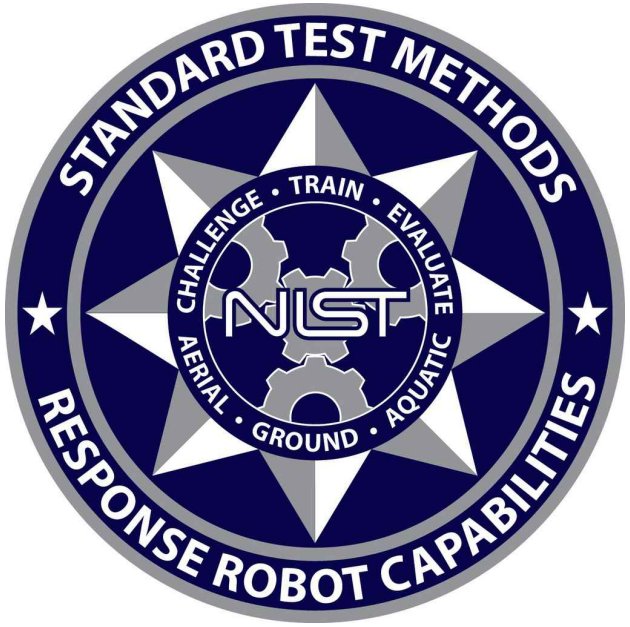
Aquatic System Tests

Introduction

Version 2021A



Online Only Meeting
February 4, 2021
10:00am – 2:00pm EST

Sub-Committee Chair:
Adam Jacoff
Intelligent Systems Division
National Institute of Standards and Technology
U.S. Department of Commerce

Committee Chair:
Phil Mattson
Science and Technology Directorate
U.S. Department of Homeland Security

Internet
RobotTestMethods.nist.gov

Email
RobotTestMethods@nist.gov

Call To Order

Aquatic System Tests

- Reminder that electronic recording of ASTM meetings is prohibited.
- This meeting will run in accordance with the ASTM Antitrust Statement (see minutes).

Antitrust Statement

ASTM International is a not-for-profit organization and developer of voluntary consensus standards. ASTM's leadership in international standards development is driven by the contributions of its members: more than 30,000 technical experts and business professionals representing 135 countries.

The purpose of antitrust laws is to preserve economic competition in the marketplace by prohibiting, among other things, unreasonable restraints of trade. In ASTM activities, it is important to recognize that participants often represent competitive interests. Antitrust laws require that all competition be open and unrestricted.

It is ASTM's policy, and the policy of each of its committees and subcommittees, to conduct all business and activity in full compliance with international, federal and state antitrust and competition laws. The ASTM Board of Directors has adopted an antitrust policy which is found in Section 19 of ASTM Regulations Governing Technical Committees. All members need to be aware of and compliant with this policy. The Regulations are accessible on the ASTM website (http://www.astm.org/COMMIT/Regs.pdf) and copies of the antitrust policy are available at the registration desk. ***For a complete list of standards, see:*** *http://www.astm.org/COMMIT/SUBCOMMIT/E5409.htm*

Agenda

Aquatic System Tests

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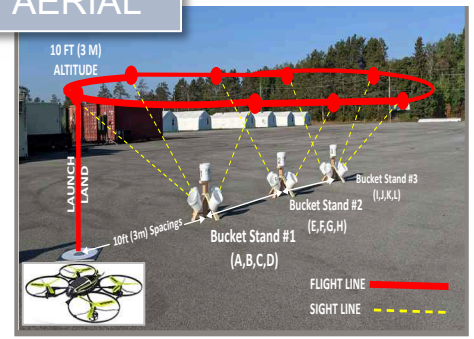
10:00 am EST Committee Overview, Use Cases, Validation Exercises

11:00 am EST Dexterity, C-IED/EOD, and Other Tests

12:00 pm EST Open Discussion

AERIAL



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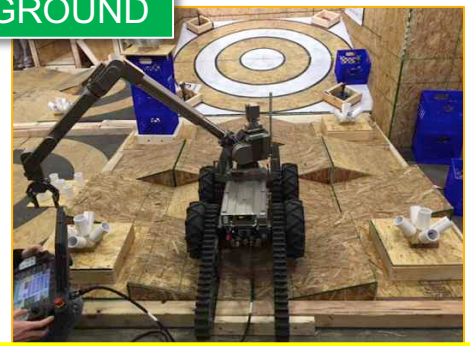

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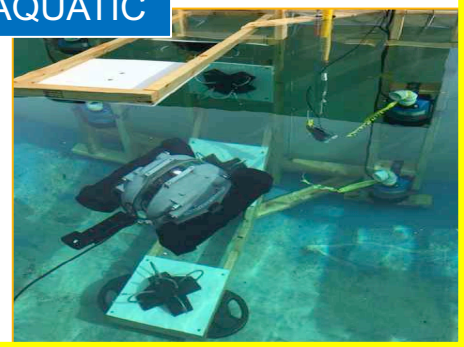

Membership

Committee Overview

Balance Report

Producer Votes Available: 28

	Producer	User	Consumer	General Interest	Unclassified	Total
Official Voting Member	5	16	0	17	0	38
Non Official Voting Member	0	0	0	8	0	8
TOTAL	5	16	0	25	0	46

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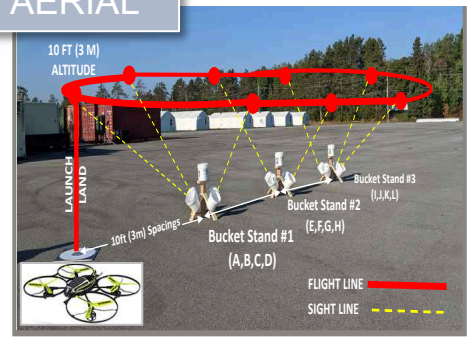

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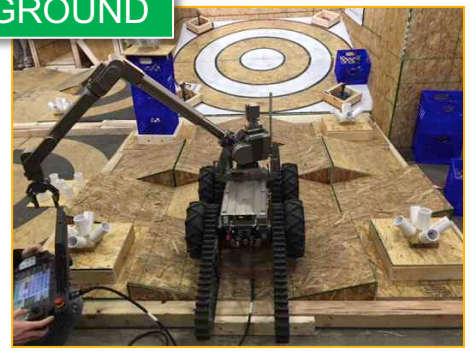

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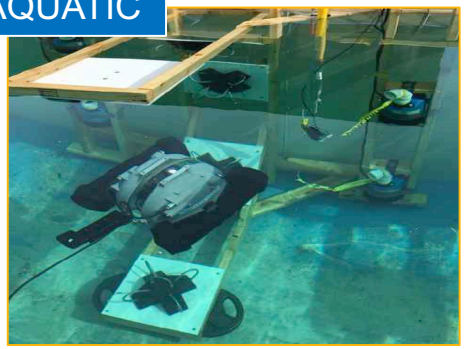


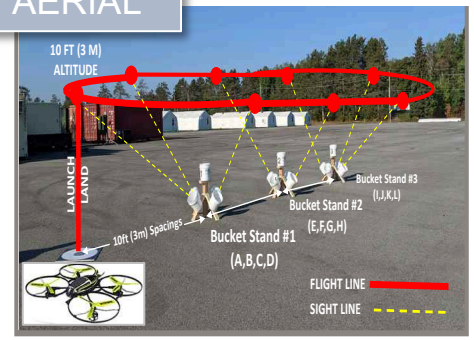
Minutes

Committee Overview

The presentations shown today will serve as the minutes of this meeting. They will be posted as PDFs to the ASTM E54.09 committee website, and on NIST RobotTestMethods.nist.gov website under Meetings where there are also pointers to the next/previous meetings.

- ASTM E54.09 Aquatic Tests – Descriptions (v2021A)
- ASTM E54.09 Aquatic Tests – Validation Exercises (v2021A)

AERIAL



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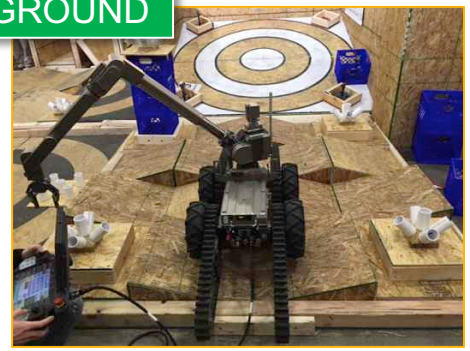

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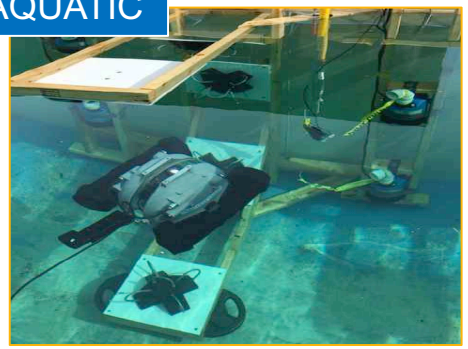
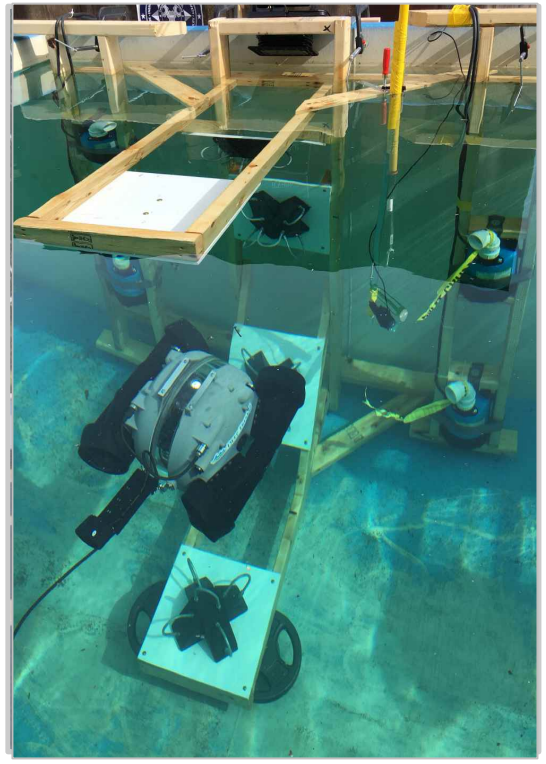


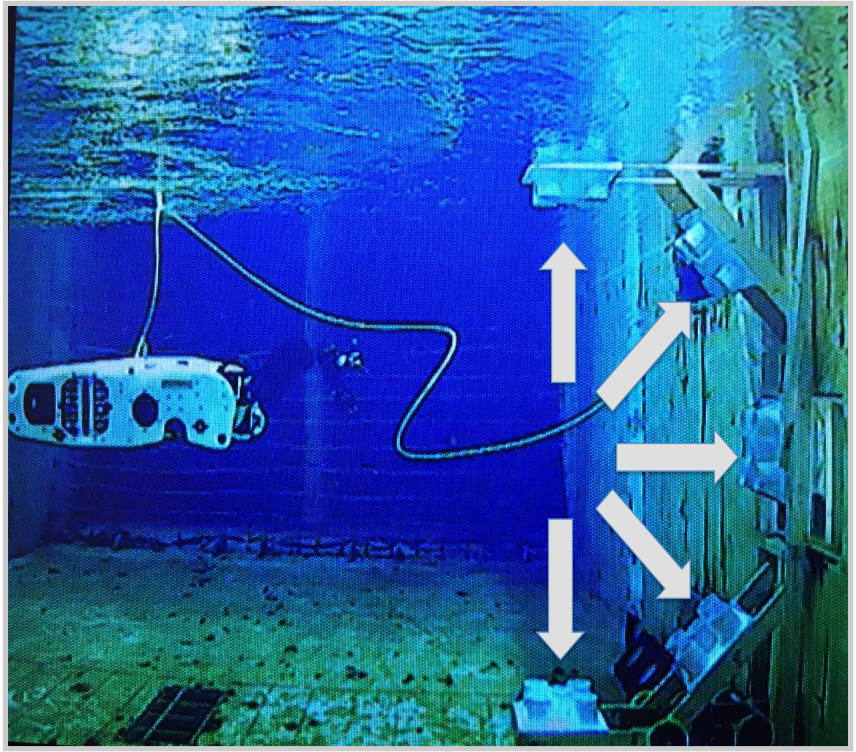
"Start Remote, Stay Remote?"

