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This TOP supersedes TOP 02-2-611 Standard Obstacles, dated 17 March 2010.

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14. ABSTRACT
This Test Operations Procedure (TOP) describes test methods used to evaluate a vehicle's capability to negotiate standard obstacles simulating conditions encountered during mission operations. Included are procedures for evaluating a vehicle's bridging, wall climbing, trench crossing and twisting capabilities, and its ability to negotiate standard aircraft and ship loading ramps, rubble piles, stairs, curbs and potholes.

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bridging; wall climbing; aircraft loading ramps; standard trench; trench-crossing; potholes; wave course; rubble pile; frame twister; wave number spectrum; stairs; street curb

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

*Test Operations Procedure 02-2-611A 13 May 2022
DTIC AD No.

STANDARD OBSTACLES

*This TOP supersedes TOP 02-2-611 Standard Obstacles, dated 17 March 2010.

1. SCOPE.

a. This Test Operations Procedure (TOP) describes test methods used to evaluate a vehicle's capability to negotiate standard obstacles simulating conditions encountered during mission operations. Included are procedures for evaluating a vehicle's bridging, wall climbing, trench crossing, and twisting capabilities, and its ability to negotiate standard aircraft and ship loading ramps, rubble piles, stairs, curbs and potholes.

b. Other obstacles, which include slopes, various size washboards, etc., are described in TOPs 02-2-610A[1**] and 01-1-011B[2].

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

Item	Requirement
Bridging Device	A device providing an adjustable gap for measuring the maximum opening a vehicle can span when unsupported.
Vertical Wall (or Step)	A vertical wall (or step) constructed to the specified height using replaceable timbers with a squared edge on the top and a concrete approach surface at the bottom.
Standard Trench	A trench formed by the intersection of two flat concrete surfaces, each at a 36-percent (20-degree) longitudinal grade.
Wave (Frame-Twister) Course	A concrete course consisting of two vertical sinusoids 180-degrees out of phase, each having amplitudes increasing with track width. Used to twist a vehicles suspension, chassis, and body to observe for necessary clearance, compliance or stiffness, and articulation of components, as well as adequate suspension travel, and wiring and tubing lengths.
Simulated Loading Ramps	Flat concrete- or metal-surfaced ramps angled to simulate various aircraft and landing craft ramps.

** Superscript numbers correspond to Appendix B, References.

Item	Requirement
Rubble Pile	Course of large boulders, concrete construction debris with steel rebar, stone and gravel. Figure 1 shows an illustration of one of the two courses located at the U.S. Army Aberdeen Test Center (ATC). Refer to TOP 01-1-011B for other examples.
Stairs	Course of stairs with mount and dismount aprons, wide enough for vehicle traffic. Stair risers are 15 centimeters (cm) (6inches (in.)) high and stair treads are 38 cm (15 in.) wide. Figure 2 shows an illustration of the course located at ATC.
Street Curb	A straight length of square or close-to-square street curb with an 8 in. reveal (height).
Pothole Course	Course of standardized potholes formed from steel or concrete, 4 to 12 in. deep with typically 45-degree sloped entry and exit profiles.

[a]Refer to TOP 01-1-011B for descriptions of the obstacles available at ATC and Yuma Test Center, including photographs and illustrations.

