Performance Metrics for Response Robots

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For the robotics industry to produce machines that can operate in search and rescue in disaster-stricken environments, it is important that there are "standard ways" to assess the performance. This article discusses the recent work in producing performance metrics.

—Alex Zelinsky,
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For response robots to be deployed in disaster or security scenarios, confidence is mandatory. To allow agencies such as homeland security to procure the *right* response robots, a set of performance standards needs to be set against which the robots can be objectively evaluated. Evaluation metrics of the performance of response robots are being standardized by the National Institute of Standards and Technology (NIST) and the American Society for Testing and Materials (ASTM) (www.astm.org) International with support from the U.S. Department of Homeland Security. The work is being done by the standardization committee E54.08.01 (Committee on Homeland Security Applications—Operational Equipment—Robots) (www.nist.gov/el/isd/ks/response_robot_test_methods.cfm).

The purpose of this standardization of test methods is as follows:

- setting procurement standards for advanced equipment for responders
- scoring measures for responders' performance at training events
- guiding and promoting technical development
- clarifying specifications for response robots.

This approach does not standardize the design of response robots but does specify the capabilities that the robots must exhibit. These test methods consist of the following items:

1) terminology (ASTM E2521-07a)
2) basic specifications
   - setup, weight, and size (ASTM E2592-07)
   - energy source and duration
3) mobility tests
   - flat pavement
   - continuous pitch–roll ramps
   - crossing pitch–roll ramp
   - symmetric step field
   - inclined planes and gaps
   - slippery steps
   - stairs and landings
   - towing
4) wireless communication tests
   - line of sight
   - nonline of sight
5) manipulation tests
   - directed perception of open access
   - grasping dexterity tasks of open access
   - grasping dexterity tasks of weighted payloads
   - door-opening and traversal tasks
6) human–system interaction tests
   - navigation tasks in random mazes
   - search tasks in random mazes
   - search tasks in underbody voids
7) sensing tests
   - visual acuity and field of view of onboard video systems (ASTM E2566-08)
   - directed search tasks in detail

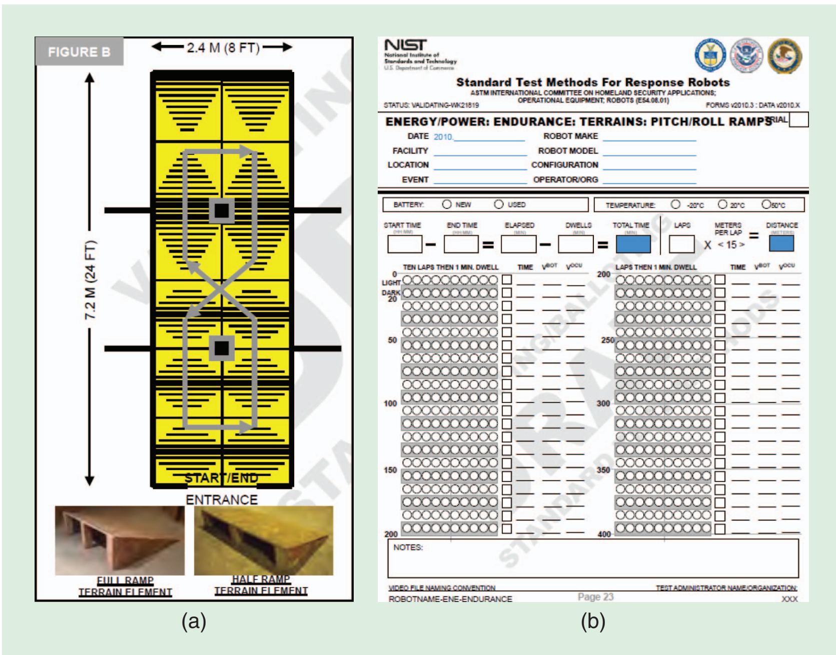

Figure 1. Endurance test on pitch–roll ramps. (a) Test field and (b) test form.

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(a) (b) (c)

Figure 2. Fields for mobility test. (a) Pipe step, (b) inclined plane, and (c) step field.

- intelligibility in identifying rhyming words

8) decontamination tests.

The input for developing the standardized tests was provided by technical search specialists from the Federal Emergency Management Agency with 100 items in 13 categories on the requirements for robots. These were analyzed and narrowed down, and standard test methods were developed to have repeatability for testing and use in field production. These methods were improved by intensive experiments using the RoboCup Rescue Robot League. The methods were verified by the first responders' evaluation of existing robots using training facilities such as Disaster City. Finally, the standards were proposed to the committee of ASTM International.

Figure 1(a) shows a field for the endurance test proposed. A robot traverses the number eight path on the ramp terrain. Distance and time per charge of battery are tested by the repetitive traverses under light and dark conditions. The test data are written in the form shown in Figure 1(b).

Figure 2 shows the test fields for mobility. In (a), a robot surmounts the step made of pipes that simulate a slippery condition by rotating, and the elapsed time is measured. Maneuvering capability, including rollover stability and detracking prevention on high-friction surfaces, is tested by using the inclined plane (b). Figure 2(c) shows a step field made of square wood posts for traversal testing.

Three standards have been approved by the committee and are active. Additionally, 19 methods for testing will soon become new standards, with more items being prepared for submission to the committee. Four test courses will be ready for testing worldwide in Gaithersburg (NIST), San Antonio (Southwest Research Institute), Kobe (International Rescue System Institute), and Koblenz (University of Koblenz-Landau).

Competitions *(continued from page 11)*

Order-of-magnitude increases in performance will only be achieved by new generations of motivated, innovative system engineers. A significant source of such engineers will continue to be the future AUV student competitions. In SAUC-E 11, NURC will pioneer the first step toward cooperative behavior by actively involving NURC's autonomous surface vehicle (ASV) in the mission profile. For one of the tasks, the competing AUV is required to track the moving ASV by searching for the signal of an acoustic pinger attached to the ASV. NURC will host the SAUC-E events for the next two years, which will provide continuity and allow organizers to make improvements each year. The NURC competition will continue to be distinguished by a real-world ocean environment and missions with cooperative vehicles. Competitions with common educational goals and a maritime focus have been fielded in the United States for a number of years and are being initiated in Singapore. The long-term vision includes a periodic World Cup that would bring together the top regional competitors. Potential sponsors of the regional or global events are encouraged to contact the author by e-mail at djapic@nurc.nato.int.