Aquatic System Tests

Simple Apparatuses

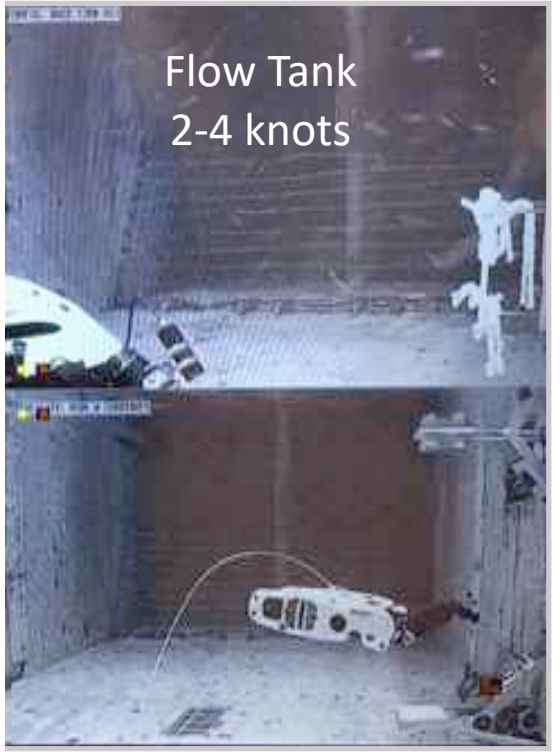


Omnidirectional Tests



System Interfaces

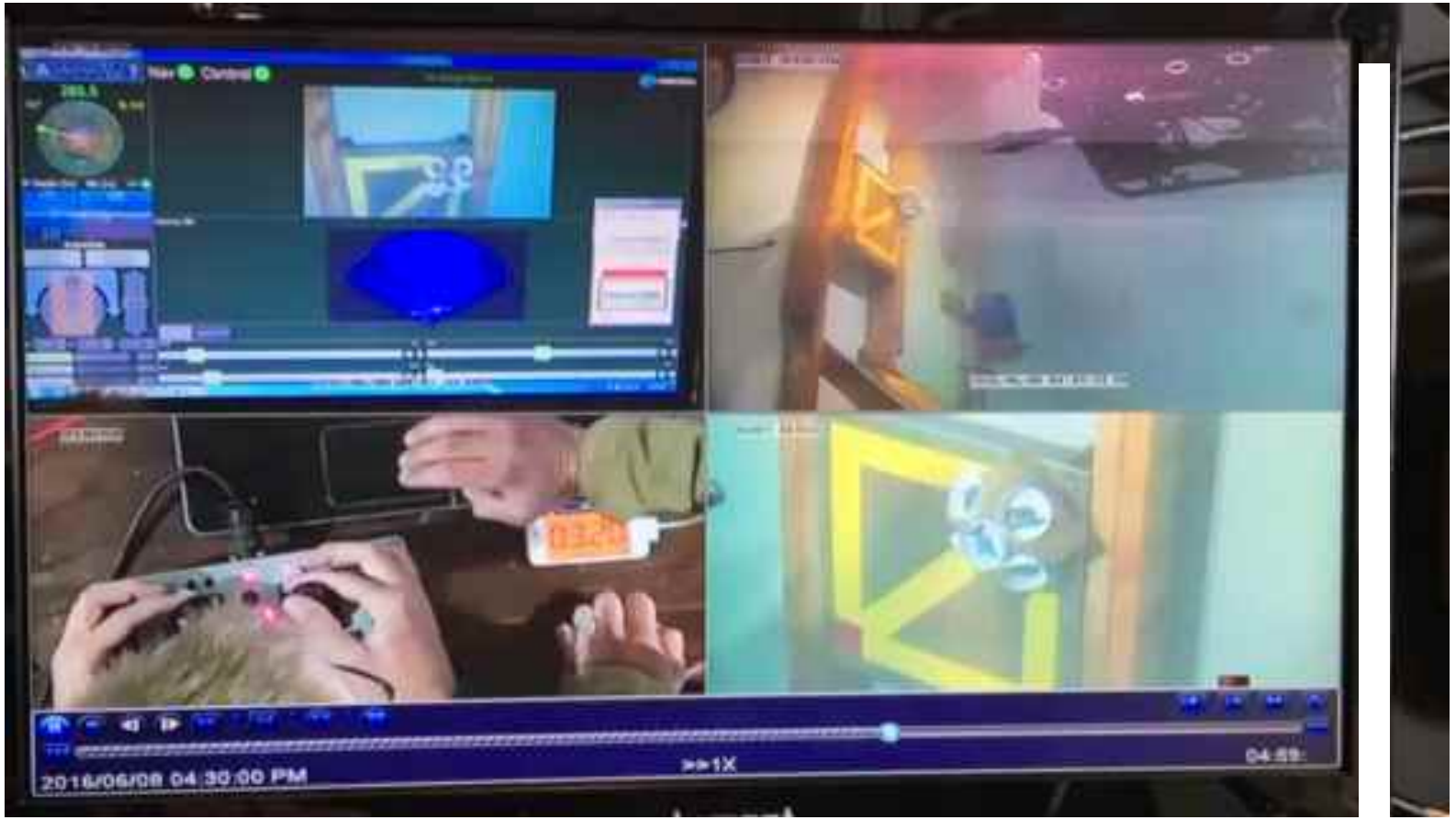
Validation Exercises



Mission Success = Robotic System Capabilities + Remote Operator/Pilot Proficiency

"Practice Makes… Relatively Reliable!"

Aquatic System Tests



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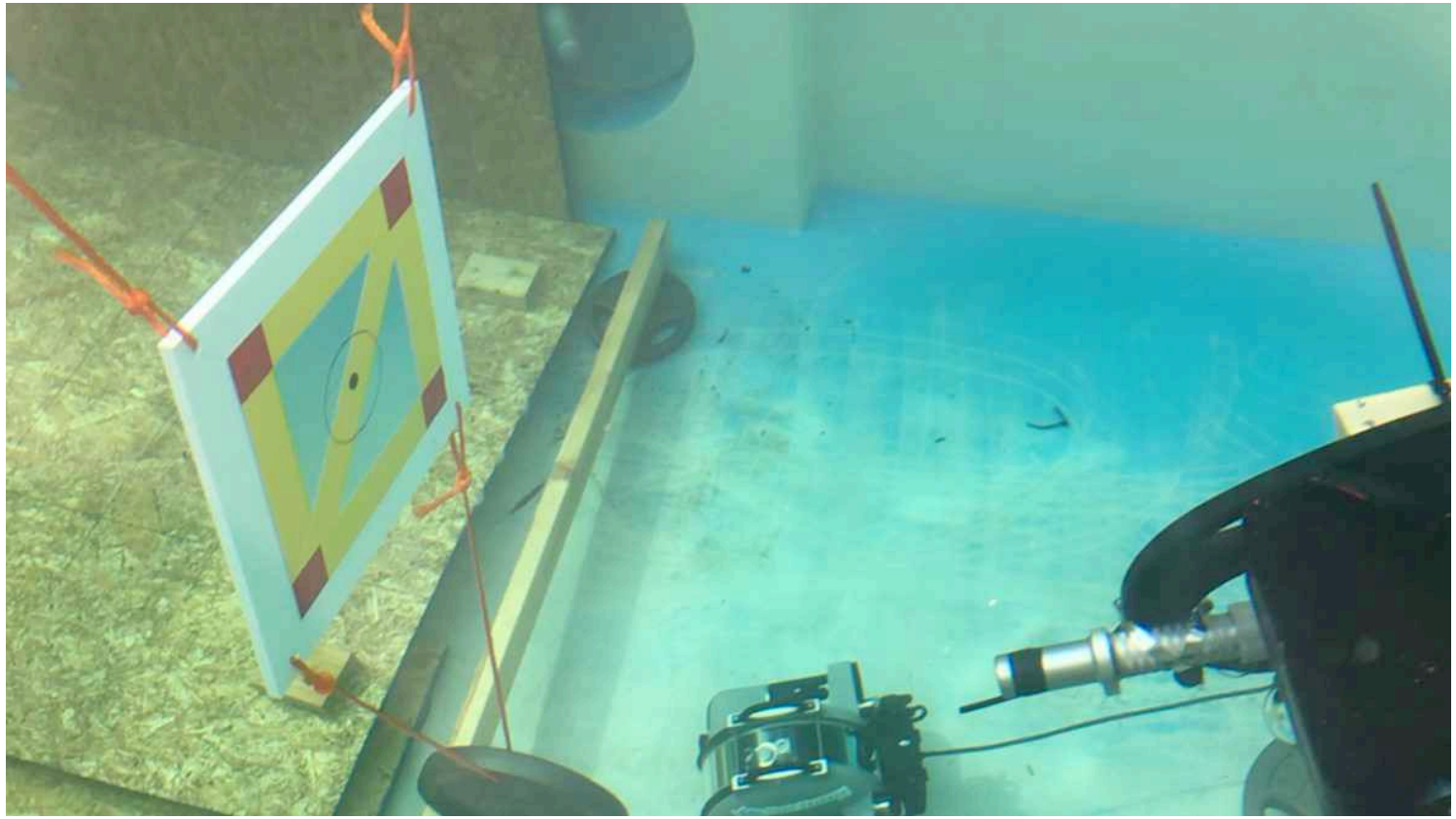