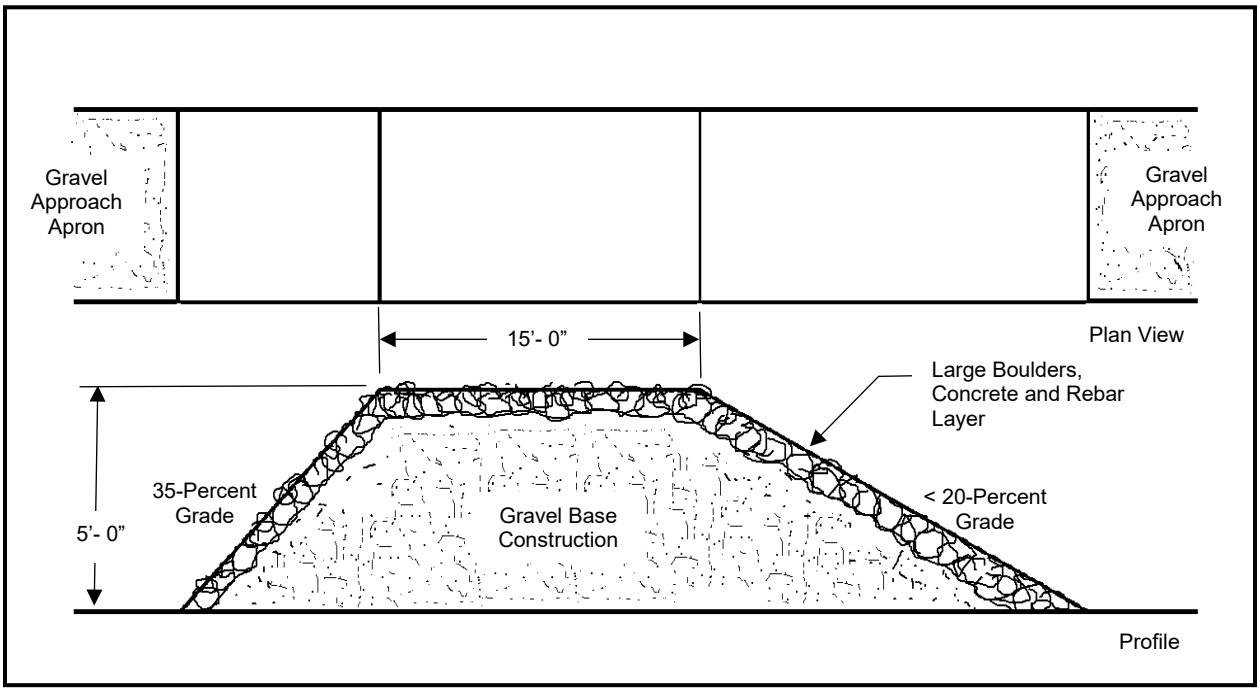

Figure 1. Rubble pile, located at ATC Munson Test Area (MTA).

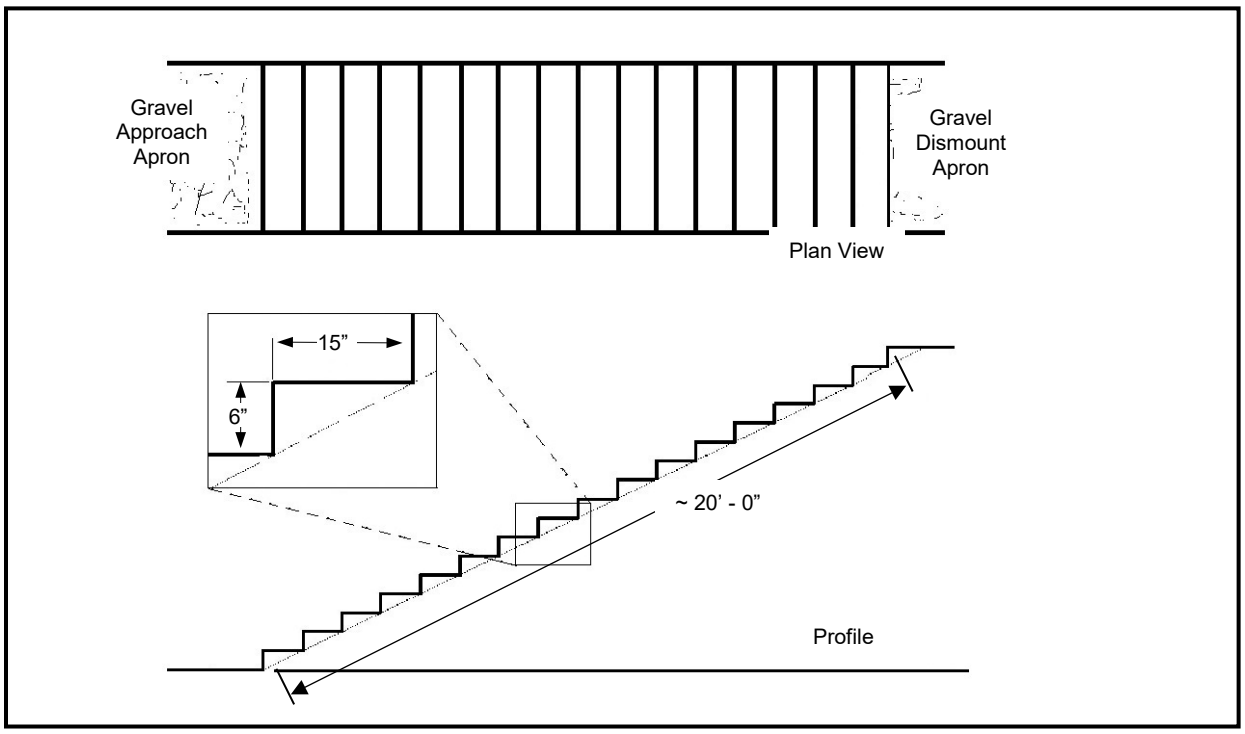

Figure 2. Stairs.

