Performance Standards for Urban Search and Rescue Robots

BY ELENA MESSINA

Foster-Miller Talon surveying a disaster area.

Robots and associated technology could help human responders save lives when disaster strikes urban areas. Robot technology is diverse and holds promise, but there has been a lack of focus on the functional needs for rescue operations. First responders need commercially available robot products that are robust and can provide the needed functionality to assist them in carrying out their missions.

ASTM Task Group E54.08.01, part of Subcommittee E54.08 on Operational Equipment within Committee E54 on Homeland Security Applications, has been working for the last year to develop performance standards for rescue robots. The effort features responders-meet-robots events where robot technology providers and their hardware interact with experienced responders. The focus is on developing a common understanding of the performance requirements and deployment scenarios for robots based on actual rescue operation needs.

FEMA USAR New York Task Force 1 responder George Hough operating a robot.

Urban search and rescue — which is defined as the combined strategy, tactics and operations for locating, medically treating and extricating entrapped victims — is a multi-faceted application. There are multiple stages during a US&R operation and responder teams are tasked with a variety of functions. Examples of functions that a Federal Emergency Management Agency US&R team can perform include: conducting physical search and rescue in collapsed buildings; providing emergency medical assessments and care to trapped victims; assessing and controlling hazards, such as damaged gas or electric lines; and evaluating and stabilizing damaged structures. Robots could potentially support rescue personnel in carrying out all of these functions.

In 2005, ASTM Task Group E54.08.01 was established to develop performance standards for robots applied to US&R deployments. The Department of Homeland Security and others noted the need for comprehensive standards to support the development, testing, and certification of effective robotic technologies for US&R applications. These standards will address robot mobility, sensing, navigation, planning, integration into operational caches (inventories of warehoused tools and equipment), and human-system interaction. Such standards will allow DHS to provide guidance to local, state, and federal homeland security organizations regarding the purchase, deployment, and use of robotic systems for US&R applications.

The task group recognizes that researchers and manufacturers are capable of devising technological solutions to particular rescue operation needs; hence the approach is to articulate performance requirements and deployment categories, and develop test methods and usage guides instead of dictating specific technical solutions or robot categories. A particular robot implementation provided by a manufacturer may be able to address multiple deployment categories. Test methods should measure how effectively a responder is able to perform a task without being tailored to a particular technology.

Just as there are many disciplines required within a search and rescue team, the components within a robot

Autonomous Solutions Inc. Chaos robot on one of the rubble piles, a very challenging path for robots to traverse.

are also quite diverse. A robot is a system of systems: it is built from mechanical, electrical, computer, software, sensing and other components, each of which is complex. The disciplines involved in the various components that comprise robots are specialized enough that different sets of expertise are required to study the requirements and develop the corresponding performance tests. The components have to integrate amongst themselves; these interactions may create additional performance requirements. To further complicate matters, the constituent technologies and the robotics discipline are still evolving.

PERFORMANCE-BASED STANDARDS APPROACH

The broad scope of the application domain, the breadth of technologies entailed within robotics, and the relative immaturity of robotics pose challenges to the standardization process. Challenges such as these cannot be allowed to impede progress toward the goal of having well-understood performance goals and means of measuring whether systems meet them.

The task group's approach to developing performance standards for US&R robots is to break the problem down into logical, cohesive, manageable categories and, for each of these categories, produce standard test methods. The test methods will objectively measure a robot's performance in a particular area. Accompanying robot deployment usage guides will provide suggested performance ranges (test results) desired for different rescue operations. Ultimately, the response organization will be able to determine which robot best suits their requirements, similar to the way consumers select products such as cars and televisions based on published third-party test results. Robot researchers and manufacturers will benefit from the definition of test methods and target operational ranges according to the type of rescue operation. The test methods will provide focus for their product development and research.

Prior to establishing the ASTM task group, the National Institute of Standards and Technology began working with responders from the Department of Homeland Security's Federal Emergency Management Agency to define the performance requirements for the robots as well as to begin itemizing the types of deployment scenarios to which the robots may be applied. Over 100 initial performance requirements were generated, along with 13 deployment categories.

The performance requirements were grouped into categories such as human-system interaction, mobility, logistics, sensing, communications, and power. For each requirement, the responders defined how they would measure performance. An example is the requirement that the responders be able to perform field maintenance on the robots. They defined a measurement scale in which a robot that requires no tools whatsoever to assemble (meaning parts can be snapped or screwed on) is preferable to a robot that requires simple tools that are already part of their cache. Least preferable is a robot that requires special tools. The foundational work on requirements and deployment categories provided the organizing principles for the task group tackling the performance standards effort. The task group continues to add and refine requirements and develop definitions of deployment categories.

