ANSI and SPRING Singapore Services Conference

DHS SCIENCE AND TECHNOLOGY

Standard Test Methods to Evaluate Response Robot Capabilities and Operator Proficiency for Emergency Response Applications

Homeland Security
Science and Technology

17 October 2017

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Background

- 2005 DHS Science & Technology Directorate (S&T) engaged in multi-year partnership with NIST to develop response robot test methods
- Initial focus robots for search and rescue, met with representatives from FEMA Urban Search and Rescue teams to identify requirements
- Identified Standards Development Organization (SDO) through which to promulgate standards – ASTM E54 Committee on Homeland Security Applications
- Developed test methods to characterize key performance parameters of response robots – did not develop robot performance standards

Background Continued

- Conducted tests, exercises, and operational exercises based on test methods to characterize robots in terms of what they could do as opposed to what the should do
- Other events had impact on program
  - 2010 Times Square bombing attempt
  - 2011 tsunami and Fukushima Daiichi nuclear disaster response and recovery
- Broader applications of robot testing program
  - Stimulated technology development
  - Supported operator proficiency training
  - Springboard for broader interagency collaboration

Performance Standards Development

Works well with:

- Mature technology
- Knowledge of
  - operational environment,
  - CONOPS
  - Threat
- Performance limits/requirements understood
- Conformance Assessment infrastructure in place or could be developed
- Examples: respiratory protection equipment, body armor, etc.

Test Method Characterization Process

Better suited where:

- Technology rapidly evolving
- Not fully defined or evolving
  - operational environment
  - CONOPS
  - Threat
- Performance limits/requirements not fully defined or evolving
- Generates data/test results, but how to apply information
- Hard performance limits could hamper innovation

The response robot test method program uses this model

Project Overview

Objective:

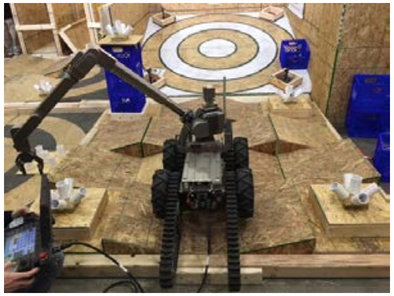
Develop the measurements and standards infrastructure necessary to quantitatively evaluate robot capabilities and operator proficiency.

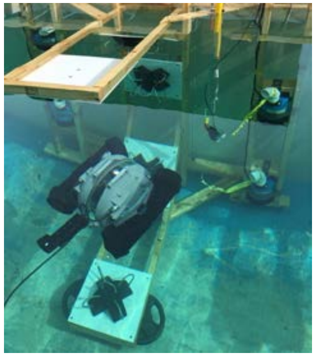
Outcomes:

Test methods, performance metrics, and data collection tools to help manufacturers apply emerging technologies toward essential robot tasks and improve product reliability.

Impacts:

Emergency responders use quantitative data to compare, purchase, train, and deploy robotic systems to perform extremely hazardous missions from safer standoff distances.





Technical Approach

- **Develop** suites of test methods, performance metrics, and data collection tools for Maneuvering, Mobility, Dexterity Sensing, Energy, Comms, Durability, Safety, Autonomy, and Operator Proficiency.
- **Measure** combinations of capabilities and emerging technologies.
- **Inspire** innovation using tests to communicate operational needs.
- **Guide** purchasing and deployment decisions with objective robot capabilities data.
- **Focus** training with repeatable tasks and measure operator proficiency.
- **Identify** gaps in equipment and/or training through local, regional, or national averages.
- **Repeat**