2.2 Instrumentation.

Devices for Measuring	Permissible Measurement Uncertainty(see NOTE 1)
Distance	0.3 percent of full scale
Angle	0.5 degrees
Speed	0.5 kilometers per hour (0.3 mile per hour)

NOTE 1: The permissible measurement uncertainty is the two-standard deviation value for normally distributed instrumentation calibration data. Thus 95 percent of all instrumentation calibration data readings will fall within two standard deviations from the known calibration value.

2.3 Specialized Equipment.

Still cameras and/or video cameras to record vehicle-to-surface contact during obstacle negotiation attempts.

3. REQUIRED TEST CONDITIONS.

3.1 Preparation for Test.

a. Review all instructional material issued with the test vehicle by the manufacturer, contractor, or government, and reports of previous similar tests on the same types of vehicles.

b. Select the applicable test facilities to be used based on the requirements documents and purpose of the test. Review the applicable test procedures listed in the detailed test plan.

c. Prepare data collection sheets to record all pre-test information, conditions of test, test results, observations, and measurements that would be valuable in analysis and assessment.

d. Ensure that all test personnel are familiar with the required technical and operational characteristics of the item, and with the required test procedures.

3.2 Test Controls.

Prior to testing, ensure that:

a. The vehicle has been prepared and equipped in accordance with standard use and/or within the specifications presented in the test plan. Particular attention should be given to track tension, tire pressures, powertrain settings, suspension settings, and fuel and oil levels.

b. The vehicle is payloaded in accordance with the test plan.

c. If applicable, the gun is positioned per test instructions.

d. The vehicle has received the proper break-in operation.

e. The manufacturer's technical/operational manual is reviewed by test personnel for powertrain settings, suspension settings, and limitations/restrictions.

3.3 Restrictions.

Tests are generally not conducted at night or during inclement weather due to safety and test repeatability concerns. Prior to test conduct on obstacles other than the rubble pile, ensure the obstacle and entry surfaces are free of dirt, gravel, debris, and moisture, that could negatively impact vehicle traction or mobility. Test course safety and operational procedures shall be carefully followed.

4. TEST PROCEDURES.

4.1 Bridging.

The bridging limit is defined as the maximum free space that a slowly moving vehicle can cross, starting from a level platform with a straight lateral edge and crossing to a like surface at the same level. Bridging may be conducted with tracked vehicles and multiple-axle wheeled vehicles (greater than 3 axles with short axle spacing).

a. Set the bridging test device at an initial opening that is within the ability of the test vehicle to span as determined from its overall length and longitudinal center of gravity component.

b. Operate the test vehicle over the set opening at minimal speed (Figures 3 and 4). Advance each road-wheel or tire slowly across the gap, stopping frequently as needed to minimize momentum.

Figure 3. Tracked vehicle negotiating bridging device.

Figure 4. Multiple-axle wheeled vehicle negotiating bridging device.

c. Increase the device opening by suitable increments until the bridging limit is reached.

d. Repeat the procedure in the reverse direction, if required.

4.2 Vertical Obstacle (or Step).

Wall climbing ability is a characteristic determined for all tactical vehicles, wheeled or tracked. Maximum capability may be limited by projections from the vehicle that extend beyond the wheels or tracks.

a. Consult the vehicle's technical/operational manual, system requirements, or detailed test plan (DTP) for proper operational settings (i.e., powertrain setting, tire pressure setting, or suspension height setting) and adjust accordingly.

b. With both tracks or front wheels of the test vehicle placed in contact with the wall, apply sufficient power to climb the obstacle (Figure 5). For wheeled vehicles, after the first axle crests the wall bring subsequent axles in contact with the wall gently by slowing or suspending vehicle forward motion, and then reapply power. A successful negotiation is considered only when the vehicle passes completely over the wall. The use of steering during the climbing attempt is allowed only to keep the vehicle aligned perpendicular to the wall.