The deployment categories include ground, aerial, and aquatic, and define the employment role, deployment method, and tradeoffs. For example, a ground peek robot would provide rapid audio-visual situational awareness or hazardous materials detection and could be left in place for data logging. It could be thrown into a building or a void space, or even deployed by a larger robot. Small size and expendability would be traded off for mobility and sensing range.

On the other hand, ground/non-collapsed structure/wide-area survey robots would be employed for long-range operations (at least a one-kilometre standoff distance) in non-compromised buildings and their surroundings. They could provide site assessment, victim identification, and could stay on duty to

Remotec Andros Mini circumnavigating a rubble pile.

provide continued monitoring. Ground survey robots would have greater mobility, endurance, and range capabilities than peek robots, but they would be larger, heavier, and likely less expendable. They may be configured in variations that include special sensors, manipulation, or breaching tools.

REQUIREMENTS-BASED WORKING GROUPS

A test method will be developed for each of the performance requirements generated. The test development effort within the task group has been broken down into working groups according to the requirements categories. At the kickoff meeting for the task group in December 2005, working groups were established for terminology, human-system interaction, mobility, operating environment, communications, sensors, logistics, power, and safety. Each working group is responsible for developing the test methods within their assigned area and surveying existing relevant standards that can be leveraged.

Task Group E54.08.01 is developing standards in a series of "waves" based on the relative maturity of the requisite technologies as well as the responder-articulated priority of the requirements. To further help focus the efforts of the task group, the responders have helped define which deployment categories should be given priority. Based on observing a wide range of robots representing most of the 13 deployment categories, three initial categories have been selected: ground peek robots, ground/ non-collapsed structure/ wide-area survey robots, and aerial survey robots. The definition of these categories serves to establish the operating ranges for which to design the test methods. For instance, the effective distance that the onboard navigation cameras must be able to see ranges from a few metres for a peekbot to several hundreds of metres for the aerial robots.

RESPONDERS MEET ROBOTS

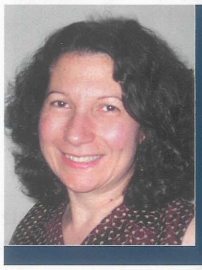
This standardization effort employs an iterative development approach to ensure that the performance requirements are appropriate and that the manufacturer and technology development communities are able to interact with end users on a frequent basis. Regular responders-meet-robots events at US&R training sites also present opportunities to dry-run testing protocols to an audience of responders and technologists. Comments from all of the stakeholders help refine and strengthen the tests. Furthermore, the events generate feedback on a frequent basis to the manufacturers and technology developers, who are able to see how their systems perform informally against the emerging performance standards.

Two such events have been held thus far. In August 2005, FEMA responders experimented with nearly 20 different robots at a Nevada US&R training facility. The second exercise was held in April 2006 at Disaster City, a US&R training facility operated by Texas A&M University. This event highlighted realistic US&R scenarios designed to help match different robots to deployment situations and to evaluate the relative maturity of various robot categories.

The scenarios used during the exercise included full-size collapsible structures that replicate community infrastructure, such as a strip mall, single family dwelling, commercial building, two train derailments (passenger and cargo), two rubble piles (wood and concrete), and a small lake. Proposed test methods were housed in a theater building and also embedded throughout the scenarios. Manufacturers were present in force, supplying 27 different robots, representing 9 of the 13 originally defined categories. After the three-day exercise, Task Group E54.08.01 met informally and selected the high priority robot deployment categories noted above and discussed several details pertaining to the proposed test methods.

BALLOTING BEGINS THIS YEAR

The first wave of standard test methods is expected to enter the balloting process in the fall of 2006. A terminology document has already been put forward for balloting. Associated robot category usage guides will also be developed for the peek-bot, wide-area survey, and aerial survey robots. Relying on the talents and energy of robot and component manufacturers, researchers, emergency responders and government agency staff, additional waves of performance test methods and guides for USAR robots will become standards in the coming years. This will advance robot capabilities and enable the integration of useful and potentially life-saving new tools into the caches of response organizations. //



ELENA MESSINA is leader of the Knowledge Systems Group within the Intelligent Systems Division at the National Institute of Standards and Technology. She works extensively on performance metrics and test methods for robots. Messina chairs the E54.08.01 Task Group on Urban Search and Rescue Robots. She can be reached at elena.messina@nist.gov. The project Web site is www.isd.mel. nist.gov/US&R_Robot_Standards.