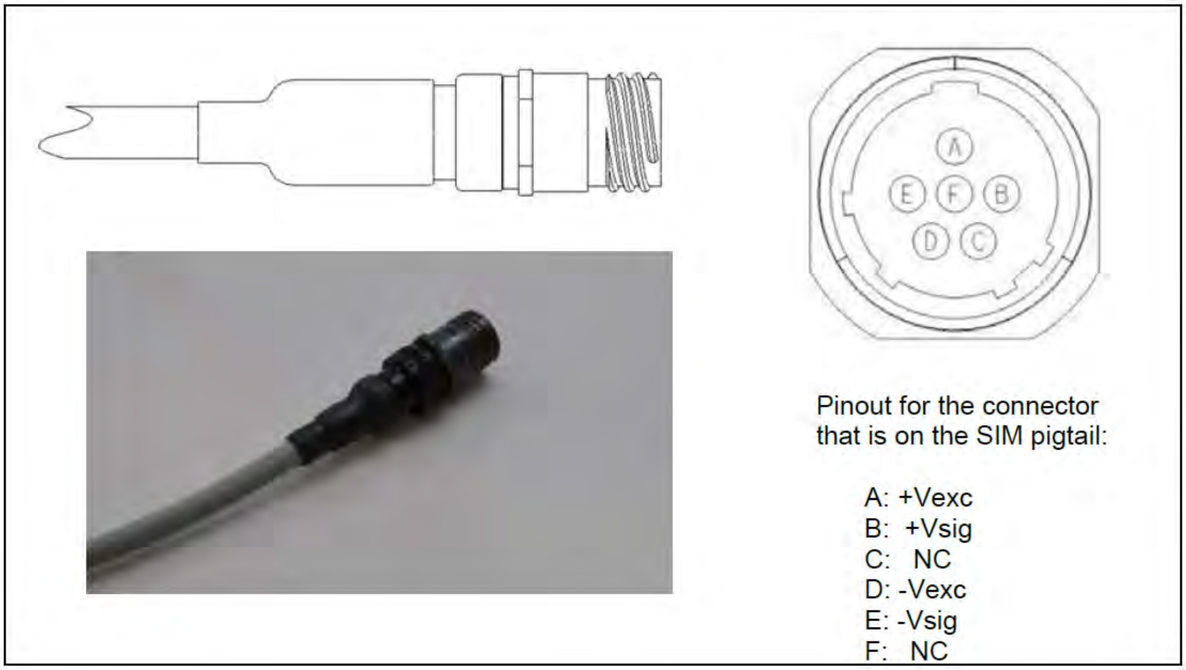


Figure C-6. End connector characteristics from the surrogate mines.

C.1.3 <u>Landmine Preparation</u>.

Trained target technicians must prepare these effectiveness instrumented landmines as follows:

a. For TM-62M and TM-46 SUMs, assemble the targets with new crushable elements (Figure C-7). Mark crushable elements with the test matrix run ID and position ID. Mark used damaged crushable elements to identify them as expended, so they were not mistakenly installed and used again. Figure C-7 shows the various crushable elements for the TM-62M and TM-46 SUM that must be fabricated (customized heat treated fabrication) and replaced after each engagement. Figure C-8 shows the assembly of changing out these crushable elements.

APPENDIX C. ROLLER TEST TARGET DESCRIPTIONS.

Figure C-7. The SUM crushable elements that must be fabricated and replaced after each engagement.

Figure C-8. Assembly of crushable elements into the targets.

C.1.4 <u>Landmine Electronic Circuity</u>.

For the SUM landmine targets, voltage output signals are recorded in the data acquisition system used for determining activate and non-activated events. Table C-1 shows the threshold that each target type had to meet or exceed to be scored as “activated”. Anything voltage values recorded less than the values shown in Table C-1 for these specific SUMs are scored as “non-activated”.

APPENDIX C. ROLLER TEST TARGET DESCRIPTIONS.

TABLE C-1. SUM LANDMINE TARGET THRESHOLD VALUES FOR SCORING AN ACTIVATION FOR EFFECTIVENESS

TARGET	VALUE
M19 (Surrogate) Antitank Mine[a]	0.192 inch
M15 (Surrogate) Antitank Mine[a]	0.310 inch
TM-46 (Surrogate) Antitank Mine[a]	0.270 inch
TM-62M (Surrogate) Antitank Mine[a]	0.113 inch

[a] 5-volts supply source when the circuit is closed. Voltage varies depending on deflection distance.

C.2. <u>OTHER ROLLER EFFECTIVENESS TARGETS</u>.

C.2.1 <u>Energetic Landmine Targets (Practice, Smoke)</u>.

Figure C-9 shows the components for the Mine, M20, Practice, Smoke. Test teams can use this target configuration if instrumented SUM landmines are not available, and mines and fuzes are in adequate inventory to meet the effectiveness engagement requirements. When engaged by the SUT, the SUT engagement will activate the fuze emitting a smoke discharge for an effectiveness activation.

APPENDIX C. ROLLER TEST TARGET DESCRIPTIONS.