Figure 5. Vehicle ascending vertical wall.

c. When required, the test is repeated with the vehicle ascending the wall in the reverse gear and can be also be repeated in the descending mode at wall heights equal to the maximum attained in the ascending mode in the forward gear.

d. If the test vehicle fails to climb the designated wall as prescribed, attempts may be made at a lower or secondary tire pressure (for wheeled vehicles) or with the vehicle aligned at an angle less than 90 degrees to the wall where only one track or front wheel makes initial contact. Note that the vehicle may become unstable at approach orientations other than 90 degrees, as shown in Figure 6.

Figure 6. Vehicle ascending vertical wall in reverse gear at a 30-degree angle with wheel lift.

4.3 Standard Trench.

Trench-crossing tests are conducted to determine whether a vehicle has angles of approach, departure, and ground clearance that are adequate to allow negotiation of an obstacle that has been accepted as a standard of comparison. The standard trench (Figure 7) has a concrete surface, but whenever insufficient traction occurs, i.e., steel tracks, an earthen ditch of the same configuration may be substituted.

Figure 7. Vehicle negotiating standard trench.

a. Attempt trench crossing in forward direction only with the test vehicle perpendicular to the trench.

b. If vehicle fails to cross the trench during its initial test, attempts with the vehicle at angles less than 90 degree can be made.

4.4 Wave (Frame-Twister) Course.

a. Wheeled vehicles only are operated over the frame twister course to determine the following:

(1) The vehicle design provides sufficient strength and clearance to allow for extreme articulation, horizontally and vertically, of wheels, shock absorbers, springs, support arms, stops, and engine and power train components.

(2) The frame, body, and their associated components have adequate stiffness or flexibility.

(3) Any part of the body, hood, compartment latches, controls, engine, power train or suspension operates improperly or becomes misaligned.

(4) Wiring, tubing, and hoses have sufficient length, flexibility, and clearance.

b. To determine the above:

(1) Operate the test vehicle over the wave course (Figure 8) utilizing a reasonable range of speeds and gears.

Figure 8. Vehicle negotiating wave course.

(2) Stop the vehicle at a point on the course where the maximum twist and the extremes of vertical suspension occur, so that the operation of the doors, controls, dump bodies, engine hoods, etc., can be checked under the most severe conditions.

4.5 Simulated Loading Ramp.

Tactical vehicles designed for transportation by either aircraft or ramp-equipped ships must be capable of entering and exiting the transporting vehicle by means of an inclined surface or ramp. The simulated loading ramp (Figure 9) enables vehicles to be tested for adequacy of approach and departure angles, ground clearance, and freedom of interference at the point of articulation between towed and towing vehicles.

Figure 9. Vehicle ascending 20-degree loading ramp.

a. Make two attempts to negotiate the prescribed ramp(s).

b. Testing will be performed in both directions.

4.6 Rubble Pile.

Conduct testing to determine a test vehicle's ability to negotiate a test course consisting of large boulders and pieces of concrete and steel (Figures 10 and 11). Mobility over the rubble pile course is successful when the vehicle traverses the length of the course at the required speed. Dimensions of the rubble pile are generally defined in the DTP or vehicle system requirements.

Figure 10. Rubble pile course.

Figure 11. Vehicle negotiating rubble pile course illustrated in Figure 1.

a. Perform tests in the forward direction only.

b. Make two attempts to negotiate the course.

4.7 Stairs.

Conduct testing to determine a test vehicle's ability to negotiate a series of stairs in an urban environment.

a. Perform the test ascending the stairs in the forward direction/gear only at an approach of 90 degrees (Figure 12) and speed determined in the DTP.

Figure 12. Vehicle negotiating the stair course at the ATC MTA.

b. Tests may be performed with or without a trailer.

4.8 Street Curb.

Conduct testing to determine a vehicle's ability to mount a street curb having a nominal height of 8-inches. Operate the vehicle parallel to the curb in the forward or reverse direction/gear or at an angle determined by the DTP.

a. For parallel operations, drive the vehicle at a predetermined speed parallel to the curb, no more them 12-inches from the curb. Turn the vehicle into the curb to mount the obstacle (Figure 13) and then away from the curb to dismount.

Figure 13. Vehicle negotiating the street curb.

b. For angle operations, orient the vehicle as required in the DTP. Operate the vehicle at a predetermined speed towards the curb in the forward or reverse gear to mount the obstacle.