Test Methods for sUAS

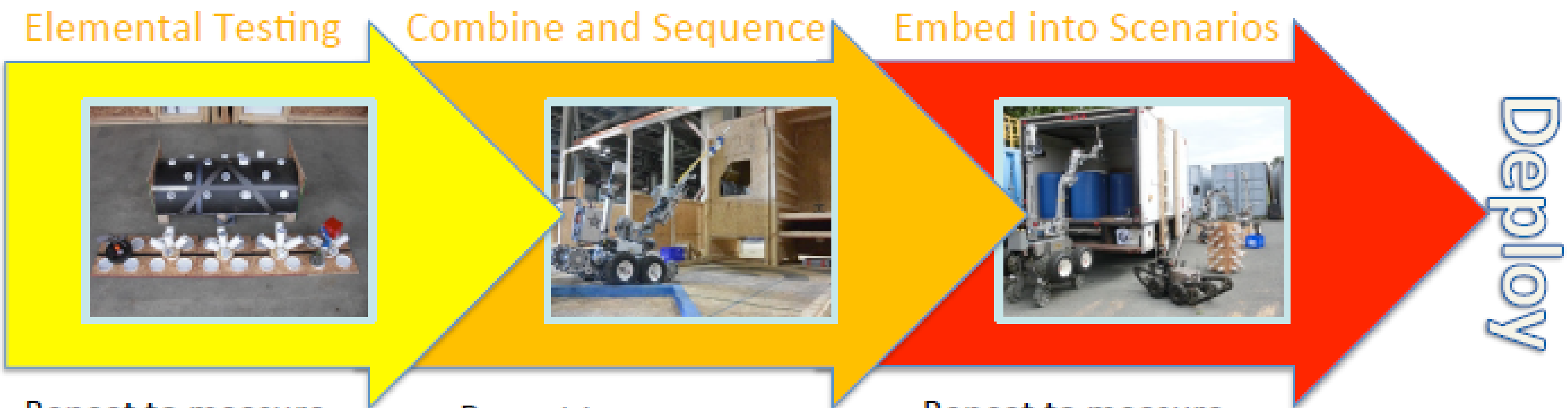
Safety | Capabilities | Proficiency

Up to 25kg (55 lbs) with Vertical Launch and Landing

(Potentially based on Impact Forces rather than weight.)

Implementing Standard Test Methods

Safety | Capabilities | Proficiency



Repeat to measure ***capabilities.***

Identify and fix weaknesses.

Practice and evaluate <u>task</u> proficiency with quantitative scores in timed trials.

Repeat to measure ***trade-offs.***

Increase complexity in stepwise ways.

Practice and evaluate <u>mission</u> proficiency with quantitative scores in timed trials.

Repeat to measure ***readiness.***

Involve uncontrolled variables.

Practice and evaluate <u>readiness</u> with quantitative scores in timed trials.

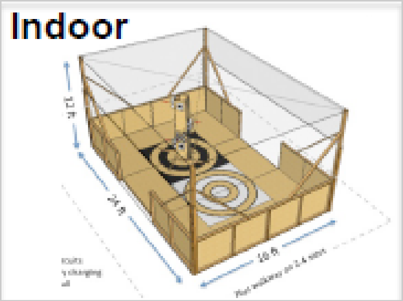
Test Methods Under Development

Safety | Capabilities | Proficiency

Airframe
- Impact Forces
- Lights and Sirens
- Prop Guards

Comms
- Lost Comms Behaviors
- Line of Sight Range
- Beyond Line of Sight
- Structure Penetration
- Interference

Energy
- Lost Power Behaviors
- Endurance Range
- Endurance Dwell



Sensors
- Visual Acuity
- Color Acuity
- Thermal Acuity
- System Latency
- Dynamic Range
- Camera Pointing

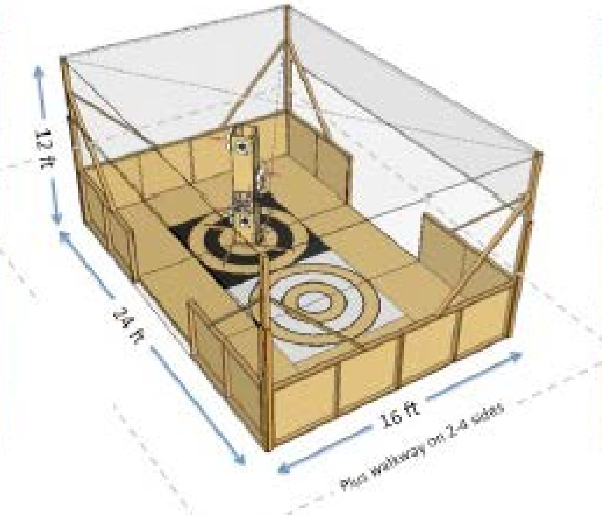
Maneuvering
- Pose Agilities
- Inspect Targets
- Center in Obstacles
- Land/Perch
- Deliver Payload

Awareness
- Point/Zoom Cameras
- Map Area (Stitched Images)

Enclosed Practice/Test Environments

Safety | Capabilities | Proficiency

- Limit safety issues to quickly implement a standards-based approach.
- All testing is in netted enclosures (outside tents when GPS is involved).
- Users train indoors (tennis or basketball court) to avoid practice in the National Airspace.

