



## Project Report

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Date: 2017-06-12  
Event: ASTM E54.09 Response Robots Committee Meeting and Exercise Summary  
Location: Hamilton Port Authority, Toronto, Canada  
Emphasis: Validated 50 test methods for Ground, Aerial, and Aquatic Response Robots  
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### General ASTM E54.09 Standards Committee Overview:

Over the past few years our suite of 30 ground robot test methods have been adopted widely across the U.S. and internationally to support purchasing and training. We are now expanding our efforts to develop test methods for small unmanned aircraft systems (sUAS) defined by the FAA as under 25kg (55lbs) and for underwater remotely operated vehicles for hazardous environments.

Remotely operated robots enable emergency responders to perform extremely hazardous tasks from safer stand-off distances. Standard test methods help robot manufacturers and users objectively evaluate system capabilities to align with mission requirements. This improves the safety and effectiveness of emergency responders as they attempt to save lives and protect property in our communities.

The ASTM International Standards Committee on Homeland Security Applications: Response Robots (E54.09) is developing the standards infrastructure necessary to inspire innovation, inform purchasing decisions, and focus training with measures of operator proficiency. Adam Jacoff from NIST's Intelligent Systems Division chairs the sub-committee with his team of robotics researchers and collaborators from all over the world. The standards committee is made up of robot manufacturers, emergency responders, test administrators, program managers, and others interested in developing the underlying measurement science necessary to quantitatively evaluate and compare robotic system capabilities and operator proficiencies.

This effort has been sponsored by the Department of Homeland Security, Science & Technology Directorate, Capability Development Support Group, Office of Standards. They along with other sponsors have facilitated these standards committee meetings and

associated test method validation exercises for nearly fifty test methods for ground, aerial, and aquatic systems.

### **Summary of Standards Committee Meeting and Validation Exercise hosted in Hamilton, Ontario:**

This meeting and exercise was hosted at the Hamilton Port Authority, Ontario, Canada. More than twenty robots provided by manufacturers, emergency responders, and military organizations evaluated their robotic capabilities and operator proficiencies within the test methods. Test administrators from collaborating facilities around the world conducted trials to learn about and validate the test methods. They also helped devise new tests to address emerging requirements articulated by responders at the meeting.



*Figure 1: A) Front view of the Hamilton Port Authority boat storage facility used to host the event. It was mostly empty for the summer. B) Back view of the same facility. They also provided dock space in the Lake Ontario to embed our underwater test methods to conduct trials in the opaque water more typically associated with response operations.*

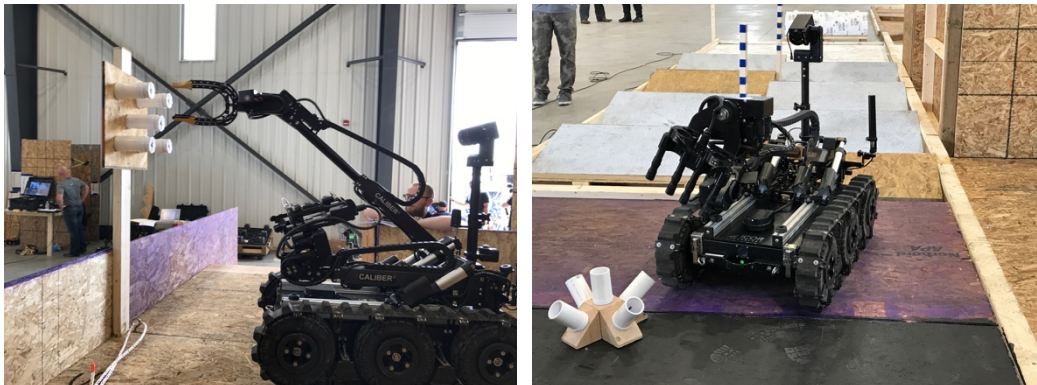
### **Ground Robot Test Methods Evaluating Bomb Squad Proficiency**

Ann Virts from the Engineering Laboratory, Adam Norton from the University of Massachusetts - Lowell, and Donny Boyd from the Montgomery County MD Fire Department administered training trials with Canadian bomb squad technicians. The bomb techs used their own service robots to validate a suite of basic skills test methods used to focus training, measuring operator proficiency for countering improvised explosive devices (C-IED). The suite of 120cm (48in) wide ground robot test methods have been used across the U.S. at several such events. They are also hosted in dozens of responder facilities enabling them to measure and compare their own proficiency against “expert” operators provided by the manufacturers, or regional and national averages. These same test methods also help identify deficiencies in equipment. This was the first time we have conducted such an exercise in Canada. See the media pointers below for the