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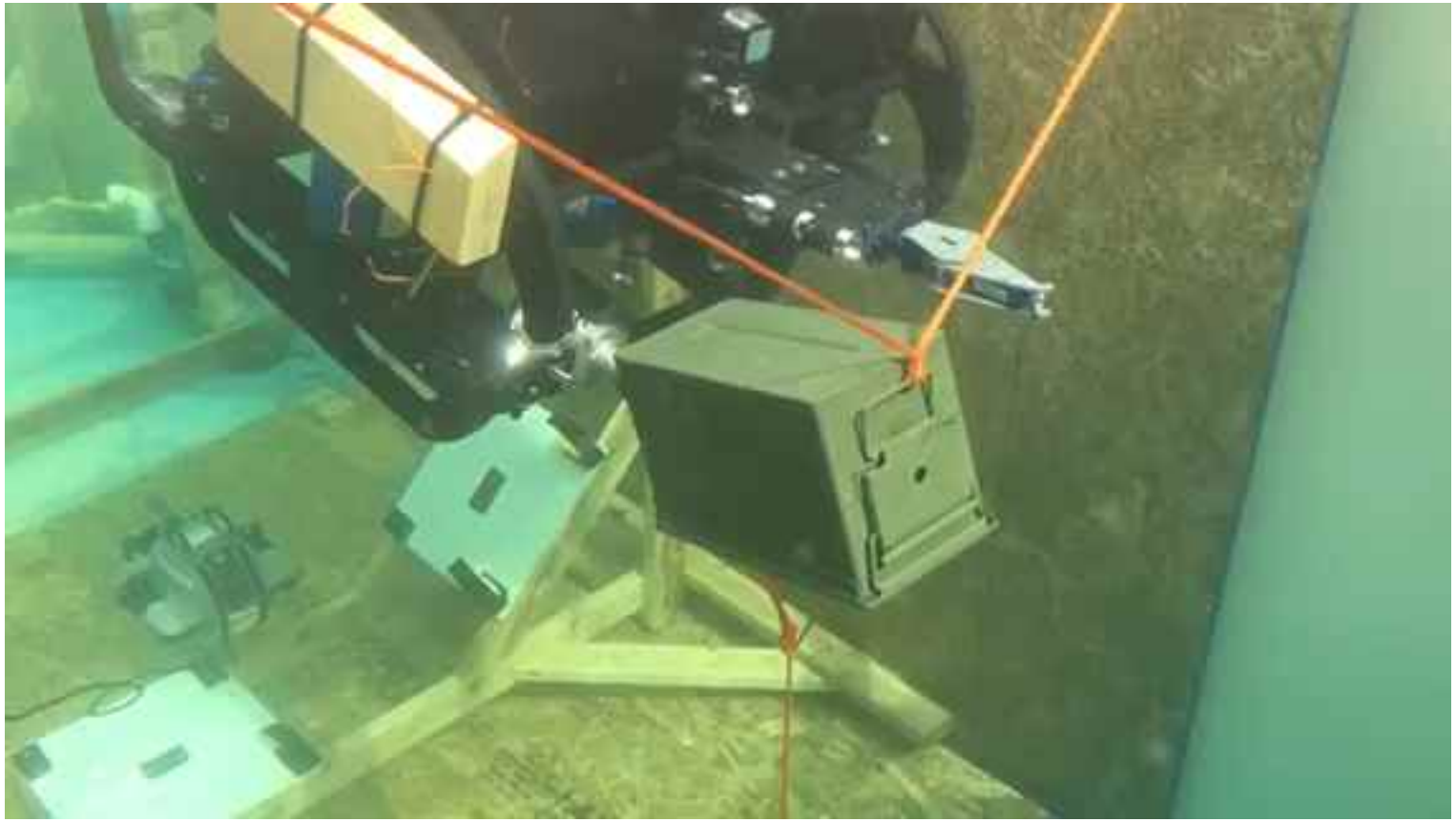
"Practice Makes… Relatively Reliable!"

Aquatic System Tests

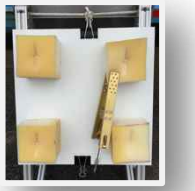


Mission Success = Robotic System Capabilities + Remote Operator/Pilot Proficiency

Omni Directional Tests

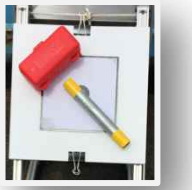
Aquatic System Tests

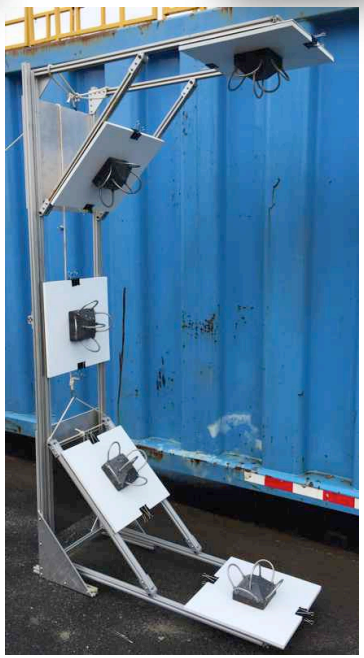
Inspect 

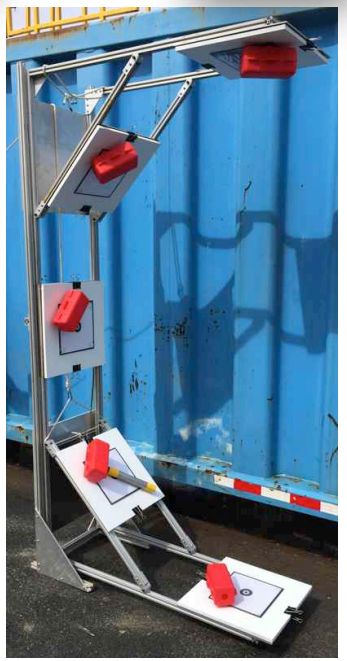
Grasp 

Hook 

Cut 

Affix/Aim 





C-Frames are typically WOOD for periodic field exercises, ALUMINUM or PVC for longer term submerged facilities

Committee Vision

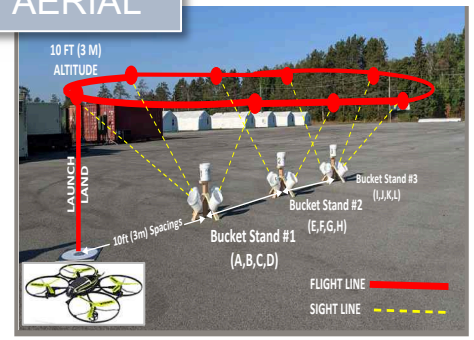
Committee Overview

Remotely operated robots, including ground, aerial, and aquatic systems, 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.

So this committee is developing the measurements and standards infrastructure necessary to quantitatively evaluate and compare robotic system capabilities and remote operator proficiency.

AERIAL



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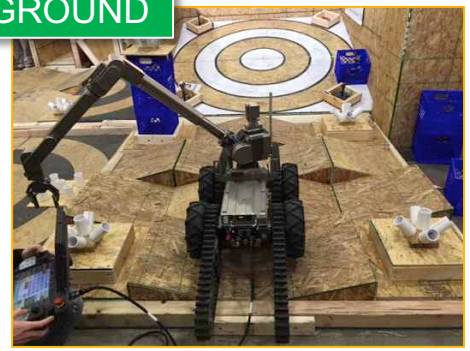

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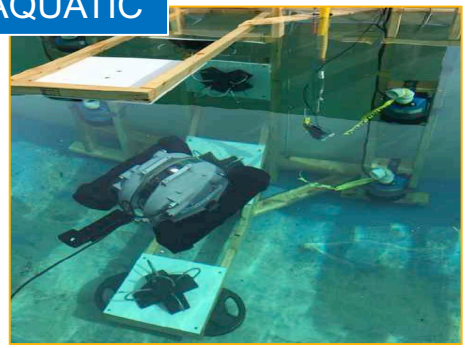

When We Started

Committee Overview

- **Lack of Coordinated Innovation and Commercialization**
  - Difficult to assess performance of robotic systems
  - Robots were not addressing end-user needs
  - No mechanism to tangibly communicate operational requirements
  - No structured training for operators to improve proficiency
  - No credentialing of remote operators and pilots

- **Standard Test Methods Need To…**
  - **Communicate** operational needs to robot researchers and developers.
  - **Promote** innovation through commercial manufacturers.
  - **Enable** users to understand emerging robot capabilities.
  - **Guide** robot purchasing, acceptance testing, and deployment decisions.
  - **Focus** training and measure operator proficiency for credentialing.

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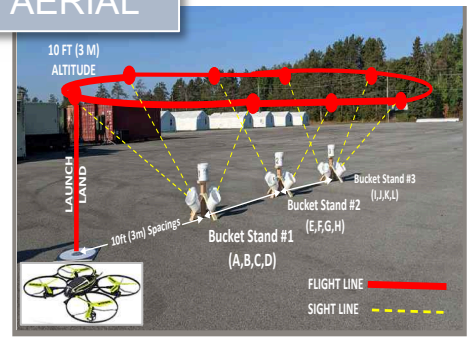

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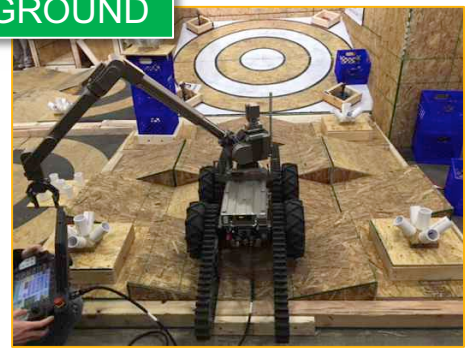

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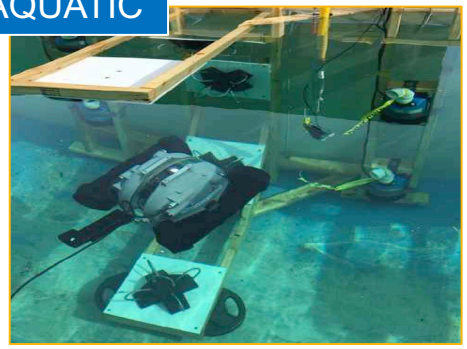


Stakeholders & Priorities

Committee Overview

Identifying our priorities:

- **Requirements workshops** with all interested stakeholders identify capability gaps and priorities.
- **Test validation exercises** with users refine and validate apparatuses, procedures, and data collection.
- **Robot evaluations** with manufacturers capture statistically significant capabilities data.
- **Standards committee meetings and exercises** prepare the tests for balloting and adoption.
- **Research competitions** validate and disseminate tests, inspire innovation, and measure progress.