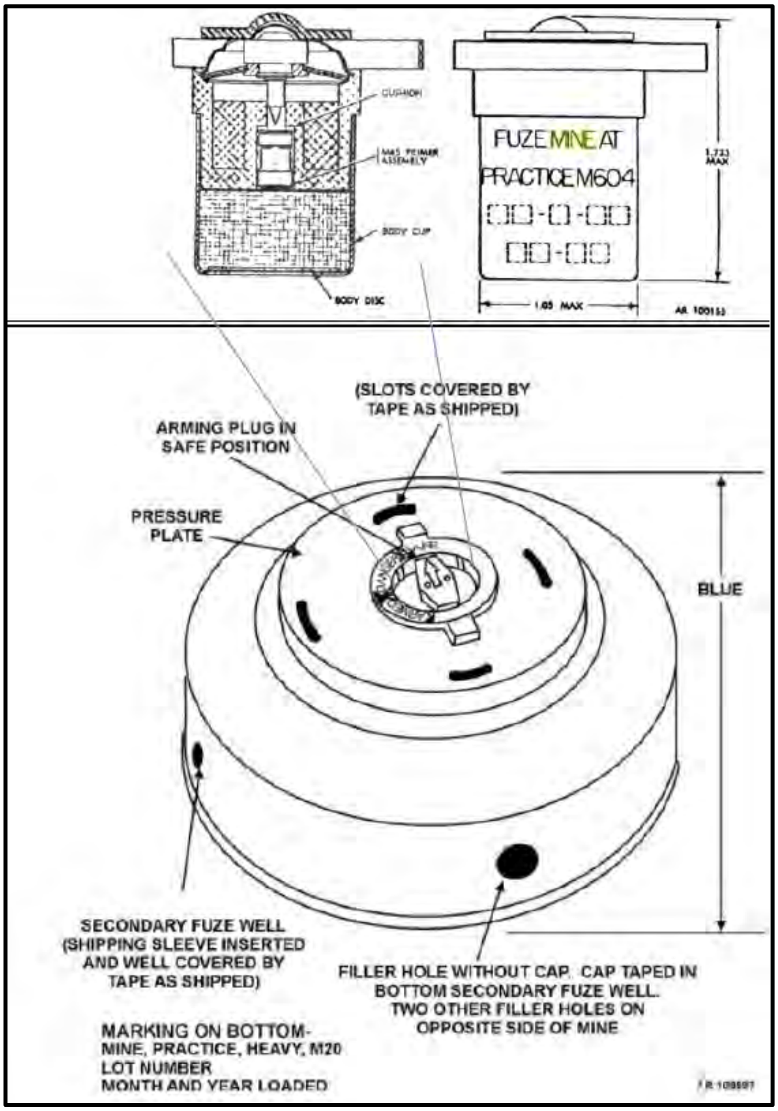


Figure C-9. Configuration characteristics of: Mine, Antitank, M20, Practice, Smoke.

APPENDIX C. ROLLER TEST TARGET DESCRIPTIONS.

C.2.2 Mechanical Fuzing Landmine Targets.

Plungers. A configuration designed to use existing training mines for repeated use as long as the mine fuzing mechanical mechanism remains functional is shown in Figure C-10. Test team must measure a plungers for movement to determine activation or not by recovering the mine from a buried to remove the fuze deflection indicator housing. Target personnel will remove the indicator to measure and determine if there was any deflection (movement) of the rod indicator within the fuze well housing. (NOTE: movement occurs if the fuze was depressed by the passing SUT; the deflection distance determines whether it was a full or partial activation, or any at all.) Personnel manually measures the deflection with a micrometer or caliper (Figure C-11) and records the displacement distance. (NOTE: After the measurement, the user resets the indicator in the housing, replaces it back in to the mine, and reburies it for follow on test runs.)

Figure C-10. Example of the M20, Mine, Antitank, Practice with deflection device.

APPENDIX C. ROLLER TEST TARGET DESCRIPTIONS.

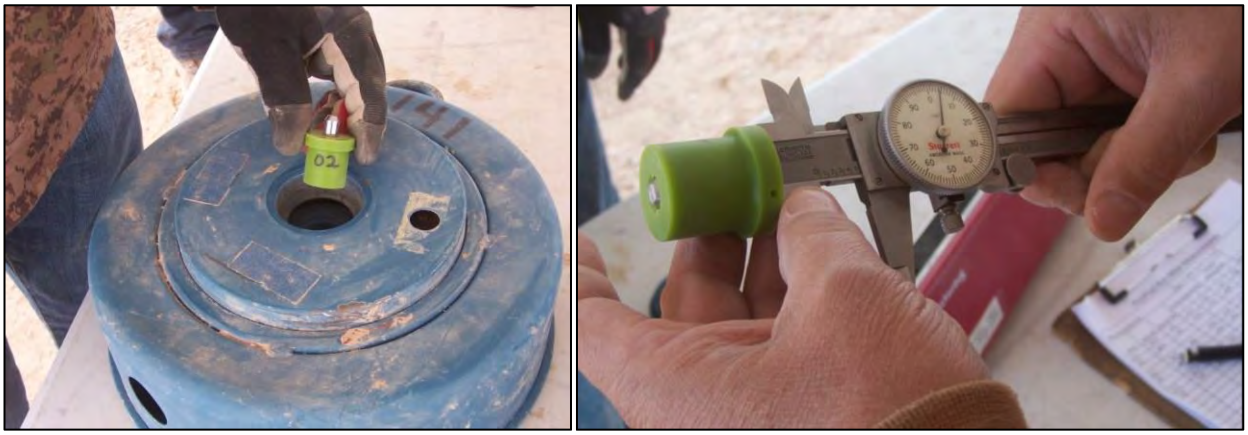


Figure C-11. Deflection rod indicator and housing (left) and measurement (right).

C.3 <u>Pressure Plate Improvised Explosive Device (PPIED)</u>.

The PPIEDs represent anti-vehicular IED trigger threats. Even though there are many, and ever changing types of PPIEDs, threat configurations must be obtained from intelligence agencies before being considered. Each PPIED must be mechanically operational with the ability to maintain an open circuit until a pre-determine load has been applied, which then closes the circuit activating an alarm device (e.g., visual, electronic, and/or acoustic). The PPIED target must contain a wire-pair that extends to the outer boundaries of the lane where it is connected to the alarm indicator (e.g., electronic data acquisition array, visual/acoustic indicator, light array, etc.). Testers must remove each PPIED device after each run and replace them with a new, unused target, because after it has been engaged by the SUT, its integrity has been compromised. The test team should check each new PPIED to ensure it’s functional within specified load parameters or removed from testing.

a. PPIED Variations. Figure C-12 shows a sample of various PPIED used for effectiveness testing. Test team must use a circuit array (e.g., strobe light, electronic data acquisition, etc.) to indicate when an engagement and activation occurs. Pressure Plates reflect a Type 7-4A STT, in accordance with ITOP 04-2-521.

APPENDIX C. ROLLER TEST TARGET DESCRIPTIONS.

Figure C-12. Various sizes and types of pressure plate trigger targets.

b. Pressure Plate (PP) Functional Calibration Check. Each PPIED target is load tested prior to use by performing a continuity check with compression of the PP trigger. Personnel will attach a power source to the target and perform compression of the trigger. A data logger is used to record the voltage reading of the closed circuit (Figure C-13), and then determines what the load (in pounds force) is required to force the closed circuit.

Figure C-13. Pressure plate load measurements technique.

c. Test teams must check each target to ensure the PPIED is within compression load specifications for that target type. When checking the inventory, the test personnel should put a

APPENDIX C. ROLLER TEST TARGET DESCRIPTIONS.

check on the target to show it was within this tolerance range; an ‘X’ should be used if it is outside this range (Figure C-14). If the PP was faulty, did not meet load specifications, or was damaged during this check, the PP will be removed from the test. Test teams can use targets outside of tolerances for practice checkout and pilot test runs, instead of using effectiveness qualified targets that may be limited in numbers.

NOTE: Tolerances may have to be expanded to allow more targets to fall within a usable range; otherwise, there may not be enough available targets (material characteristics). The design of the targets using commercial plywood sheets may not be consistent, thus creating a varying degree of strength as determined by the load measurement process.