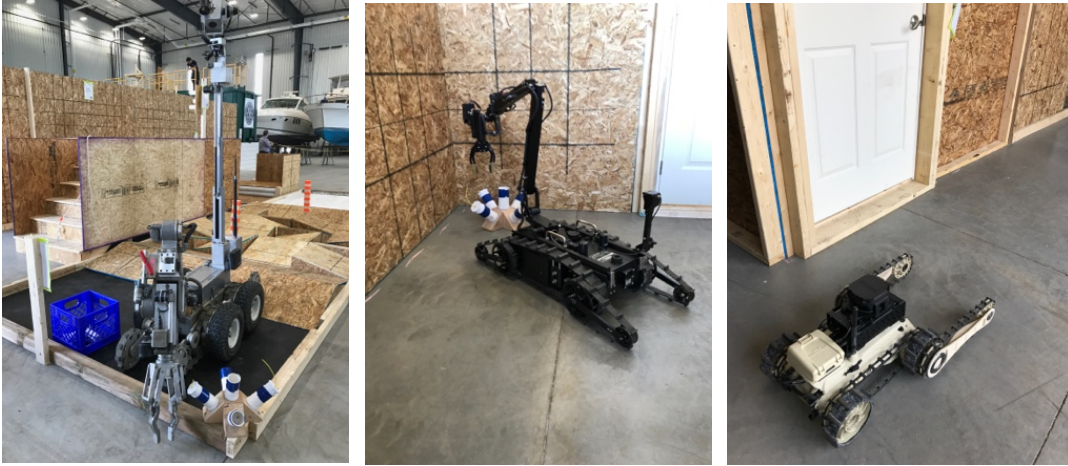
reaction from the local bomb squad commanders.



*Figure 2: A) The apparatuses set up to the left are the Basic Maneuvering and Dexterity suite of test methods. They are performed sequentially in time limited trials. B) The Access Buildings suite of test methods includes Terrains, Stoops, Stairs, Doors, and Hallway Labyrinths all with embedded Dexterity and Mapping tasks.*



*Figure 3: The main service robot used by these regional bomb squads is manufactured in Canada. A) It is shown performing the Dexterity: Rotate task using the parallel apparatus at door knob elevation. B) Here it is performing the Dexterity: Inspect task using the omni-directional apparatus.*



*Figure 4: A variety of other robots were also run through the test methods.*

### **Aquatic Test Methods in the Clear Water Tank and Harbor Scenarios**

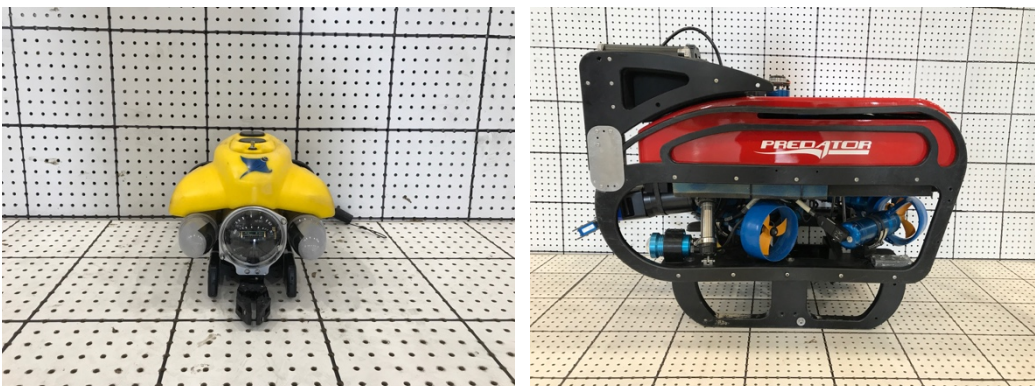
Jesse Pentzer from Pennsylvania State University, Capt. Tom Haus from the Los Angeles Fire Department, CA, and Battalion Chief Parry Boogard from the Valley Regional Fire Department, WA administered underwater system testing in the clear water tank and off the harbor dock. These fire fighters are members of the new FEMA US&R Robotics Standards Committee. They are tasked with selecting suites of standard test methods to evaluate ground, aerial, and aquatic systems to purchase for US&R Task Force equipment caches nationwide. Since the facility had docks in Lake Ontario, we took the opportunity to embed our various underwater test methods as operational training scenarios in the brackish water. Embedding the test methods into operational scenarios is always the next step. The embedded standard test methods enable quantitative evaluation and comparison of capabilities from clear water tank tests with turbulence from submerged pumps to more operationally significant and uncontrolled environments with brackish water in the harbor (submerged pumps can be added as well to add turbulence).