FEDERAL SPONSORS AND COLLABORATORS

COMMERCIAL PROCUREMENTS

$200 M THROUGH 2020

STANDARDS ORGANIZATIONS

ROBOTICS RESEARCH COMPETITONS

Our Approach

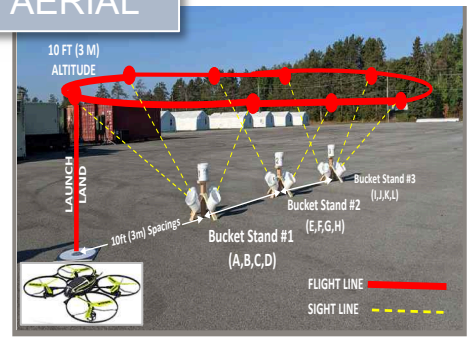
Committee Overview

- **Develop test methods**
  - Representative
  - Repeatable
  - Reproducible
  - Science-based
  - Inexpensive & easy to conduct
- **Enable innovation**
  - Competition challenges
  - Identify and communicate gaps
- **Measure performance**
  - Compare different system capabilities
  - Track and compare operator proficiency

50+ TESTS FOR

Maneuvering
Mobility
Sensing
Endurance
Radio Comms
Dexterity
Durability
Logistics
Safety
Mapping
Autonomy

AERIAL



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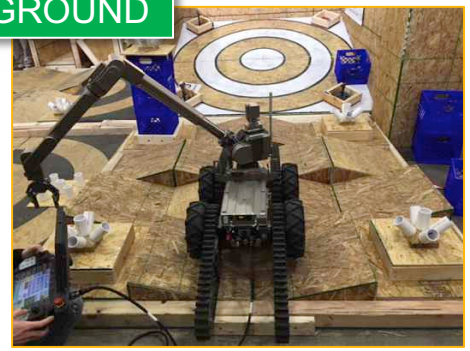

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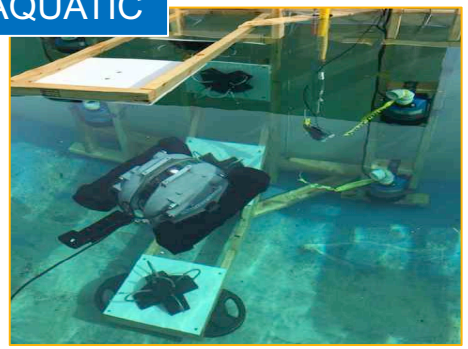

Our Process

Committee Overview

REPEAT

- ***Develop*** suites of reproducible test methods that are quick and easy to conduct repeatedly.
- ***Measure*** combinations of existing capabilities and emerging technologies.
- ***Inspire*** innovation using tests to communicate operational needs and technological gaps.
- ***Guide*** purchasing and deployment decisions with objective capabilities data.
- ***Focus*** training with repeatable tasks to measure and compare operator proficiency.
- ***Identify*** readiness issues with equipment and/or training through local, regional, or national averages.

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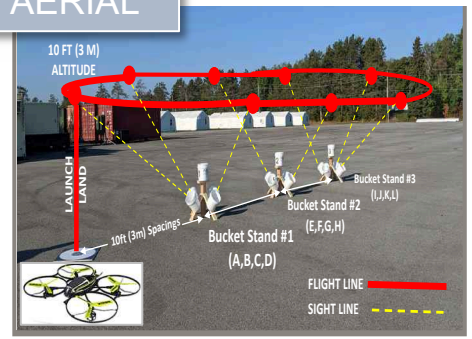

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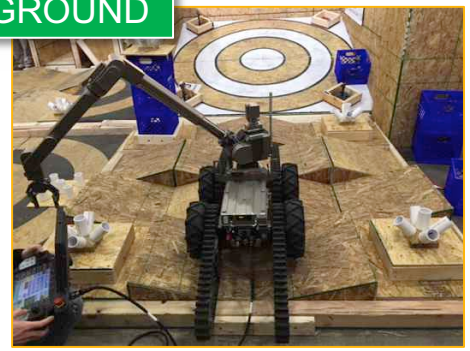

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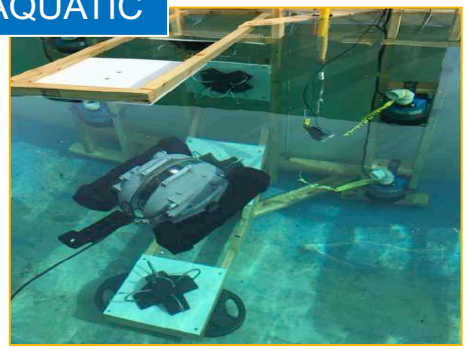


Same Tests Help Different Users and Robots

Committee Overview

Robot Developers

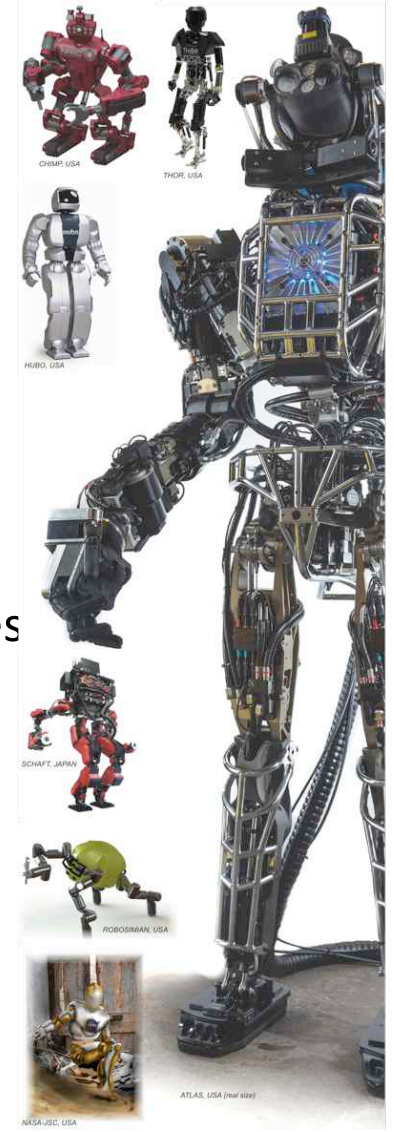
- Understand missions through tangible test apparatuses
- Practice and refine robot designs, make trade-off decisions
- Highlight “Best-In-Class” capabilities

Responders, Soldiers, Other Users

- Compare robots with objective data, not marketing
- Specify purchases based on existing combinations of capabilities
- Align expectations with deployment decisions

Program Managers

- Describe objectives with a collection of tangible tasks
- Challenge conventional approaches and inspire innovation
- Measure baseline capabilities and document progress



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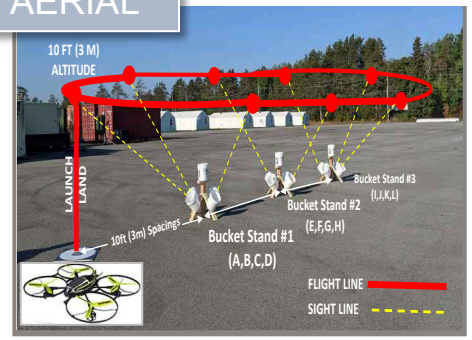

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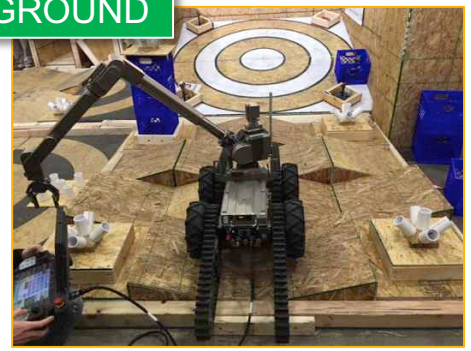

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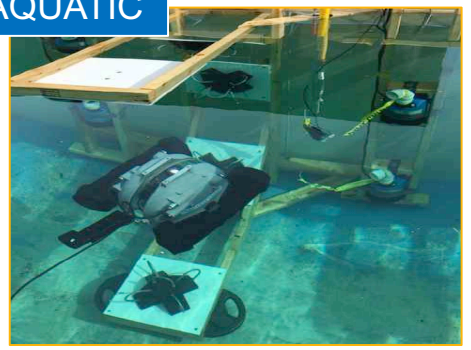

Previous Meetings with Validation Exercises

Committee Overview

ASTM E54.09 Meeting and Test Validation Exercise

Host:
Virginia Beach Fire Dept.,
Virginia Beach, VA

January 2017

Interview with Kathy Morgan, President of ASTM International

Previous Meetings with Validation Exercises

Committee Overview

ASTM E54.09 Meeting and Test Validation Exercise

Host: Canadian Explosives Technicians Association

Hamilton, Ontario, Canada

June 2017 (AND JUNE 4-7, 2021)

"The tremendous work in design, validation, and delivery of NIST's Emergency Response Robots Project has opened the door to operationalization of a training/qualification environment. ***Similar to weapon qualifications, CETA sees the NIST program as just that for public safety professionals, minimum standards.***"

Previous Meetings with Validation Exercises

Committee Overview

ASTM E54.09 Meeting and Test Validation Exercise

Host: San Dieg, Fire Dept. and Navy, SPAWAR

San Diego, CA

June 2018

Previous Meetings with Validation Exercises

Committee Overview

ASTM E54.09 Meeting and Test Validation Exercise

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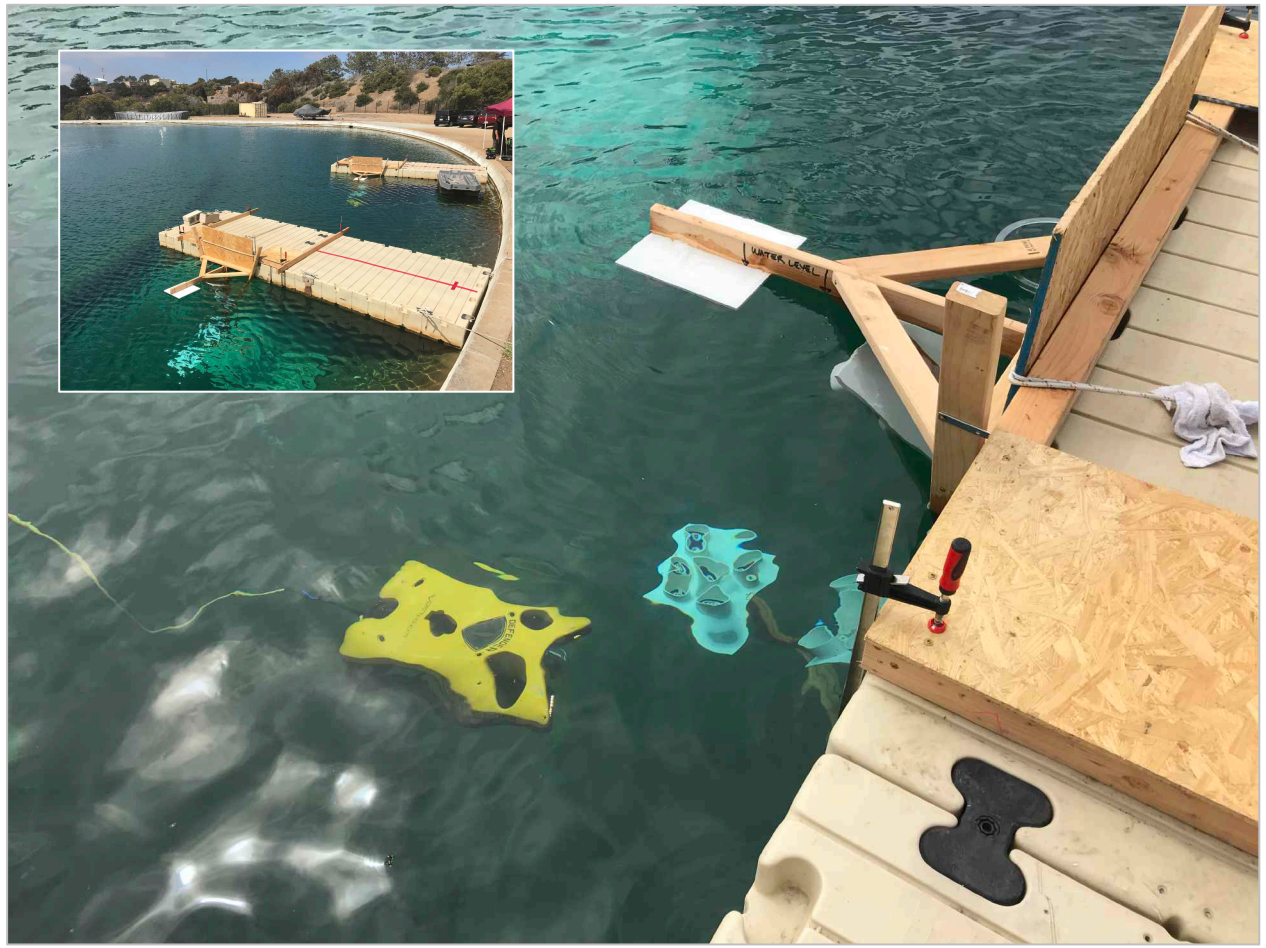
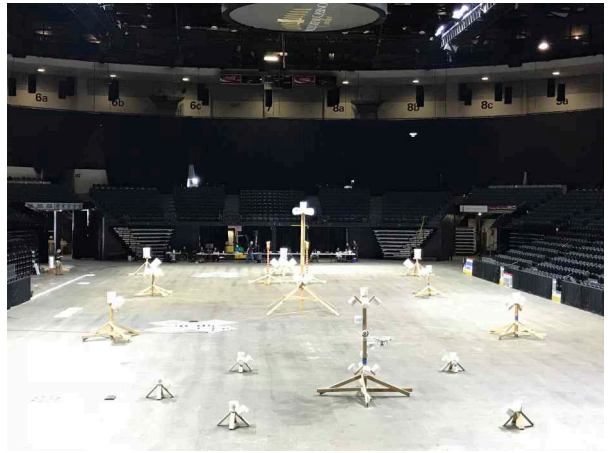
San Diego, CA