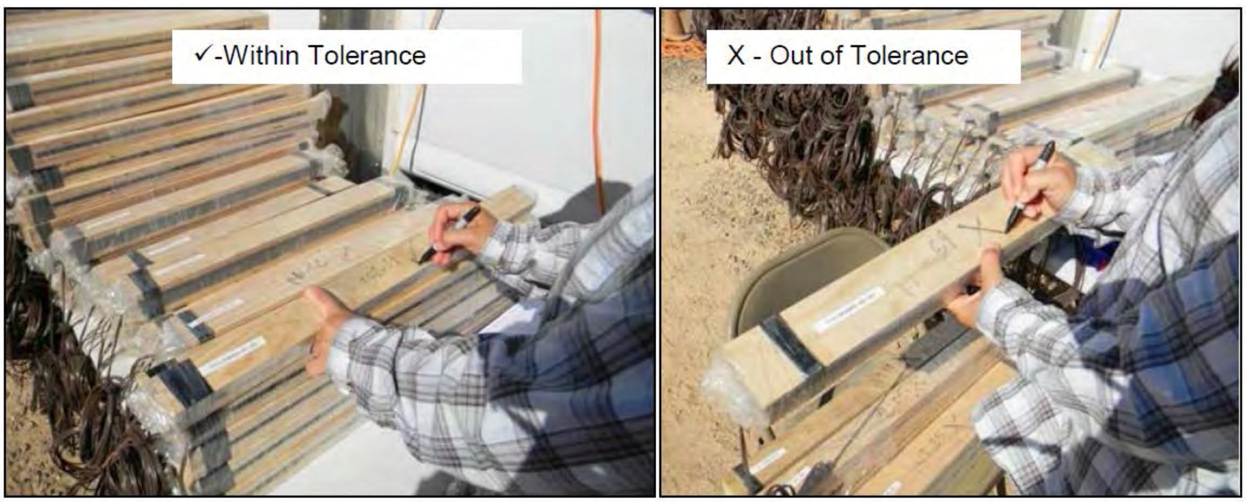


Figure C-14. Mark on target to indicate load tolerance screening results.

d. Test teams will emplace the PPIED targets on top of a rigid base for pre-determine depth, and then hook up to the data acquisition circuitry as shown in Figure C-15.

APPENDIX C. ROLLER TEST TARGET DESCRIPTIONS.

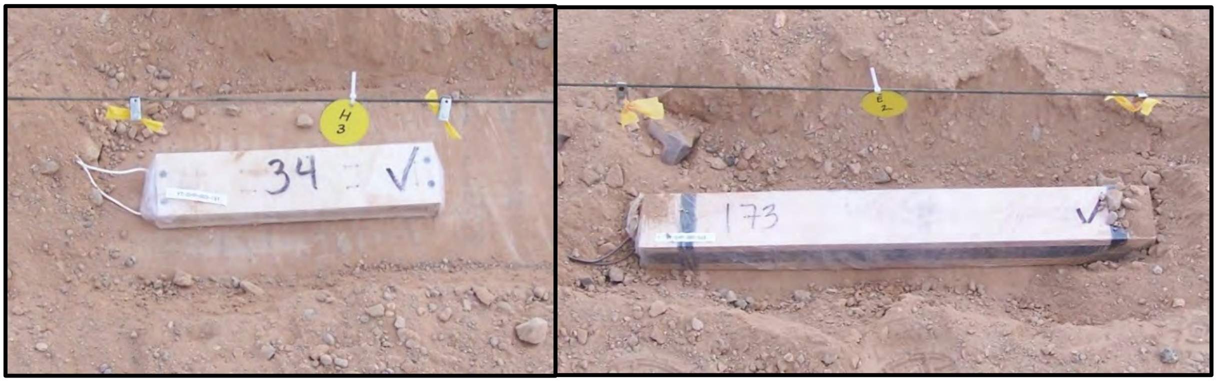


Figure 15. Examples of the pressure plate trigger devices installed on the test lane.

NOTE: PPIED triggers can be fabricated locally but must maintain tactical operational load capability to test against actual vehicle load weight. Design configuration must be approved by customers and evaluating agency.

C.4. <u>DATA ACQUISITION RECOMMENDATIONS</u>.

a. The SUM and PPIED targets provide an output voltage signal (e.g., 0-5 Volts) that is proportional to pressure plate deflection or from switch closure (see Appendix D). This electronic signal needs to be captured by the data acquisition system with adequate resolution to determine the maximum deflection during an overpass. This is then compared to the critical deflection for each particular target to determine whether or not the MRS or PM activated the target.

b. Depending on the overpass speed of the test, it is usually recommended that a data acquisition (DAQ) system capable of 5,000 samples/second/channel is used to measure the SUM signals. An analog to digital converter of 16-bit or greater amplitude resolution is also recommended.

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APPENDIX D. PRESSURE PLATE TARGET ELECTRONIC SYSTEM CONFIGURATION.

D.1. PPIED TARGET SYSTEM.

D.1.1 Pressure Plate Trigger System Setup.

The test team must prepare pressure plate triggers as follows:

a. Perform compression checks to ensure each PPIED meets load tolerance specifications (see Appendix C), and document the load and deflection measurements. Remove triggers that are beyond the limits outlined in the specified tolerance constraints (±20%, or ±40% of overall average) for that target type.

b. Emplacement and connection to data acquisition instrumentation array. For each PPIED, connect a customized signal conditioning circuit and wire pull apparatus as shown in Figure D-1. The test team must standardize this setup configuration for all PPIED triggers targets for effectiveness test runs.

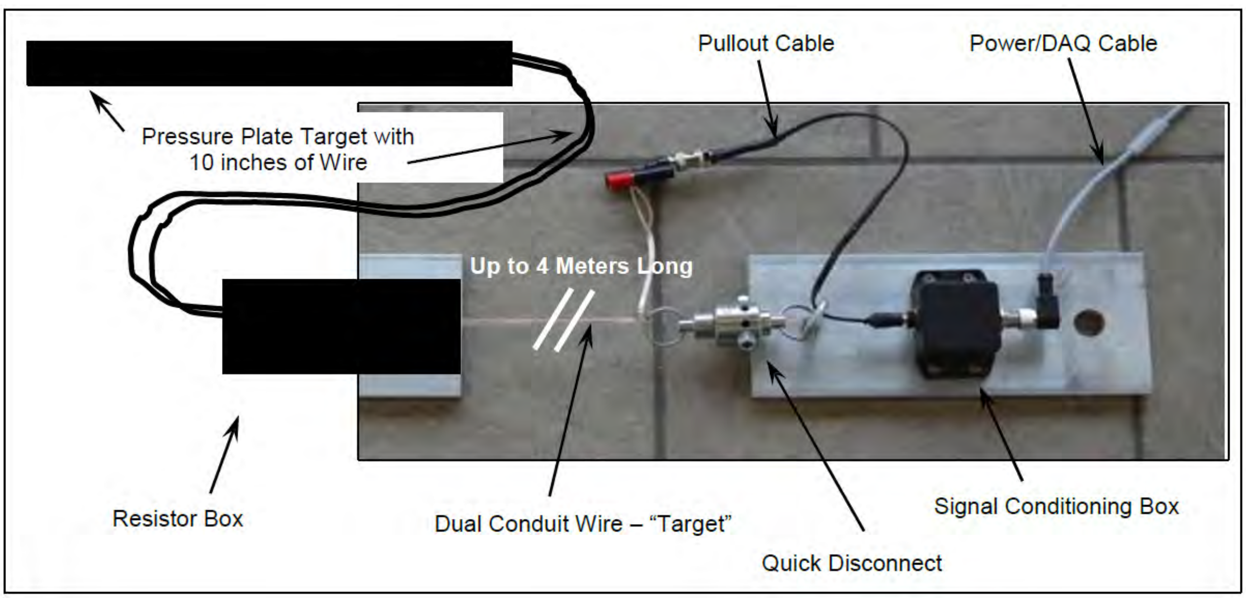

Figure D-1. Example of the pressure plate signal conditioning test instrumentation array.

