INTERNATIONAL

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Standard Test Method for Evaluating the Mobility Capabilities of Emergency Response Robots Using Towing Tasks: Grasped Sleds[1]

This standard is issued under the fixed designation E2830; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 *Purpose:*

1.1.1 The purpose of this test method, as a part of a suite of mobility test methods, is to quantitatively evaluate a teleoperated ground robot's towing capability with the task of grasping loads and traversing a specified route on a flat and paved surface.

1.1.2 Robots shall possess a certain set of mobility capabilities, including towing, to suit critical operations such as emergency responses. This capability would be required to perform such emergency response-related tasks as delivering critical supplies, moving victims to safe locations, or transporting suspected packages away from humans.

1.1.3 Emergency response ground robots shall be able to handle many types of obstacles and terrains. The required mobility capabilities include traversing gaps, hurdles, stairs, slopes, various types of floor surfaces or terrains, and confined passageways. Yet additional mobility requirements include sustained speeds and towing capabilities. Standard test methods are required to evaluate whether candidate robots meet these requirements.

1.1.4 ASTM Task Group E54.08.01 specifies a mobility test suite, which consists of a set of test methods for evaluating these mobility capability requirements. This towing-by-grasping test method is a part of the mobility test suite. The apparatuses associated with the test methods challenge specific robot capabilities in repeatable ways to facilitate comparison of different robot models as well as particular configurations of similar robot models.

1.1.5 The test methods quantify elemental mobility capabilities necessary for ground robot emergency response applications. As such, the test suite should be used collectively to represent a ground robot's overall mobility performance.

NOTE 1—Additional test methods within the suite are anticipated to be developed to address additional or advanced robotic mobility capability requirements, including newly identified requirements and even for new application domains.

1.2 *Performing Location*—This test method shall be performed in a testing laboratory or the field where the specified apparatus and environmental conditions are implemented.

1.3 *Units*—The values stated in SI units are to be regarded as the standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E2521 Terminology for Evaluating Response Robot Capabilities

E2592 Practice for Evaluating Response Robot Capabilities: Logistics: Packaging for Urban Search and Rescue Task Force Equipment Caches

2.2 *Other Standards:*

National Response Framework U.S. Department of Homeland Security[3]

3. Terminology

3.1 Terminology E2521 lists additional definitions relevant to this test method.

[1] This test method is under the jurisdiction of ASTM Committee E54 on Homeland Security Applications and is the direct responsibility of Subcommittee E54.09 on Response Robots.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Federal Emergency Management Agency (FEMA), P.O. Box 10055, Hyattsville, MD 20782-8055, http://www.fema.gov.

3.2 *Definitions:*

3.2.1 *abstain, v*—the operator's action of notifying the administrator to withdraw from the test, causing the result not to be reported and the test form to be marked as abstained.

3.2.1.1 *Discussion*—The operator is the only person who can convey the decision to abstain the test. The abstention may be made when the robot configuration is not designed nor equipped to perform the test. The testing sponsor should make a consistent policy about the time period during which the abstention is allowed. The abstention is granted only before the test, as reflected in the procedure.

3.2.1.2 *Discussion*—Being marked as abstained indicates that all the parties involved in the test acknowledge the omission of the performance data while the test method was available at the test time.

3.2.2 *administrator, n*—person who conducts the test.

3.2.2.1 *Discussion*—The administrator shall ensure the readiness of the apparatus, the test form, and any required measuring devices such as stopwatch and light meter; the administrator shall ensure that the specified or required environmental conditions are met; the administrator shall notify the operator when the safety belay is available and ensure that the operator has either decided not to use it or assigned a person to handle it properly; and the administrator shall call the operator to start and end the test and record the performance data and any notable observations during the test.

3.2.3 *fault condition, n*—during the performance of the task(s) as specified by the test method, a certain condition may occur that renders the task execution to be failed and such a condition is called a fault condition.

3.2.3.1 *Discussion*—Fault conditions include robotic system malfunction, such as detracking, and task execution problems, such as excessive deviation from a specified path or failure to recognize a target.