June 2018





Annual Test Validation Events

Committee Overview

We go where the robots are!

ANNUAL EVENTS VALIDATING OUR TESTS YEARS	'21	'20	'19	'18	'17	'16	'15	'14	'13	'12	'11
© RoboCupRescue International Championships	X	–	X	X	X	X	X	X	X	X	X
© RoboCupRescue Regional Open, Germany	X	–	X	X	X	X	X	X	X	X	X
© RoboCupRescue Regional Open, Japan	X	–	X	X	X	X	X	X	X	X	X
© RoboCupRescue Regional Open, Thailand	X	–	X	X	X	X	X	X	X	X	X
Robot Test Facility Openings (1+ per year), Int'l	X	–	X	X	X	X	X	X	X	X	X
© DARPA Robotics Challenge for Disaster Response, USA							X	X	X		
© World Robot Summit Disaster Challenge, Japan	X	–	X	X							
European Robotics League / Eurathlons, Europe	X	–	X	X	X	X	X	X	X		
Robot Rodeos and Raven's Challenges, USA/Canada	X X	– X	X X	X X	X X	X X	X X				
Conference Expos with Demonstrations, USA	X X	– X	X X	X X	X X	X X	XX	X X	X X	X X	X X
ASTM E54 Response Robot Exercises, USA	X X	– X	X X	X X	X X	X X	X X	X X	X X	X X	X X

Test Facilities Worldwide

Committee Overview

1: Test Director: Andrew Moore
Southwest Research Institute
Dept. of Electronics and Robotics
San Antonio, TX, USA
(Established 2010)

2: Test Director: Satoshi Tadokoro
International Rescue System
Institute and Tohoku University
Kobe and Sendai, Japan
(Established 2011)

3: Test Director: Johannes Pellenz
Bundeswehr Technical Center for
Engineer and General Field Equipment
Koblenz, Germany
(Established 2012)

4: Test Director: Holly Yanco
New England Robot Validation
and Experimentation Center
Lowell, MA, USA
(Established 2013)

5: Test Directors: Raymond Sheh and Bill Collidge
Curtin University of Technology and
Western Australia Police Bomb Response Unit
Perth, WA, Australia
(Established 2013)

6: Test Director: Christopher Scrapper
SPAWAR
Systems Center Pacific
San Diego, CA, USA
(Established 2014)

7: Test Director: Capt. Sam Hsu
U.S. State Department
Anti-Terrorism Assistance Training Facility
Kabul, Afghanistan
(Established 2015)

8: Test Director: Michal Karczewski
Industrial Research Institute
for Automation and Measurements
Warsaw, Poland
(Established 2015)

9: Test Director: Shinji Kawatsuma
Fukushima Robot Test Facility
Japanese Atomic Energy Agency
Naraha, Fukushima, Japan
(Established 2016)

10: Test Director: Steve Wheeler
Remote Applications in Challenging Environments
UK Atomic Energy Agency
Oxford, United Kingdom
(Established 2016)

11: Test Director:
Korean Atomic Energy
Research Institute
Daejeon, South Korea
(Established 2016)

12: Test Director: Tom Prentice
Reveille Ranch Test Facility
Burnet, TX
(Established 2018)

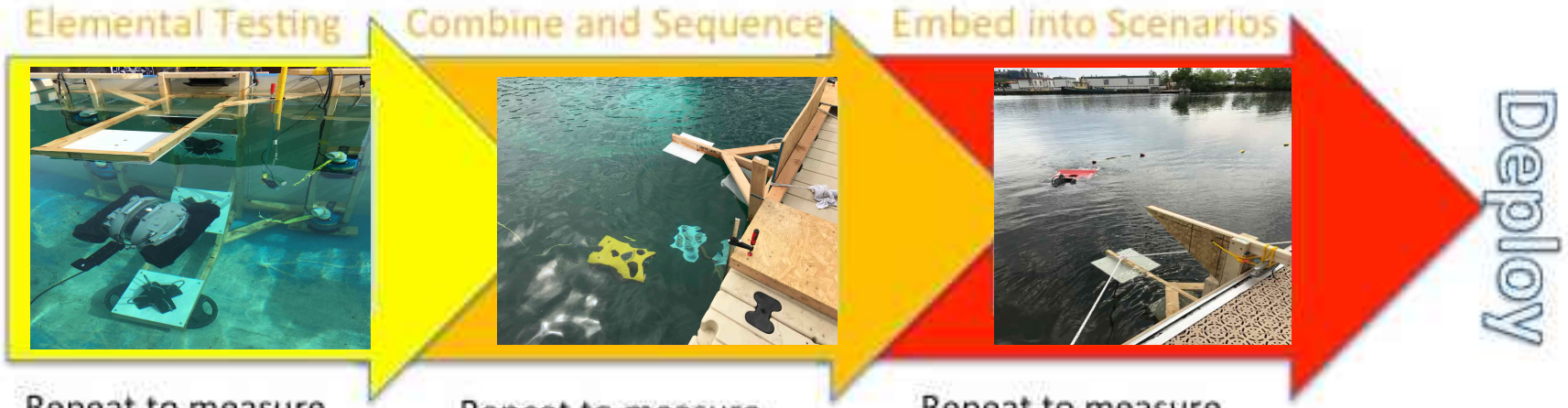
13: Test Director: Ben Miller
Colorado Center of Excellence
Aerial Technology Firefighting
Rifle, CO , USA
(Established 2018)

14: Test Director: Andy Olesen
Fire and Emergency Service Training Institute
Pearson International Airport
Mississauga Ontario Canada
(Established 2019)

15: Test Director: Andy Olesen
Grimsby Regional Training Centre
Grimsby Ontario, Canada
(Established 2019)

Conducting Standard Test Methods

Safety | Capabilities | Proficiency



Repeat to measure ***capabilities.***

Identify and fix weaknesses.

Practice and evaluate task proficiency with quantitative scores in timed trials.

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

Increase complexity in stepwise ways.

Practice and evaluate mission proficiency with quantitative scores in timed trials.

Repeat to measure ***readiness.***

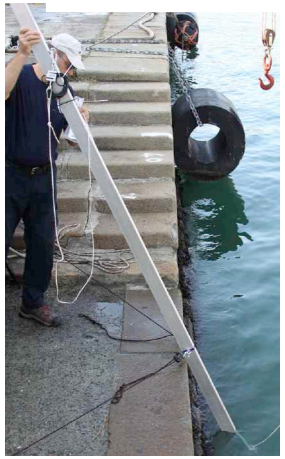
Involve uncontrolled variables.

Practice and evaluate readiness with quantitative scores in timed trials.

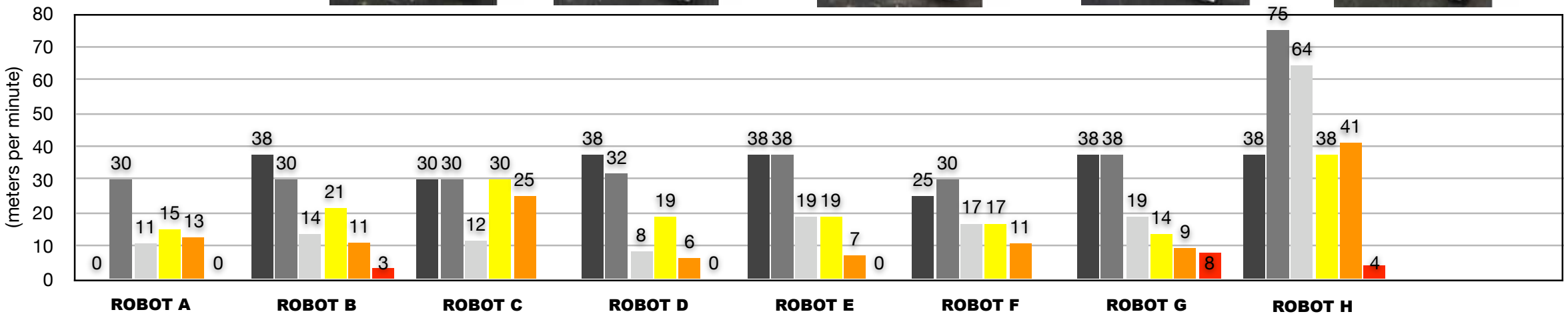
Compare Robot Capabilities or Proficiency