NOTE: For this example in Figure D-1, a resistor-integrated circuit component is not incorporated into the design of the PPIED; therefore, a separate box must be integrated into the signal conditioning circuit and wire pull apparatus (instrumentation array).

APPENDIX D. PRESSURE PLATE TARGET ELECTRONIC SYSTEM CONFIGURATION.

c. For the roller test, between runs, the test team does not have to disturb the data acquisition cables except the PP target itself (cables remain in place

d. Verify continuity to data acquisition system, and troubleshoot to check for any discrepancies. Change any components as required.

e. Ensure targets are at the correct burial depth per test matrix with the soil overburden measured from the top of surface to top of target (Figure D-2).

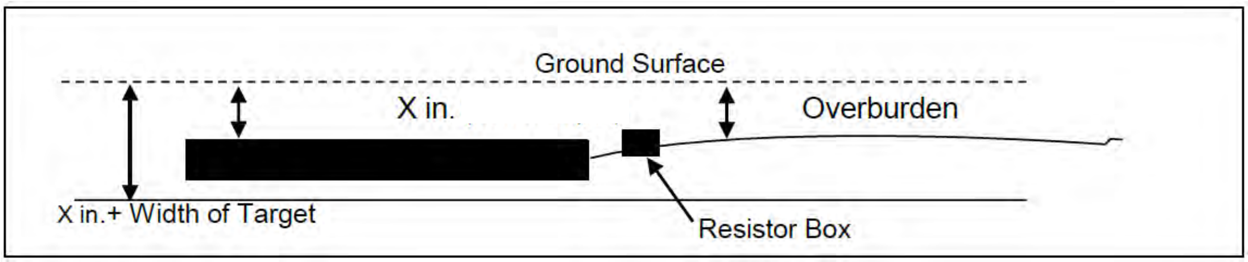

Figure D-2. Example of typical burial configuration for a pressure plate and cable.

D.1.2 PPIED Array Circuitry.

Figure D-3 depicts the circuitry components of a PPIED trigger mechanism to support this electronic array during effectiveness testing and instrumentation circuity methodology. The in-line resistors allow the ability to have a working trigger mechanism for circuit. An example of an external resistor box is shown in Figure D-4. Figure D-5 shows the possible results of when the roller engages the PPIED trigger: e.g., activation or non-activation engagements.

APPENDIX D. PRESSURE PLATE TARGET ELECTRONIC SYSTEM CONFIGURATION.

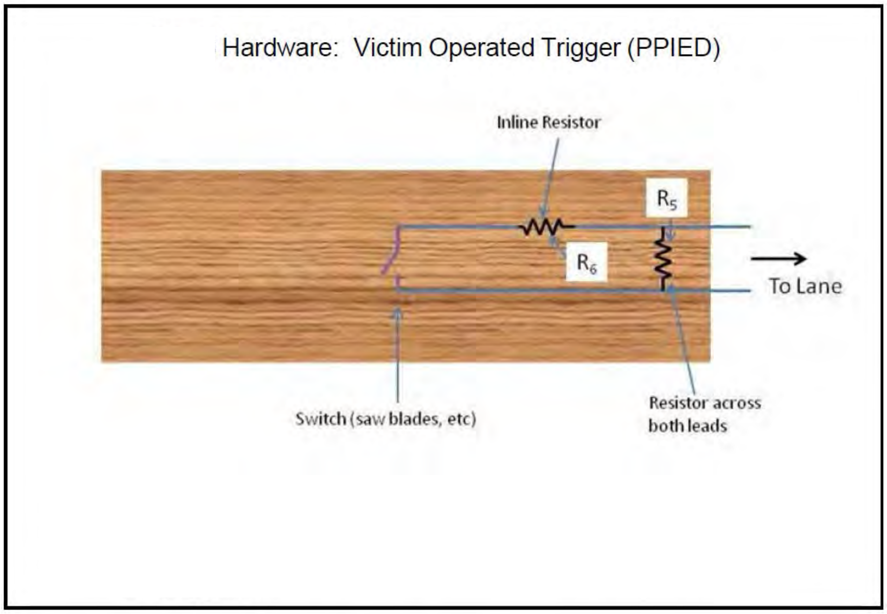

Figure D-3. Pressure plate with resistor circuit integrated into the trigger circuity.

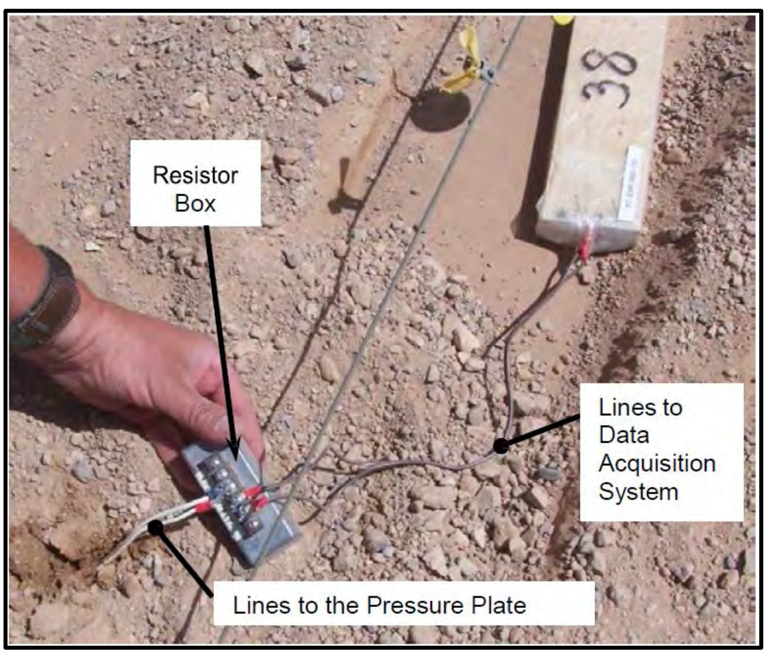

Figure D-4. Pressure plate circuit with resistor box from trigger to data acquisition system.