3.2.4 *human-scale, adj*—used to indicate that the object, a response robot or an associated target, is in a volumetric and weight scale for a human or a small team of humans to handle properly, such as carrying it using nothing more than hand tools.

3.2.4.1 *Discussion*—No precise size and weight ranges are specified for this term. The test apparatus constrains the environment in which the tasks are performed. Such constraints, in turn, limit the types of robots to be considered applicable to emergency response operations.

3.2.5 *operator, n*—person who controls the robot to perform the tasks as specified in the test method; she/he shall ensure the readiness of all the applicable subsystems of the robot; she/he, through a designated second, shall be responsible for the use of a safety belay; and she/he shall also determine whether to abstain from the test.

3.2.6 *operator control unit (OCU), n*—a device used by an operator to teleoperate the robot.

3.2.7 *operator station, n*—apparatus for hosting the operator and her/his operator control unit (OCU) to teleoperate (see Terminology E2521) the robot; sight and sound insulation from the robot may be required as specified by the testing sponsor.

3.2.8 *repetition, n*—robot's completion of the task as specified in the test method and readiness for repeating the same task when required.

3.2.8.1 *Discussion*—In a traversing task, the entire mobility mechanism shall be behind the START point before the traverse and shall pass the END point to complete a repetition. A test method can specify returning to the START point to complete the task. Multiple repetitions, performed in the same test condition, may be used to establish the test performance to a certain degree of statistical significance as specified by the testing sponsor.

3.2.9 *test event or event, n*—a set of testing activities that are planned and organized by the test sponsor and to be held at the designated test site(s).

3.2.9.1 *Discussion*—Testing may be done with or without being associated with a test event. A testing event may be organized for particular program purposes, such as procurement or applicability study. In such a case, the program and the organization names should be considered a part of the event name. Meanwhile, a robot may also be tested for its performance record purposes independent of any particular event. A test event can also serve such additional purposes as promoting the robotic tool in a new user community and facilitating user training.

3.2.10 *test form, n*—form corresponding to a test method and contains fields for recording the testing results and the associated information, including: *(1)* Metrics and corresponding measuring scales and ranges; *(2)* Any additional testing features such as those reflecting performance proficiency; *(3)* Important notes to be recorded during the test, including particular fault conditions that occurred, the reason for abstaining, any observations by the administrator that could augment the recorded results in either positive or negative ways, or any comments that the operator requests to be put on the form; *(4)* Administrative information including: names of the involved personnel, organizations, and robot; testing date(s) and time; version number of the form; testing conditions on the environment and the apparatus; and robotic configuration (tether versus radio communication for example). If audio/video recording is done during the testing, the file names should be recorded on the form.

3.2.11 *test sponsor, n*—organization or individual that commissions a particular test event and receives the corresponding test results.

3.2.12 *test suite, n*—designed collection of test methods that are used, collectively, to evaluate the performance of a robot's particular subsystem or functionality, including mobility, manipulation, sensors, energy/power, communications, human-robot interaction (HRI), logistics, safety, and aerial or aquatic maneuvering.

4. Summary of Test Method

4.1 The task for this test method, towing by grasping, is defined as when the robot grasps either the specified sled that carries the operator-selected weight and traverses from the START post for a specified route to the END post and back fully. The default route shall be a figure eight, also known as a continuous “S” that is anchored by the two posts, as described in Section 6. See Fig. 1 for an illustration.

4.2 The robot’s towing capability is defined as when the robot is able to complete the task with the associated effective speed. Further, the test sponsor can specify the statistical reliability and confidence levels of such a capability and thus dictate the number of successful task performance repetitions that are required. In such a case, the average effective speed will be used, instead, as the robot’s capability.

4.3 Teleoperation shall be used from the operator station specified by the administrator to test the robots using an OCU provided by the operator. The operator station shall be positioned and implemented in such a manner so as to insulate the operator from the sights and sounds generated at the test apparatuses.