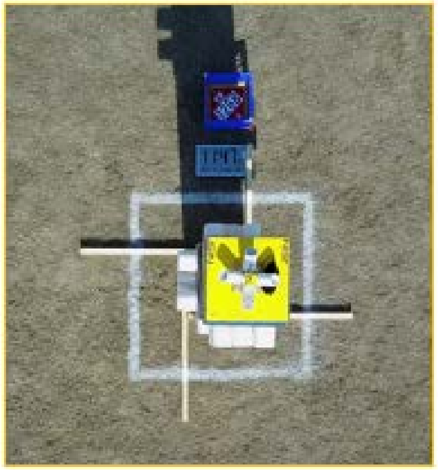


Outdoor sUAS Test Methods

Safety | Capabilities | Proficiency

- Hold Position and Orientation
- Point and Zoom Cameras (optical, thermal)
- Inspect Targets (downward, spiral, omnidirectional)
- Endurance (with and without max payload)
- Map Area with Stitched Images





Embedding into Training Scenarios

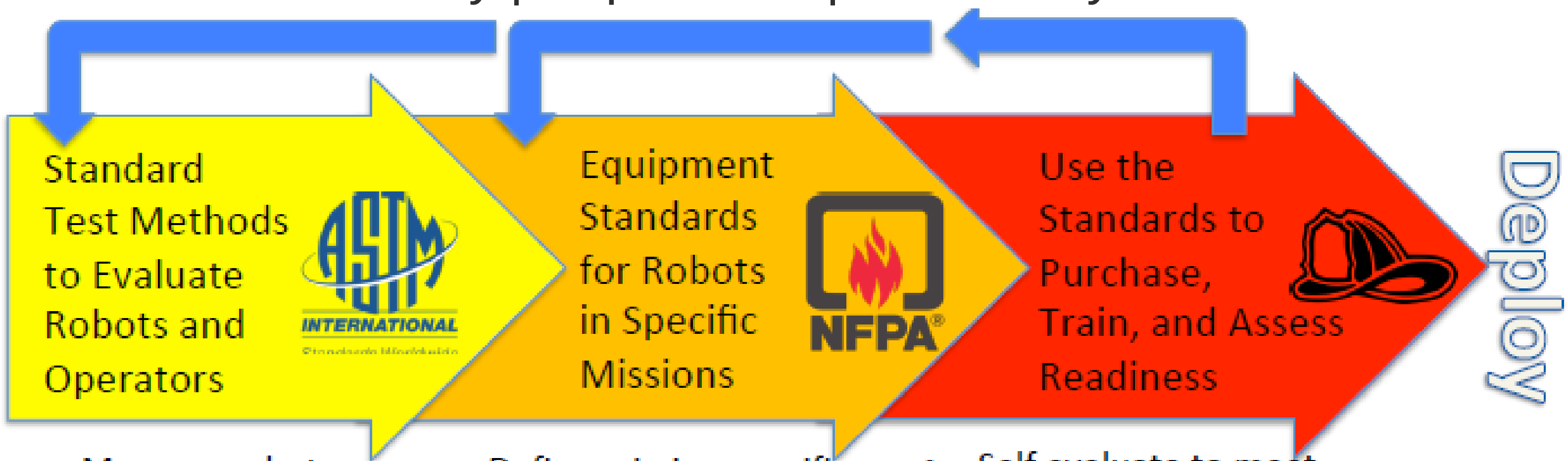
Safety | Capabilities | Proficiency

- Hold Position and Orientation
- Point and Zoom Cameras (optical, thermal)
- Inspect Targets (downward, spiral, omnidirectional)
- Endurance (with and without max payload)
- Map Area with Stitched Images




Model for Standards Collaboration

Safety | Capabilities | Proficiency



- Measure robot capabilities and reliability in statistically significant trials.
- Compile and disseminate data.
- Fill gaps in tests.

- Define mission specific suites of ASTM standard test methods.
- Set thresholds to guide purchases and acceptance testing.
- Set thresholds to guide operator proficiency.