APPENDIX D. PRESSURE PLATE TARGET ELECTRONIC SYSTEM CONFIGURATION.

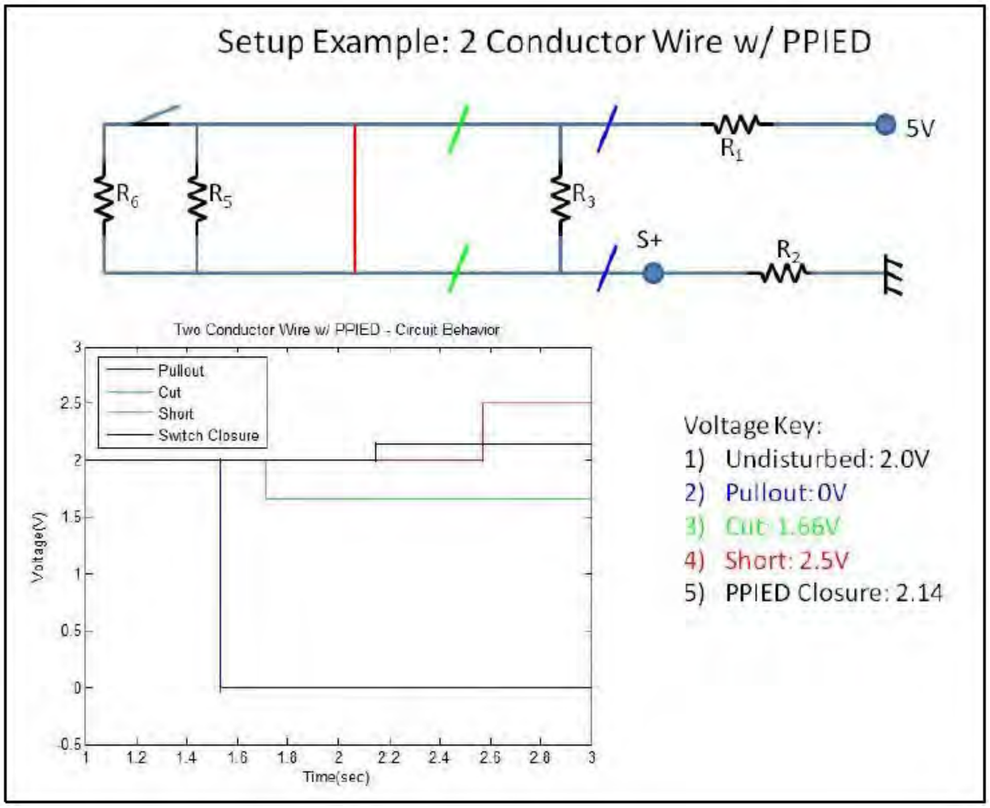

Figure D-5. PPEID circuit voltage behavior.

APPENDIX E. TARGET OVERBURDEN.

E.1. ROLLER LANDMINE TARGETS.

The overburden is the material on top of the targets. Figures E-1 and E-2 are examples of the definition of overburden used for effectiveness testing.

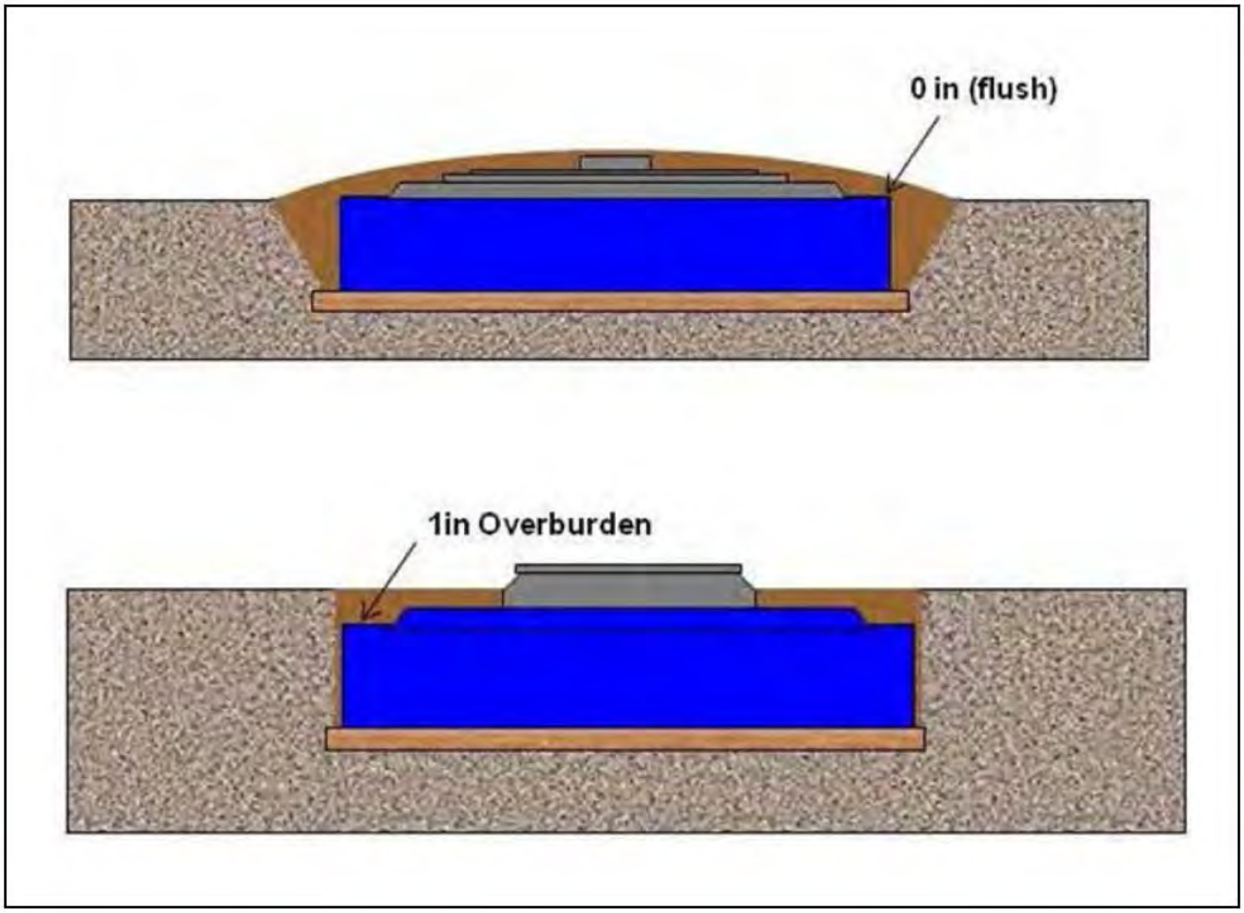

Figure E-1. Schematic example of the backfill overburden depth over landmine targets.