Safety | Capabilities | Proficiency

Thrust | Inspect | Grasp | Cut | Hook | Affix



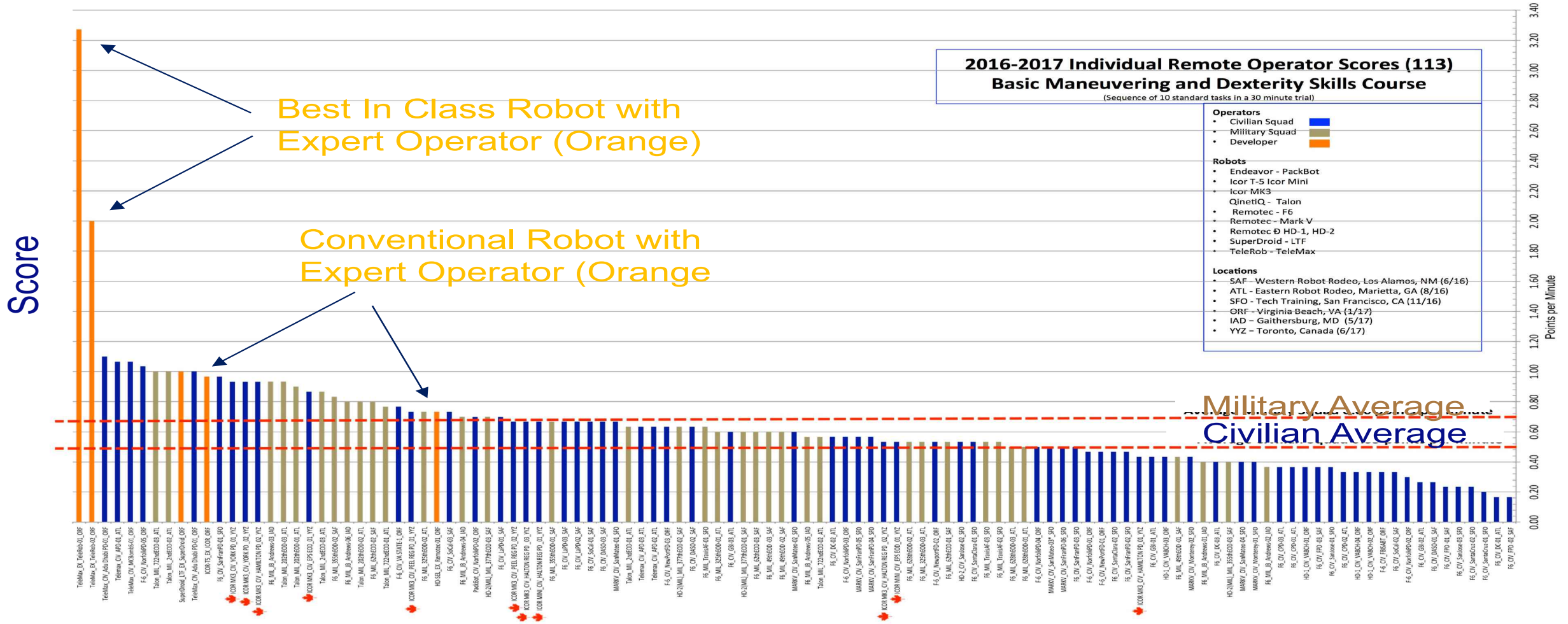


Average Rate of Advance on Terrain for At Least 100m (meters/minute)

Compare Robot Capabilities or Proficiency

Safety | Capabilities | Proficiency



100+ Bomb Techs Using Their Operational Robots (USA & Canada)

Simple Rules for Comparing Scores

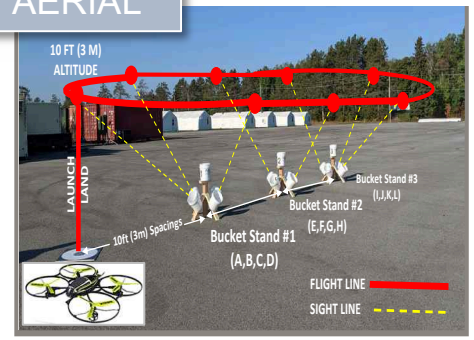
Focus Training and Evaluate Proficiency for Credentialing

- Compare scores in the same tests or embedded scenarios
  Use ALL tests and scenarios that apply to the robot or to the intended missions.

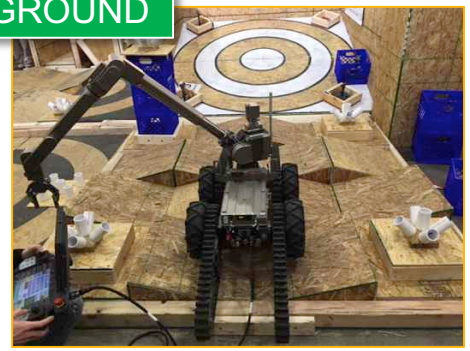
- Compare scores with the same trial times
  Trial time limits help normalize fatigue across several tests, so novices don't get worn out unnecessarily. They provide enough time for an "expert" to easily perform a complete trial. Longer times can be used for scenarios with embedded tests.

- Compare scores to "average" or "best-in-class" across organizations
  - "Expert" operators designated by the manufacturer capture the system's best possible performance in each test. This is the 100th percentile of remote operator proficiency for that system. Your score is 1-100% of that "expert" score
  - For training, use the entire time limit and track your scores. When they become repeatable, your learning phase is over. The best indicator of your proficiency in each test is the average of your last 5 trials.
  - We will post "average" and "expert" scores and rates as we collect them.

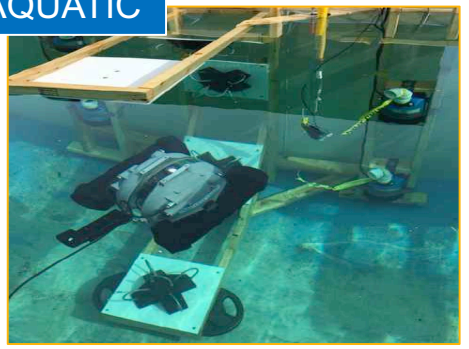
AERIAL



GROUND



AQUATIC



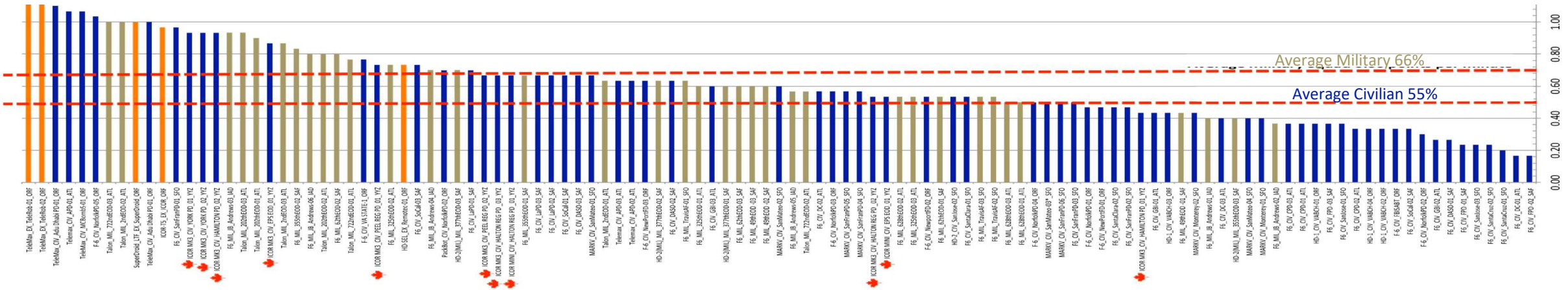
Set Your Minimum Thresholds for Pass/Fail

Focus Training and Evaluate Proficiency for Credentialing

- Organizations can set their own threshold for pass/fail in these tests based on their tolerance for reliability and/or efficiency. Complete trials are assumed.

- Measure everybody repeatedly over time and graph the results to help people understand their strengths and weaknesses. Then set minimum thresholds relative to the average or “expert” scores. Or adopt other organization’s thresholds as a central credentialing reference.

- At deployment time, each organization needs to consider their environmental variables, and mission complexity (night ops, BVLOS, etc.) to select a robot and operator that is likely to succeed.



Example proficiency data shown from bomb squads in ground robot tests

Related Awards

Committee Overview

This same process will work similarly well for AERIAL and AQUATIC systems.

Presidential Gears of Government Award (2020)

For developing the first ever comprehensive suite of emergency response robot test methods and data collection tools to evaluate and improve bomb-disposal robots and operators. These efforts led to enhanced testing and use of advanced robot capabilities that enable emergency responders to perform extremely hazardous missions from safer standoff distances.

Secretary Ron Brown Excellence in Innovation Award, U.S. Department of Commerce (2019)

Gold Medal Award, U.S. Department of Commerce (2019)

Award of Merit, ASTM International Standards Society (2015)

Measurement Science Award, National Institute of Standards and Technology (2014)

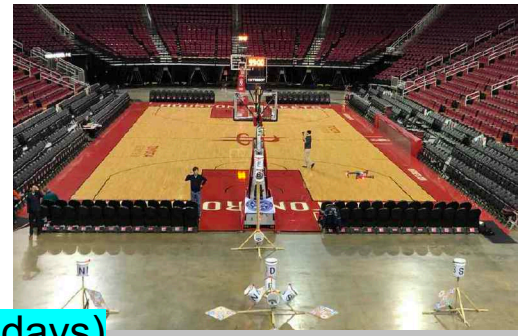
Commendations from Dept. of Justice (2020, 2016), Air Force (2018), DARPA (2015), Dept. of Homeland Security (2014), Dept. of State (2014), JIEDDO (2010), several state and local responder organizations and international organizations.

Validation Exercises

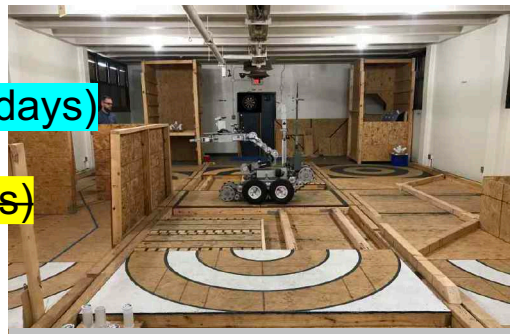
Committee Overview

Color Key: Ground Aerial Aquatic Multiple Standards

- 2020.08 DHS/DOJ sUAS Procurement Testing ($35M), Montgomery County Police Facility, MD (1 days)
- 2020.10 Air Force Large Ground Robot Procurement ($70M), Tyndall AFB, FL (Weeks)
- 2020.08 DHS/DOJ sUAS Procurement Testing ($35M), Montgomery County Police Facility, MD (5 days)
- ~~2020.09 Canadian Fire Training Facility Opening Exercise, Toronto Airport, Ontario, Canada (4 days)~~
- ~~2020.08 World Robot Summit Disaster Response Championship, Fukushima, Japan (4 days)~~
- ~~2020.06 RoboCupRescue International Championship, Bordeaux, France (5 days)~~
- ~~2020.05 AUVSI Exponential Conference (netted aviary), Boston, MA (3 days)~~
- ~~2020.04 Fire Dept. International Conference (FDIC) Hands-On Training, Indianapolis, IN (3 days)~~
- ~~2020.03 UTAC UAS Conference, Guardian Center, Perry, GA (4 days)~~
- 2020.03 Public Safety UAS Conference Validation Exercise, Crozet, VA (5 days)