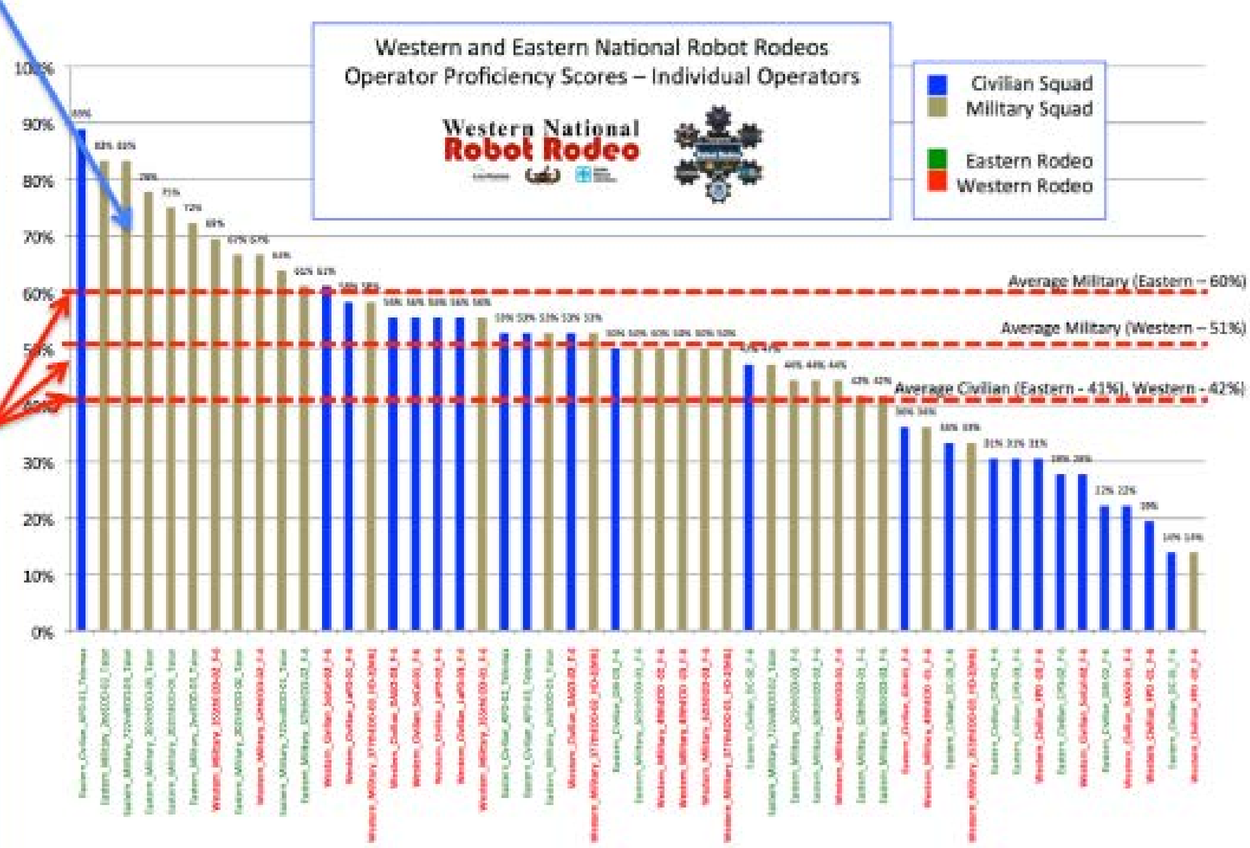
- Self evaluate to meet specified thresholds in time limited trials.
- Measure strengths and practice weaknesses.
- Learn how emerging technologies may help.
- Identify gaps in tests.

Capture Data, Set Thresholds

Safety | Capabilities | Proficiency

Develop standard test methods and collect robot capability and reliability data with "expert" operators

Select standard test methods and set thresholds to define readiness for mission essential tasks (or adopt user averages)



Concurrent Validation Sites

Safety | Capabilities | Proficiency

- NIST, Gaithersburg, MD (National Capital Region)
- Southwest Research Institute, San Antonio, TX
- Austin Fire Dept. Austin TX
- Disaster City, College Station, TX
- UK Atomic Energy Authority, Oxfordshire, UK
- Japan Atomic Energy Agency, Fukushima/Naraha, Japan
- York County, VA Department of Fire and Life Safety
- Germany
- Australia

Response Robot Program Outcomes

- Project pioneered the use of quantitative robot capabilities data to guide and specify procurement of over $70 million worth of robots by multiple agencies
- This project developed standard measures of proficiency that enable operators to compare themselves to “expert” performance using a circuit training model.
- Test methods developed at request of bomb squad community for Vehicle Borne Improvised Explosive Device (VBIED) response robots
- “Standard Test Methods in a Box” deployed around the country to support bomb squad robot operator training and over seas
- Test methods adopted by Japan to support Fukushima Daiichi decommissioning and decontamination

Outcomes Continued

- Hosted dozens of robot competitions with thousands of participants to refine and validate test apparatuses while guiding developers toward implementing the combinations of capabilities necessary to perform essential mission tasks.
- Several “best-in-class” robots have emerged including the only robot capable of mapping upper floors of the Fukushima nuclear plant disaster.
- Test methods and testing stimulate the development of technology in directions of interest to user community
- The stage is set for establishing performance thresholds for categories of response robots
- Standardized test methods allow for reproducible test results at different locations
- Lessons learned from ground based response robots can be applied to unmanned aircraft systems.
    - Equipment characterization
    - Operator training
    - Procurement guidance

Same Test Methods Help Different Users

- **Robot Developers**
  - Understand missions through tangible, reproducible test apparatuses
  - Practice and refine robot designs, optimize trade-offs
  - Highlight “Best-in-Class” capabilities
- **Responders and other users**
  - Compare robots with objective data, not marketing
  - Specify procurements based on existing combinations of capabilities
  - Align expectations with deployment considerations
- **Program Managers**
  - Describe objectives with a set of tangible tasks
  - Challenge conventional approaches and stimulate innovation
  - Measure baseline capabilities and document progress
  - Obtain quantifiable data in support of operational demonstrations

For Further Information

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