APPENDIX E. TARGET OVERBURDEN.

Figure E-2. Example of the overburden over landmine targets.

E.2. PPIED TARGETS.

Figure E-3 shows the overburden for PPIED.

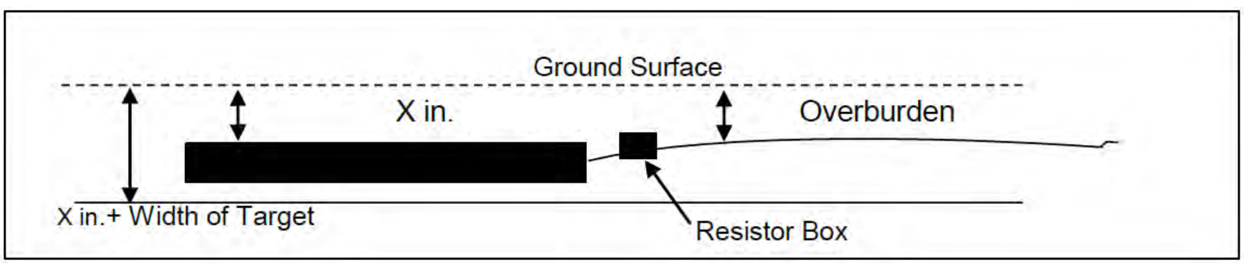

Figure E-3. Example of the overburden depth over the pressure plate and wire.

APPENDIX E. TARGET OVERBURDEN.

E.4. EXAMPLES OF STANDARDIZED TARGET OVERBURDEN DEPTHS FOR ROLLER EFFECTIVENESS TESTING.

NOTE: The overburden depth specification has been standardized by the countermine and mechanical clearing community (e.g. TARDEC, ATEC, Project Manager Close Combat Systems (PM CCS), etc.) as follows:

E.4.1 Deep Phase Overburden Depths.

a. Landmines:

(1) TM46: 2.0 inches.

(2) M19: 1.0 inch.

(3) TM62: 1.0 inch.

(4) M20: 2.0 inches.

b. Pressure Plates.

(1) Long foam: 2.0 inch.

(2) Long sheet metal: 1.5 inch.

(3) Short foam: 1.0 inch.

(4) Short wood: 1.0 inch.

E.4.2 Shallow Phase Overburden Depths.

a. Landmines:

(1) TM46: 0 - 0.5 inch.

(2) M19: 0 - 0.5 inch.

(3) TM62: 0 - 0.5 inch.

(4) M20: 0 - 0.5 inch.

APPENDIX E. TARGET OVERBURDEN.

b. Pressure Plates.

(1) Long foam: 0 - 0.5 inch.

(2) Long sheet metal: 0 - 0.5 inch.

(3) Short foam: 0 - 0.5 inch.

(4) Short wood: 0 - 0.5 inch.

NOTE: Tester may use other overburden depths, but the depths should be reviewed and approved by customer and/or evaluating agency.

APPENDIX F. EFFECTIVENESS SCORING DEFINITIONS.

Testing terms are defined as follows for Roller SUT Effectiveness testing:

a. Run - A single pass within a bounded, straight path that includes a complete set of targets outlined in the execution matrix.

b. Data Point - Full/partial engagement of an activated or non-activated target by either the system under test or Prime Mover (vehicle/platform) (NOTE: missed target or no test is not included as a valid data point).

c. Full Engagement - System under test engages target completely 100 percent coverage on the target within the SUT coverage area - functional mechanism on target (valid data point).

d. Partial Engagement - Target encounter that does not meet full engagement requirements.

(1) Engagement of greater than 50 percent of target (valid data point).

(2) Engagement of less than 50 percent of target (Miss - No Test).

e. Miss

(1) Target within SUT coverage (but falls in between wheel gap, etc.), valid non-activation data point.

(2) Target was not within the SUT coverage area (No Test), not a valid data point.

f. Activation - Target was engaged and the trigger mechanism was initiated.

g. Non-Activation - Functional target was engaged (full, or partial at 50% or greater) but trigger mechanism was not initiated.

h. Critical Non-Activation - A target was engaged and the trigger mechanism was not initiated by roller component under test, but was initiated by Prime Mover.

i. No Test (no data point) - Possible reasons include: (1) target device was not functioning (e.g., wires severed or not connected); (2) loss of power to data collecting instruments; (3) partial engagement (less than 50% of target); (4) miss target. Comments shall be placed into the remarks section of the data sheet.

j. Secondary Effects - During a post-run inspection of a non-activated target with a valid engagement, the target is activated by means other than its intended functionality (such as activation during unearthing, short circuit, etc.). Comments shall be placed into the remarks

APPENDIX F. EFFECTIVENESS SCORING DEFINITIONS.

section of the data sheet. The test officer makes the determination whether it was a valid run (non-activation) or not (no test) for a final score.

k. Verification For Valid Non-Activated Score - For targets that are engaged (full or partial), but were "not activated", the test team must determine if the target was functional at the time of the engagement.

l. Pre-Operational Check - Personnel will verify with electronic scoring whether the target had a valid signal to and from the target to ensure it was operational prior to test run. Pre-functional checks are performed prior to runs to confirm and validate target readiness. This is important, because it's a quality check to say the target was operational prior to the run. If the wire was cut during the run, and not disconnected from the data acquisition system, then it would be scored as a defeat of the target.

m. Post-Operational Check - After the run, and for target positions that were not activated without disturbing the buried target, test personnel will manually perform a quality functional check to determine if the target is operational to confirm the subsystem under test had a valid target for engagement. Personnel will manually activate the target to acquire the following results:

(1) Target Array Verification - Receives a signal; the run is scored as "Non-Activation".

(2) Target Array Verification - Does not receive a signal, test personnel will check the power supply and wires leading to target. If conditions and data reflect a valid operational target, the test officer makes the determination whether it was a valid run (non-activation) or not (no test) for a final score. If wire is pulled or separated from data acquisition test apparatus connectors, then it cannot be scored as a valid data point (e.g., not a valid cut or defeat of target).

APPENDIX G. SECURITY CLASSIFICATION EFFECTIVENESS GUIDE.

Guidelines for determining the security classification of effectiveness scoring is provided in Figure G-1.