*Figure 5: Local responders collaborated with manufacturers demonstrating the newest available remotely operated vehicle technologies in an 18,000 gallon water tank with more than a dozen test methods. The repeatable tasks and clear water videos provided key insights into the capabilities of the systems and helped measure important upgrades implemented by manufacturers since the previous exercise. Submerged pumps surrounding the test apparatuses provide constant turbulence while performing the tasks, encouraging automatic holding of position and orientation to improve performance. A blackout tarp over the top of the tank can provide darkened conditions. Beyond the obvious training benefits, these test methods provide useful de-bugging tools and readiness assessments, especially after repairs.*



*Figure 6: A) The C-frame apparatuses provide five different orientations for each task (0°-45°-90°-135°-180°). B) The walkways on top of the tank appear helpful, but they actually hindered inserting the large apparatus frames into the tank. So open top tanks are preferred. C) The same test methods were replicated off the dock in the brackish water with natural currents and sediment in the harbor. We embed the apparatuses into these operationally relevant scenarios to measure the degradation in performance due to the uncontrolled environmental variables.*



*Figure 7: A variety of underwater systems participated. A) The smallest system is typically intended to perform reconnaissance tasks. B) The largest system is much more capable and includes a \$100K sonar.*

### **Aerial System Test Methods**

Kam Saidi from the Engineering Laboratory and Al Frazier from the North Dakota Airborne Law Enforcement Association administered two indoor netted aviaries containing more than a dozen test methods to evaluate small unmanned aircraft systems (sUAS). These systems were provided and operated by manufacturers and responder organizations leading the effort to safely and effectively incorporate these emerging technologies into their public safety operations. The test methods quantify essential safety features and airworthiness while providing useful practice tasks that measure proficiency for responders or hobbyists prior to flying in the national airspace.



*Figure 8: A) The indoor netted aviaries provided safe flight testing while validating the test methods and collecting essential data for the standardization process. B) A wall of fans provided turbulence for the aerial systems, encouraging automatic holding of position and orientation to improve performance of tasks.*



Figure 9: One aviary focused on Maneuvering test methods.



Figure 10: The other aviary focused on Situational Awareness and Sensor test methods.



Figure 11: A) The outdoor testing took place in a more remote section of Ontario where the local responders are cleared to fly their systems outdoors. B) We set up our Situational Awareness test methods to practice and validate them using an aerial system manufactured in Canada and used by all the responders. C) Because aerial systems need to handle weather conditions, we adapted a sprinkler system to the Spiral Inspect test apparatus to enable testing resilience of the system to rain.

## Radio Communications Attenuation Tests

Rick Candell, Kam Saidi, and Kenny Kimble fabricated a new radio communications attenuation test apparatus at the event. The intent of the apparatus is to attenuate the radio signal from the operator interface as if the remote robot has entered a structure. We have attempted a few different apparatus concepts in the past but this one seemed to work while accommodating even the smallest handheld operator interfaces and detachable antennas.



*Figure 12: Kam is shown operating an aerial system in the netted aviary from an operator control unit within the new Radio Attenuation test method apparatus. It is essentially a glove box coated with radio attenuation tiles. The signal from the robot is shown on a remote display outside the box. The next revision will contain a camera inside the box so the operator can see his/her own hands as well.*

### Media Pointers

News interview with President of the Canadian Explosives Technicians Association

<https://www.thespec.com/videopopup/7369896?popUp=true>

Local news

<http://www.chch.com/bomb-disposal-robots/>

Other media

[https://motherboard.vice.com/en\\_us/article/these-robots-will-explore-tunnels-dug-by-looters-in-egypt](https://motherboard.vice.com/en_us/article/these-robots-will-explore-tunnels-dug-by-looters-in-egypt)



**Standard Test Methods for Response Robots**  
ASTM International Standards Committee for Homeland Security Applications;  
Response Robots (E54.09)



More information is available on our website: [RobotTestMethods.nist.gov](http://RobotTestMethods.nist.gov) see Meetings/Exercises.

-Adam