2019 Host: Houston Fire Dept



2018 Host: San Diego Fire Dept

2017 Host: Canadian CETA

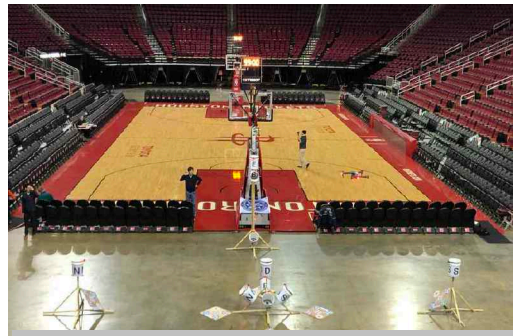
Validation Exercises

Committee Overview

Color Key: Ground Aerial Aquatic Multiple Standards

2020.02 ASTM E54.09 Response Robots Meeting and Exercise, Atlanta, CO (3 days)

- 2020.01 Ohio Fire Training Facility Opening, Ohio (2 days)
- 2020.01 FDIC Fire/Rescue East, Daytona, FL (2 days)
- 2020.01 Los Angeles Fire Dept. Training, Los Angeles, CA (3 days)
- 2019.12 FAA Requirements Workshop for Fire Depts and Emergency Services, NIST (1 day)
- 2019.11 Atlantic Future Forum, UK HMS Queen Elizabeth, Annapolis, MD (2 days)
- 2019.11 DHS Familiarization Exercise, Army Camp Shelby, MS (5 days)
- 2019.10 World Robot Summit, Fukushima, Japan (5 days)
- 2019.09 NATO Aerial and Ground Exercise, Base Borden, Ontario, Canada (3 days)
- 2019.07 Aerial Validation Exercise at NIST (3 days)
- 2019.06 RoboCupRescue International Championship, Sydney, Australia (5 days)



2019 Host: Houston Fire Dept

2018 Host: San Diego Fire Dept

2017 Host: Canadian CETA

Validation Exercises

Committee Overview

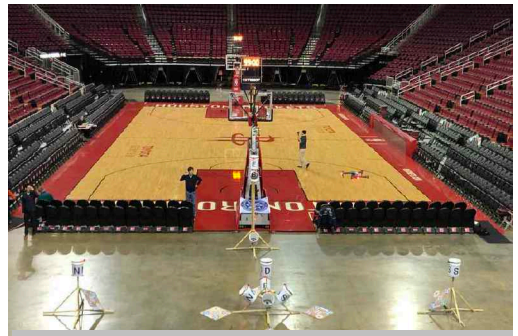
Color Key: Ground Aerial Aquatic Multiple Standards

2019.06 ASTM E54.09 Response Robots Meeting and Exercise, Denver, CO (5 days)

- 2019.05 Western Regional Robot Rodeo, Sandia/Kirtland, Albuquerque, NM (5 days)
- 2019.05 Canadian Police College Training Exercise, London, ON Canada (7 days)
- 2019.04 Thermite RS2 firefighting robot capabilities evaluation (1 day)
- 2019.04 Army Tank Automotive Research and Development facility fabrication (remote)
- 2019.04 Fire Dept Training Conference (FDIC), Indianapolis, IN (3 days)
- 2019.04 Guardian Center Training, Perry, GA (2 days remote)
- 2019.04 Reveille Ranch Calibration, Texas Dept of Public Safety, Burnet, TX (2 days)
- 2019.04 InstantEye UAS capabilities evaluation, NIST (3 days)

2019.03 ASTM F38 standard balloted referencing 6 of our aerial test methods

- 2019.03 Navy Explosive Ordinance Disposal Tech Division facility fabrication (remote)
- 2019.03 Virginia UAS Summit on Public Safety, Crozet, VA (3 days)