4.9 Potholes.

a. Conduct testing to determine a vehicle's ability to traverse a course of standardized potholes (see TOP 01-1-011B), either staggered across the vehicle's left and right tracks or in a straight line (with each track encountering the potholes individually). Optional plates can be installed in the potholes to adjust the depth.

b. Drive the vehicle at a predetermined speed in the forward direction across the course at the required pothole depths. Pay close attention to suspension travel and clearance areas between tires and wheel-wells and the bottom of the vehicle.

5. DATA REQUIRED.

a. Bridging.

(1) The bridging limit in the forward direction, and reverse direction if required.

(2) Powertrain, suspension height, and tire pressure settings (if applicable).

(3) Location of vehicle contact, other than the tracks or wheels, with the edge of the platform.

b. Vertical Obstacle.

(1) Maximum height of wall traversed in the forward gear in the ascending mode and in the descending mode and/or reverse direction/gear when required.

(2) Powertrain, tire pressure, and suspension height settings (if applicable).

(3) Vehicle angle to the wall when less than 90 degrees.

(4) Location of vehicle contact, other than the tracks or wheels, with the wall or ground during the climb.

c. Standard Trench.

(1) Dimensions of trench if other than the standard.

(2) Powertrain, tire pressure, and suspension height settings (if applicable).

(3) Vehicle-to-trench approach angle and the vehicle's success for each crossing attempt.

(4) Location of any vehicle-to-trench contact during each attempt.

d. Wave (Frame-Twister) Course.

(1) Description of test course.

(2) Observations and photographs of any contact between body components and the ability of those components to function at maximum twist angle.

(3) Speed of the test vehicle during test operations.

(4) Powertrain, tire pressure, and suspension height settings (if applicable).

e. Simulated Loading Ramp.

(1) Description of ramp.

(2) Powertrain setting along with tire pressure settings (if applicable).

(3) Successes and failures of the test vehicle to negotiate the designated ramp.

(4) Vehicle-to ramp contact points, and damage, if any.

f. Rubble Pile.

(1) Successes and failures of the test vehicle to negotiate the course.

(2) Powertrain, tire pressure, and/or suspension height settings (if applicable).

(3) Location of any vehicle-to-vehicle or vehicle-to-course contact points.

(4) Vehicle speed.

g. Stairs.

(1) Successes and failures of the test vehicle to negotiate the course.

(2) Powertrain, tire pressure, and/or suspension height settings (if applicable).

(3) Location of any vehicle-to-vehicle or vehicle-to-course contact points.

(4) Vehicle speed.

h. Street Curb.

(1) Successes and failures of the test vehicle to negotiate the course.

(2) Powertrain, tire pressure, and/or suspension height settings (if applicable).

(3) Vehicle angle or orientation to the curb.

(4) Location of any vehicle-to-vehicle or vehicle-to-course contact points.

(5) Vehicle speed.

i. Pothole Course.

(1) Successes and failures of the test vehicle to negotiate the course.

(2) Powertrain, tire pressure, and/or suspension height settings (if applicable).

(3) Location of any vehicle-to-vehicle or vehicle-to-course contact points.

(4) Vehicle speed.

6. PRESENTATION OF DATA.

Tabulate the results of the vehicle attempts to negotiate specific obstacles and compare them to the requirements and to a baseline vehicle when specified. Photographs should be taken to document significant results.

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APPENDIX A. ABBREVIATIONS.

ATC	U.S. Army Aberdeen Test Center
cm	centimeter
DTIC	Defense Technical Information Center
DTP	Detailed Test Plan
in.	inch
MTA	Munson Test Area
TOP	Test Operations Procedure

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APPENDIX B. REFERENCES.

1. TOP 02-2-610A, Gradeability and Side Slope Performance, 20 April 2020.

2. TOP 01-1-011B, Vehicle Test Facilities at Aberdeen Test Center and Yuma Test Center, 12 December 2017.

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APPENDIX C. APPROVAL AUTHORITY.

Placeholder for Director, Directorate for Capabilities Integration (DCI) Approval for Publication

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Forward comments, recommended changes, or any pertinent data that may be of use in improving this publication to the following address: Policy and Standardization Division (CSTE-CI-P), U.S. Army Test and Evaluation Command, 6617 Aberdeen Boulevard, Aberdeen Proving Ground, Maryland 21005-5001. Technical information may be obtained from the preparing activity: Automotive Instrumentation Division (TEDT-AT-ADI), U.S. Army Aberdeen Test Center, 6943 Colleran Road, Aberdeen Proving Ground, MD 21005-5059. Additional copies can be requested through the following website: https://www.atec.army.mil/publications/documents.html, 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.