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Events for the Application of Measurement Science to Evaluate Ground, Aerial, and Aquatic Robots*

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Abstract—**This paper reports on three measurement science field exercises for evaluating ground, aerial, and aquatic robots. These events, conducted from February to June 2017, were conducted in close co-ordination with the responder community, standards organizations, manufacturers, and academia. Test data from a wide variety of robot platforms were gathered in a wide variety of standard and prototypical test methods ranging from mobility and manipulation to sensors and endurance.**

I. INTRODUCTION

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 Response Robots for Homeland Security Applications (E54.09) is developing the standards infrastructure necessary to inspire innovation, inform purchasing decisions, and focus training with measures of operator proficiency [1].

The underlying measurement science is being developed to quantitatively evaluate and compare robotic system capabilities. Along with the standards committee meeting, comprehensive test method validation exercises were organized with sponsorship from the Department of Homeland Security, Science & Technology Directorate, Capability Development Support Group, Office of Standards. These exercises provided an opportunity for robot manufacturers, emergency responders, and international collaborators to validate 50 test methods for ground, aerial, and aquatic systems. This paper reports on three of these exercises, conducted in the first half of 2017.

The first was a five day meeting and exercise, hosted at the Virginia Beach Fire Department Training Facility in February in conjunction with the January 2017 E54.09 meeting. This is home to the Federal Emergency Management Agency's (FEMA's) Virginia Task Force 2 Urban Search and Rescue (US&R) Team. Roughly 100 people participated each day from Canada, Germany, Israel, Japan, Korea, UAE, UK, and the USA. More than 30 robots provided by manufacturers, emergency responders, and military organizations evaluated their robotic capabilities and operator proficiencies within the test methods.

The second was a one day exercise hosted by the Virginia Department of Public Safety and took place in Charlottesville, VA in March as part of the National Unmanned Aerial Systems Summit. The purpose of the summit was to demonstrate the use of aerial systems in public safety applications and included speakers and panels on fire, search and rescue, and law enforcement. Roughly 20 manufacturers and 150 attendees participated and watched as the final day included aerial systems operating within various training scenarios.

The third event was a week-long inter-laboratory experiment attached to the June 2017 E54.09 meeting and hosted by the Canadian Explosive Technicians' Association at the Hamilton Port Authority near Toronto, Ontario, Canada. They were supported in conducting robot operator training, across ground, aerial and aquatic systems using the DHS-NIST-ASTM International standard test methods to measures and compare their proficiency across more than 20 ground, aerial, and aquatic systems.

The rest of this document reports on the specific outcomes of the three events before summarizing the overall impacts and the plans for the future.

II. VIRGINIA TASK FORCE 2

FEMA's new US&R Robotics Standards Committee met for the first time. 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. The Virginia Beach Fire Department Training Facility has several US&R training scenarios that were embedded with standard test methods to enable quantitative evaluation of robots even within the uncontrolled and very difficult environmental variables.

Dozens of civilian and military bomb squad technicians in the region participated with their own ground robots to validate new approaches toward standardized robot operator training for countering improvised explosive devices (C-IED). This suite of 60 cm (24 in) and 120 cm (48 in) wide ground robot test methods have been used across the country at several such events and hosted in dozens of responder facilities. The test methods are shown in Figure 1. The smallest 30cm (12in) wide ground robot test methods were also deployed along with rapidly manufactured robot kits that were built on 3D printers and laser cutters to create truly disposable robots for the most hazardous tasks [2].

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Underwater explosive ordinance disposal (EOD) teams from the local Navy base collaborated with robot manufacturers demonstrating the newest available remotely operated vehicles (ROVs) in an 18,000 gallon water tank with more than a dozen test methods plus apparatuses to add turbulence and various lighting conditions. The repeatable tasks in various orientations, floating, and on the tank bottom, along with the clear water and videos of the tasks being performed provided key insights into the capabilities of the systems and helped measure important upgrades implemented by manufacturers since the previous exercise. Beyond the obvious training benefits, these test methods provide useful de-bugging tools and readiness assessments, especially after repairs.

Figure 1: Ground robot tests for Operator Proficiency – Basic Skills at 120 cm (front) and 60 cm (rear) scales.

Indoor and outdoor netted aviaries contained more than a dozen test methods to evaluate small unmanned aircraft systems (sUAS) in both still and turbulent air. These systems were provided and operated by manufacturers and responder organizations leading the effort to safely and effectively incorporate these emerging technologies. These 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.

Several embedded scenarios were deployed to capture quantitative scores within the uncontrolled environmental variables. These included a random maze inside the “smoke house” to test sensor degradation due to obscurants, a vehicle-borne improvised explosive device (truck bomb) and a rubble pile and surrounding wide area survey embedded with visual, thermal, and mapping targets.

III. National Unmanned Aerial Systems Summit

This outdoor event helped manufacturers and emergency responders validate the test methods within their own training scenarios conducted by fire departments, law enforcement, and others. In fact, most of the test method apparatuses were brought to the site by local responders, who used the aerial system test methods to train and evaluate firefighters in their departments. NIST set up a comprehensive evaluation station shown in Figure 2, with 10 test methods developed to measure maneuvering, endurance, sensing, and situational awareness.

These test methods augmented the surrounding scenarios by providing objective, quantitative, repeatable, and reproducible measures enabling direct comparison of system capabilities and operator proficiency. The training scenarios for "Structure Fire" and "Hazardous Materials" included some of NIST's test apparatuses embedded to demonstrate how to capture quantitative scores even within uncontrolled environmental variables such as winds gusting over 20 knots. Other scenarios included "Disaster Mapping," "Search and Rescue," and "Law Enforcement."

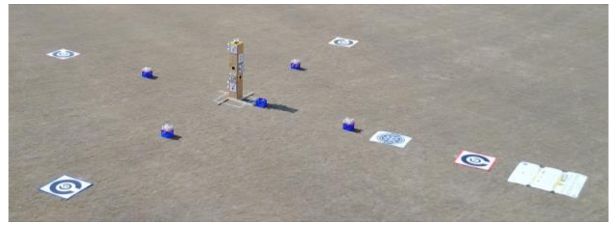

Figure 2: Overview of the outdoor aerial tests. For scale, the center pillar is 2.4 m (8 ft) tall.

IV. Canadian Explosive Technicians’ Association

Like the event held with the Virginia Task Force 2, this event engaged the responder and manufacturer communities with the standard test method process. The new FEMA US&R Robotics Standards Committee also used the event to select suites of standard test methods to evaluate ground, aerial, and aquatic systems to purchase for US&R Task Force equipment caches nationwide.

For the first time in Canada, ground robot exercises were conducted, focusing on evaluating bomb squad proficiency and using the 128 cm (48 in) suite of ground robot tests. Underwater robot tests were conducted both in a dedicated watertank as well as in Lake Ontario, with a focus on the evaluation of embedded test apparatuses for best-in-class sonar and vision. Aerial tests were deployed in both a netted aviary and an outdoor scenario. These included initial prototypes of a test for resilience of systems to water, as well as the latest iteration of a radio communications attenuation test for handheld operator interfaces.

V. Conclusion

These events, and those that preceded them, have resulted in responder organizations around the world adopting the test methods into their training and procurement procedures. These events also encourage the responders’ involvement in the development of these standard test methods, as a crucial part of the standard test method process. These events continue to be refined and seeded with the latest prototyping test methods and initiatives.

References

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