Defeat effectiveness performance results from formal testing of mature system design configurations are classified as specified below.

a. Statements regarding quantitative defeat performance at specific (quantitative) depths against specific models of *US* ***landmines*** are SECRET. Statements regarding performance against generic US landmine types (e.g., simulators or surrogates) or generic depths (e.g., shallow or deep) or statements in which the system is not identified (unless it is identified in the larger context of a document) are UNCLASSIFIED. Examples are as follows:

(1) SECRET: Name of System Under Test (SUT) True Name defeats XX% of specific US landmine nomenclature at specific depths

(2) UNCLASSIFIED: Name of SUT defeats XX% of specific US landmine nomenclature at generic depths

(3) UNCLASSIFIED: " SUT- Y" (coded name) defeats XX% of specific US landmine nomenclature at specific depths

(4) UNCLASSIFIED: " SUT-Y" (coded name) defeats XX% of specific US landmine nomenclature at generic depths

(5) UNCLASSIFIED: Name of SUT defeats specific US landmine nomenclature

(6) UNCLASSIFIED: Name of SUT defeats XX% of generic US landmine type at specific depths

(7) UNCLASSIFIED: Name of SUT defeats XX% of generic US landmine type at generic depths

b. Statements regarding quantitative defeat performance at specific (quantitative) depths against specific models ***foreign landmines*** are SECRET. Statements regarding performance against generic foreign landmine types or generic depths (e.g., shallow or deep) or statements in which the system is not identified (unless it is identified in the larger context of a document) are UNCLASSIFIED. Examples are as follows:

(1) SECRET: Name of SUT defeats XX% of specific foreign landmine nomenclature at specific depths

(2) UNCLASSIFIED: Name of SUT defeats XX% of specific foreign landmine nomenclature at generic depth

(3) UNCLASSIFIED: " SUT-Y" (coded name) defeats XX% of specific foreign landmine nomenclature at specific depths

Figure G-1. Effectiveness security classification scoring guidelines.

APPENDIX G. EFFECTIVENESS SECURITY CLASSIFICATION SCORING GUIDE.

(4) UNCLASSIFIED: " SUT-Y" (coded name) defeats XX% of specific foreign landmine nomenclature at generic depths

(5) UNCLASSIFIED: Name of SUT defeats specific foreign landmine nomenclature

(6) UNCLASSIFIED: Name of SUT defeats XX% of generic foreign landmine type at specific depths

(7) UNCLASSIFIED: Name of SUT defeats XX% of generic foreign landmine type at generic depths

c. Statements regarding quantitative defeat performance at specific (quantitative) depths against specific EH other than landmines ***(non-landmine** EH),* which are IEDs (high explosive component, excluding the trigger mechanism, see d below) are SECRET. Statements regarding performance against generic non-landmine EH or generic depths (e.g., shallow or deep) or statements in which the system is not identified (unless it is identified in the larger context of a document) are UNCLASSIFIED. Examples are as follows:

(1) SECRET: Name of SUT defeats XX% of specific non-landmine EH at specific depths

(2) UNCLASSIFIED: Name of SUT defeats XX% of specific non-landmine EH nomenclature at generic depth

(3) UNCLASSIFIED: "SUT Y" (coded name) defeats XX% of non-landmine EH nomenclature at specific depths

(4) UNCLASSIFIED: "SUT Y" (coded name) defeats XX% of specific non-landmine EH nomenclature at generic depths

(5) UNCLASSIFIED: Name of SUT defeats specific non-landmine EH nomenclature

(6) UNCLASSIFIED: Name of SUT defeats XX% of generic non-landmine EH type at specific depths

(7) UNCLASSIFIED: Name of SUT defeats XX% of generic non-landmine EH type at generic depths

Figure G-1. Effectiveness security classification scoring guidelines (continued).

APPENDIX G. EFFECTIVENESS SECURITY CLASSIFICATION SCORING GUIDE.

d. Statements regarding quantitative defeat performance against specific ***trigger mechanisms*** used to actuate IEDs, regardless of depth, are SECRET. Statements regarding performance against Trigger Mechanisms in general or statements in which the system is not identified (unless it is identified in the larger context of a document) are UNCLASSIFIED. Examples are as follows:

(1) SECRET: Name of SUT defeats XX% of (specific trigger mechanism description)

(2) UNCLASSIFIED: "SUT Y" (coded name) defeats XX% of (specific trigger mechanism description)

(3) UNCLASSIFIED: Name of SUT defeats (specific trigger mechanism description)

(4) UNCLASSIFIED: Name of SUT defeats XX% of trigger mechanism

Figure G-1. Effectiveness security classification scoring guidelines (concluded).

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APPENDIX H. EFFECTIVENESS SAMPLE SIZE DETERMINATION.

H.1 SAMPLE SIZE EVALUATION.

a. A test team must understand the sample size requirement before developing the test matrix. Requirements documents may or may not provide all the sample size information needed. Several key pieces of information are required before a sample size can be determined.

b. Consider the following questions:

(1) What test categories are required (target types, target depths, road types, and any other objectives)?

(2) Is there a success rate requirement and if so what type of statistic is needed (percentage or reliability)?

(3) Is the success rate requirement an overall requirement or for each test category (or differ between categories)?

(4) How many unsuccessful encounters are acceptable?

(5) Has the customer provided a test matrix with sample sizes for all the test categories?

b. An optimum sample size is a sample of minimum quantity or number of encounters that will estimate the probability of target activation with sufficient precision and confidence. A scenario consists of each combination of road/terrain type, target type, and target depth (e.g., 30 encounters are required for a single type of target, at a specific depth, in a specific road configuration, and then repeated for each parameter change). The sample size can be determined using a binomial distribution for any given reliability and confidence level.

H.2 STATISTICAL REQUIREMENTS.

a. Percent Success Rate: If the success rate requirement is stated as a point estimate percentage, then the sample size is not directly determined by a statistical requirement. The point estimate percentage is as follows: percent success rate is equal to the number of successful engagements divided by the number of engagements. In this case the sample sizes for each test category need to be provided, or developed and provided to the customer and/or evaluator for approval.

b. Reliability Success Rate: The reliability success rate is often confused with percent success rate, as it is stated as a percent reliability. The binomial distribution along with the lower confidence level are used to calculate percent reliability. The binomial distribution is used as the success rate of the MRS having only two independent outcomes. Each encounter is scored as a successful engagement or not. It is common for a test requirements document to be written

APPENDIX H. EFFECTIVENESS SAMPLE SIZE DETERMINATION.

where only the percent reliability is given. Request clarification if this is the case. Safety related requirements require higher reliabilities and higher confidence levels. When meeting safety requirements, expect to see both the percent reliability and the lower confidence level to be 90-percent or above (see example Table H-1).