4.4 The operator is allowed to practice before the test. She/he is also allowed to abstain from the test before it is started. Once the test begins, there shall be no verbal communication between the operator and the administrator regarding the performance of a test repetition other than instructions on when to start and notifications of faults and any safety related conditions. The operator shall have the full responsibility to determine whether and when the robot has completed a repetition, and notify the administrator accordingly. However, it is the administrator’s authority to judge the completeness of the repetition.

NOTE 2—Practice within the test apparatus could help establish the applicability of the robot for the given test method. It allows the operator to gain familiarity with the standard apparatus and environmental conditions. It also helps the test administrator to establish the initial apparatus setting for the test when applicable.

4.5 The test sponsor has the authority to select the test methods that constitute the test event, to select one or more test site(s) at which the test methods are implemented, to determine the corresponding statistical reliability and confidence levels of the results for each of the test methods, and to establish the participation rules including the testing schedules and the test environmental conditions.

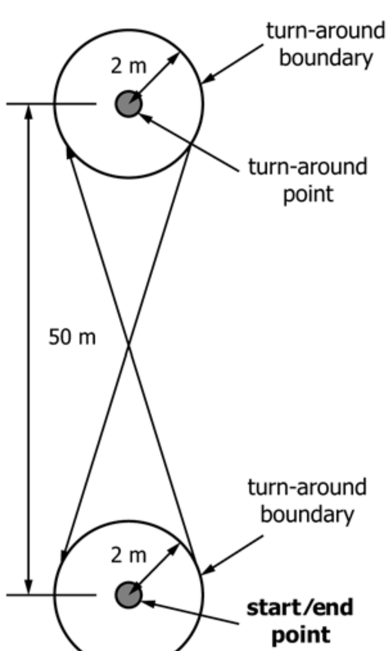

FIG. 1 Towing Apparatus

5. Significance and Use

5.1 This test method corresponds to the requirements as specified by U.S. emergency responders and additional constituents. A robot’s performance in this test is indicative of its capabilities needed in such operations as emergency responses. To have the successfully tested robots available to the emergency operations is consistent with the National Response Framework.

5.2 Although these test methods were developed first for emergency response robots, they may be applicable to other operational domains, such as law enforcement and military. They can also be used to ascertain operator proficiencies during training or serve as practice tasks that exercise robot actuators, sensors, and OCUs.

5.3 The standard apparatus is specified to be easily assembled to facilitate robotic developers’ self evaluation of the robots and facilitate the emergency responders’ and other users’ proficiency training in applying the robotic tools.

5.4 The objective of using robots in emergency response operations is to enhance the emergency responder’s capability of operating in hazardous or hard-to-reach environments. The testing results of the candidate robot shall describe, in a statistically significant way, how reliably the robot is able to traverse the obstacle, thus enabling emergency responders to determine the applicability of the robot.

6. Apparatus

6.1 This test apparatus includes a flat, paved surface. Each of the START and END points is identified with a post and they are 50 m (164 ft) apart from each other. The path is a figure eight or a continuous “S” and is marked with white chalk, with the turning radius around the START and END points being a 2-m (6.5-ft) radius (Fig. 1). The effective distance for the traversing task is 100 m (328 ft) and the robot is allowed to turn around with as small a radius as it chooses.

6.1.1 The apparatus also includes a loading device for carrying the towing load and a set of weights of 2 and 11 kg (5 and 25 lb). Backpacks with weights lighter than the loading device can also be used as stand-alone towing weights when the weight of the sled itself is too heavy for some of the testing robots.

6.1.2 The loading device, such as a sled or a medical stretcher, is not standardized. Users of this test method may select a device that fit their needs with the following requirements:

6.1.2.1 Include the weight of the device as a part of the towing capability;

6.1.2.2 Use the same device for comparison purposes. Also, the test sponsor has the authority to determine whether a tow line is to be used and tied to the loading device to facilitate the grasping. Such a decision shall be applied consistently to all the robots that are to be compared against each other.