TABLE H-1. SAMPLE SIZE EXAMPLE FOR PERCENT RELIABILITY FOR A GIVEN LOWER CONFIDENCE LIMIT

ENGAGEMENT	NUMBER OF VALUES FOR RELIABILITY SUCCESS RATE					
80-percent Reliability With a 80-percent Lower Confidence Limit						
Samples	8	14	21	27	33	39
Successes	8	13	19	24	29	34
Failures	0	1	2	3	4	5
80-percent Reliability With a 90-percent Lower Confidence Limit						
Samples	11	18	25	32	38	45
Successes	11	17	23	29	34	40
Failures	0	1	2	3	4	5
80-percent Reliability With a 95-percent Lower Confidence Limit						
Samples	14	22	30	37	43	50
Successes	14	21	28	34	39	45
Failures	0	1	2	3	4	5
90-percent Reliability With a 90-percent Lower Confidence Limit						
Samples	22	38	52	65	78	91
Successes	22	37	50	62	74	86
Failures	0	1	2	3	4	5
90-percent Reliability With a 99-percent Lower Confidence Limit						
Samples	44	64	81	97	112	128
Successes	44	63	79	94	108	123
Failures	0	1	2	3	4	5
99-percent Reliability With a 90-percent Lower Confidence Limit						
Samples	229	388	531	665	796	926
Successes	229	387	529	662	792	921
Failures	0	1	2	3	4	5

NOTE: Non safety reliability statistical requirements are generally set at an 80-percent lower confidence level and the percent reliability is 80-percent or higher.

APPENDIX H. EFFECTIVENESS SAMPLE SIZE DETERMINATION.

H.2.1 Examples of Information Available to Evaluate Sample Size Requirements.

H.2.1.1 Case I: Requirements Documents Include A Test Matrix With Samples Sizes For All Test Categories With No Related Statistical Requirement.

This is the simplest case as there is no statistic requirement. If the test is not an evaluated government test, such as an engineering test, then the test team need only to consider lane setups and the number of encounters needed to meet the sample size requirements for the different test categories. However, if the test is an evaluated government test, then it is prudent to ask what the reliability requirement is. Determining the reliability of the system to successfully engage a target and defeat a target is a critical safety related requirement.

H.2.1.2 Case II: Test Matrix With Samples Sizes For All Test Categories With A Related Statistical Requirement.

a. If the statistical requirement is a percent success rate the test team need only to consider lane setups and the number of encounters needed to meet the sample size requirements for the different test categories.

b. If the success rate requires a percent reliability with a lower confidence level then verify the sample size for each test category (target types, target depths, road types and for any other objectives) meets the percent reliability requirement. Use the binomial distribution to determine how many unsuccessful engagements can occur while still meeting the percent reliability statistic with the given lower confidence level. If this turns out to be zero, make sure the customer understands that the test item will fail the percent reliability requirement if there are any unsuccessful engagements - non-activations.

H.2.1.3 Case III: Test Categories Defined With A Related Statistical Requirement (Test Matrix Does Not Include The Number Of Samples).

a. If the statistical requirement is a percent success rate and the test team needs to recommend a sample size for the test categories, recommend a minimum of 38 samples per test category (38 samples allows for 1 failure with a 90-percent reliability and a 90-percent lower confidence level - critical safety related issue).

b. If the success rate requires a percent reliability with a given lower confidence level, then use a binomial distribution to calculate the required sample size. It is recommended that at least one failure be included in the calculation.

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APPENDIX I. ABBREVIATIONS AND ACRONYMS.

AT	antitank
AST	ATEC System Team
ASTM	American Society for Testing and Materials
ATEC	U.S. Army Test and Evaluation Command
DAQ	data acquisition
FM	Field Manual
GPS	Global Positioning System
GVW	gross vehicle weight
IAW	in accordance with
ID	identification
IED	improvised explosive device
ITOP	International Test Operations Procedure
kg	kilogram
lb	pound
mph	miles per hour
MRS	mine roller system
OM	Operator Manual
PM	prime mover
PM CCS	Project Manager Close Combat Systems
PP	pressure plate
PPIED	pressure plate improvised explosive device
SOP	Standard Operating Procedure
STT	standard test target
SUM	surrogate mine
SUT	system under test
TARDEC	U.S. Army Tank Automotive Research, Development, and Engineering Center
TM	Technical Manual
TO	Test Officer
TOP	Test Operations Procedure

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APPENDIX J. REFERENCES.

1. ITOP 04-2-526 Mechanical Clearing and Breaching Equipment for Countermine, 22 July 2005.

2. ASTM International Designation: D2488 - 09a, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), 2009.

3. ASTM International Designation: D2216 - 10, Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass, 2010.

4. ASTM International Designation: D 6938 - 17, Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth), 2017.

5. ITOP 04-2-521 Target Standardization for Countermine and Demining Testing, 20 May 1999.

6. FM 20-32 Mine/Countermine Operations, 30 September 1992.

7. Jane's Mines and Mine Clearance, 2012.

For information only (related publications).

a. ITOP 03-1-005 Statistics for Test Assessment, 23 October 2003.

b. ASTM International Designation: D 3441 - 05, Standard Test Method for Mechanical Cone Penetration Tests of Soil, 2005.

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APPENDIX K. APPROVAL AUTHORITY.

CSTE-TM 4 December 2017

MEMORANDUM FOR

Commanders, All Test Centers
Technical Directors, All Test Centers
Directors, U.S. Army Evaluation Center
Commander, U.S. Army Operational Test Command

SUBJECT: Test Operations Procedure (TOP) 04-1-010 Effectiveness Testing of Mechanical Clearing Systems - Roller Systems Operating in a Straight Path, Approved for Publication

1. TOP 04-1-010 Effectiveness Testing of Mechanical Clearing Systems - Roller Systems Operating in a Straight Path, has been reviewed by the U.S. Army Test and Evaluation Command (ATEC) Test Centers, the U.S. Army Operational Test Command, and the U.S. Army Evaluation Center. All comments received during the formal coordination period have been adjudicated by the preparing agency. The scope of the document is as follows:

The purpose of this TOP is to provide the tester standardized testing methodologies and procedures to assess roller systems to analyze effectiveness against landmines and improvised explosive devices and trigger threats. Testing is performed on a primary (hard packed), secondary (compacted gravel or dirt surfaces), and/or improved, controlled lanes with buried threat targets at various depths.

2. This document is approved for publication and will be posted to the Reference Library of the ATEC Vision Digital Library System (VDLS). The VDLS website can be accessed at https://vdls.atc.army.mil/.

3. Comments, suggestions, or questions on this document should be addressed to U.S. Army Test and Evaluation Command (CSTE-TM), 2202 Aberdeen Boulevard-Third Floor, Aberdeen Proving Ground, MD 21005-5001; or e-mailed to usarmy.apg.atec.mbx.atec-standards@mail.mil.

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Director, Test Management Directorate (G9)

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Policy and Standardization Division (CSTE-TM), U.S. Army Test and Evaluation Command, 2202 Aberdeen Boulevard, Aberdeen Proving Ground, Maryland 21005-5001. Technical information may be obtained from the preparing activity: Munitions and Weapons Division (TEDT-YPY-G-MW), U.S. Army Yuma Proving Ground, 301 C Street, Yuma, Arizona 85365. Additional copies can be requested through the following website: http://www.atec.army.mil/publications/topsindex.aspx, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.