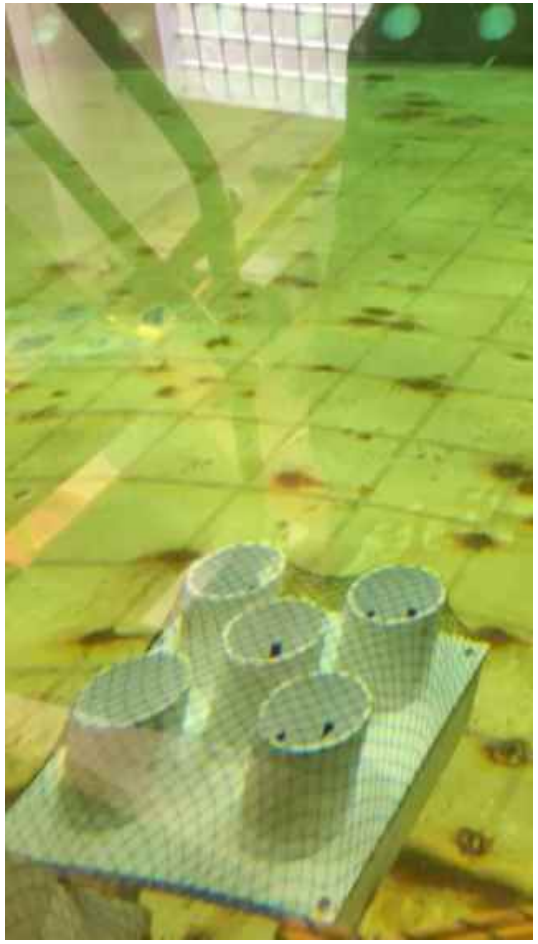
2019 Host: Houston Fire Dept

2018 Host: San Diego Fire Dept

2017 Host: Canadian CETA

Flow Tank (4 knots), Carderock, MD

Validation Exercises

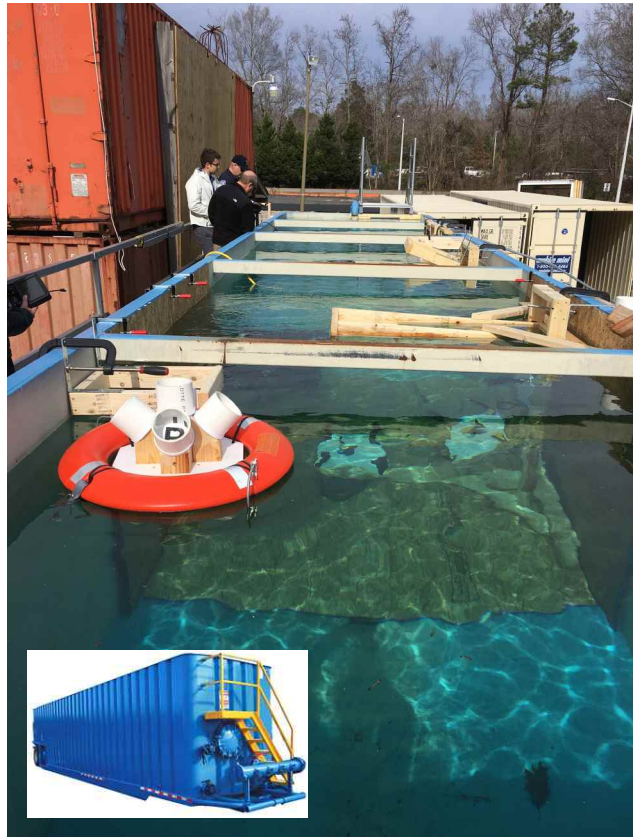


Port Hueneme, CA

Validation Exercises

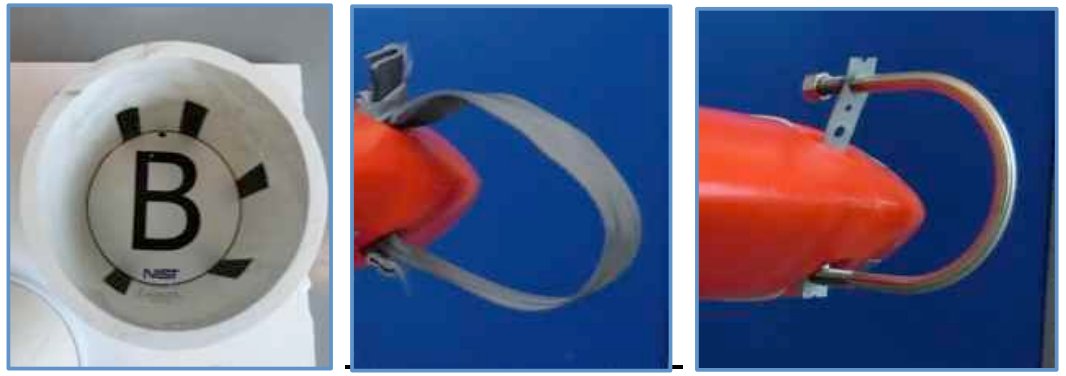
Virginia Beach Fire, Dept., VA

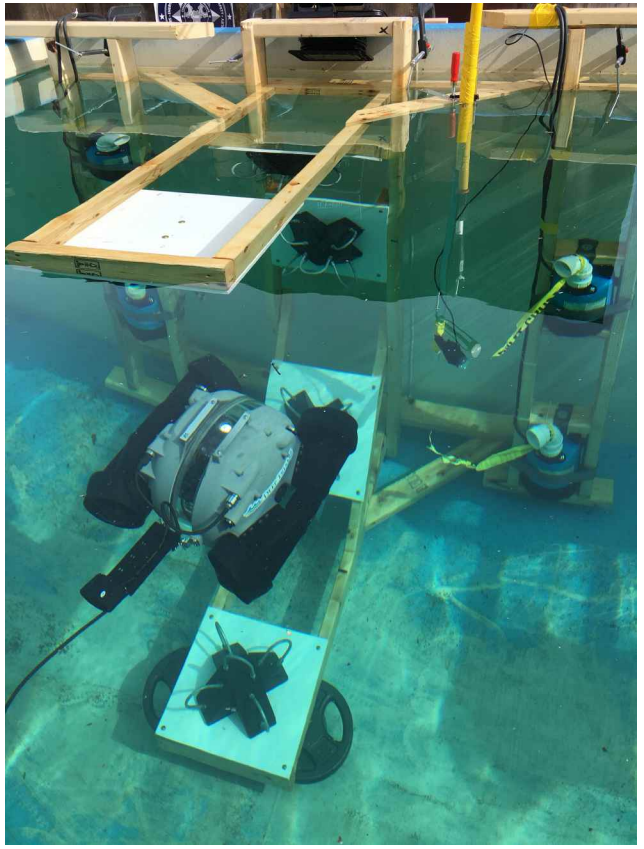
Validation Exercises



Rented Frac Tank or Pool

Floating Surface Tasks

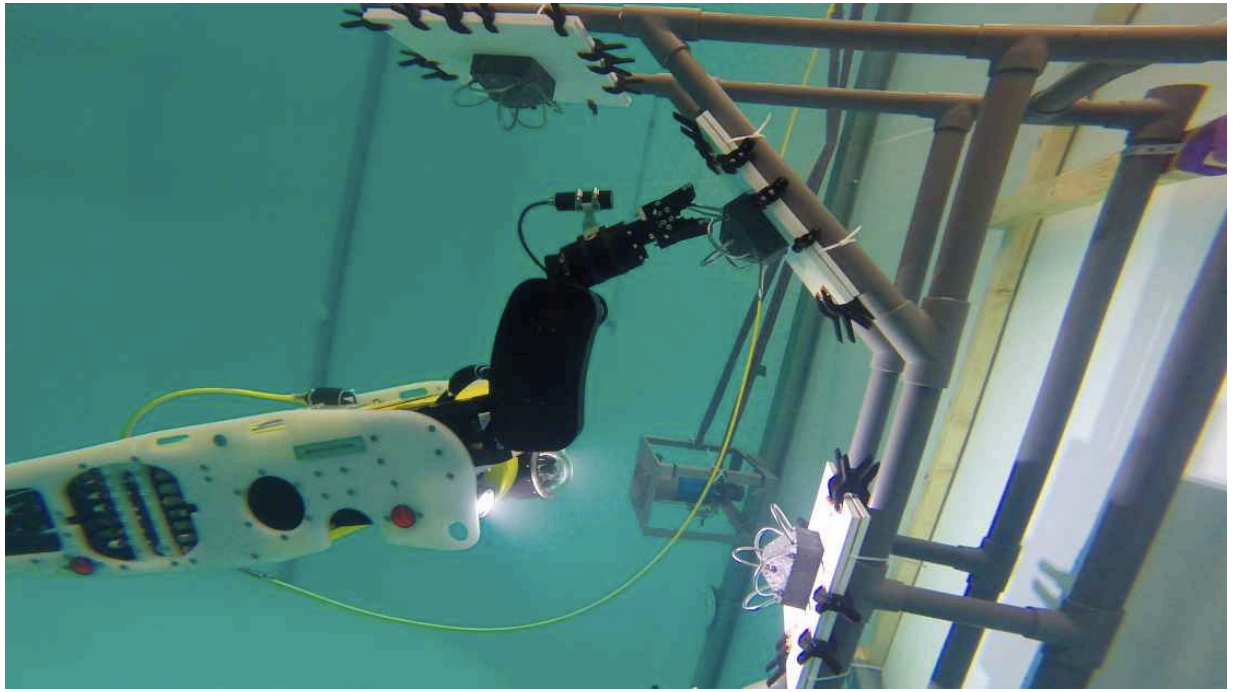


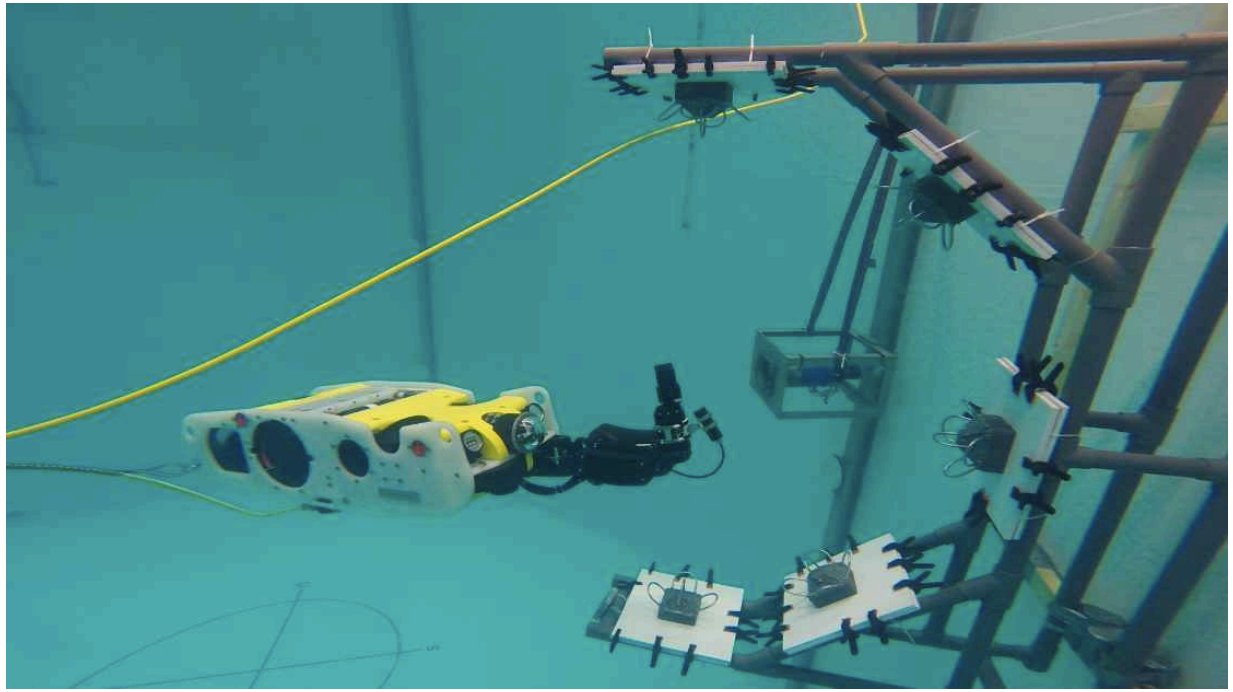


Add Turbulence with Submerged Pumps

SAAB Manufacturer Site, Sweden

Use Case Examples





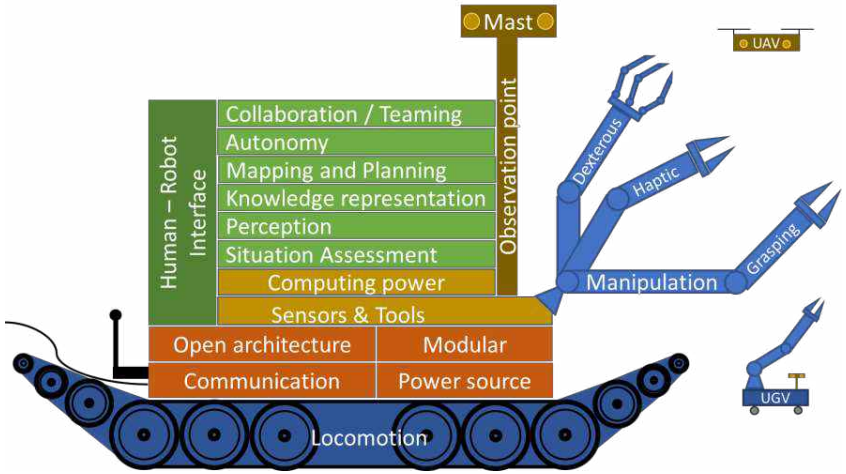
NATO SCI-342 Research Task Group

Use Case Examples

- Adopting and extending our tests to measure robot dexterity and remote operator proficiency necessary to perform explosive ordinance disposal (EOD) missions from remote standoff distances.
- Will replicate the modular dexterity tests in several collaborating NATO countries, including the NATO Center of Excellence for C-EOD Operations in Slovakia.
- Adam Jacoff leads the Subgroup 4 Evaluation (Testing & Metrics)
- The charter will be active 2020-2023

Subgroup 4 Evaluation (Testing & Metrics)

- Adam Jacoff
- Aurélie Lepoil
- André Volk
- Johannes Pellenz
- Eric den Breejen



Canadian CETA and CERRA Training/Credentialing

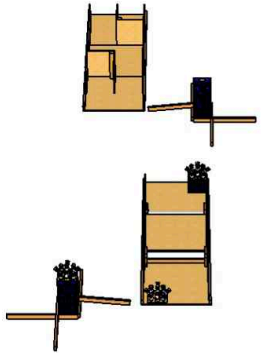
Use Case Examples

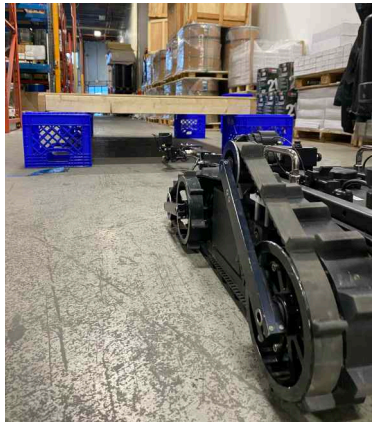
Lead Agencies;
CETA- Canadian Explosives Technicians Association
CERRA- Canadian Emergency Responders Robotics Association

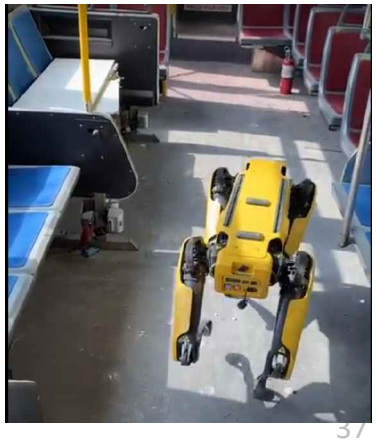
Primary Locations:
Pearson International Airport (Toronto Canada)
Grimsby Regional Training Centre (Grimsby, Ontario , Canada)

CETA
CETA is the national association for police/military/government agencies tasked with response to explosives , chemical, biological, and radiological incidents in Canada. Current projects include EOD Standard training methods for both robots and bomb techs deployed in bomb suits.

CERRA
Spring 2020 established with focus on the public safety deployment of ground, air, water based robotics. Membership is open to any current or former public safety member or agency or any supporting government agency with an interest in response robots.







World Robot Summit, Fukushima, Japan (2018-2020)

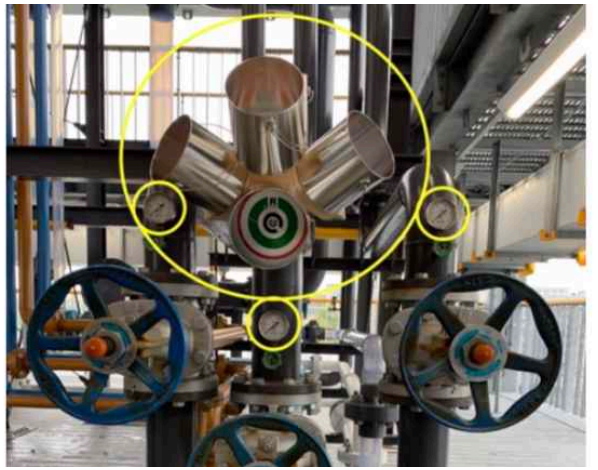
Use Case Examples

Standard Disaster Robotics Category, Fukushima Robot Test Field, Fukushima, Japan



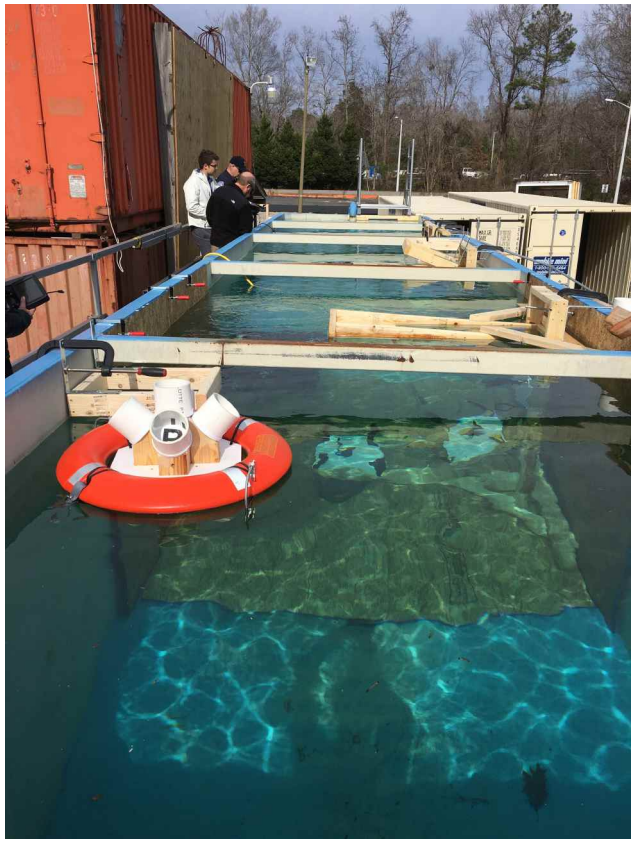


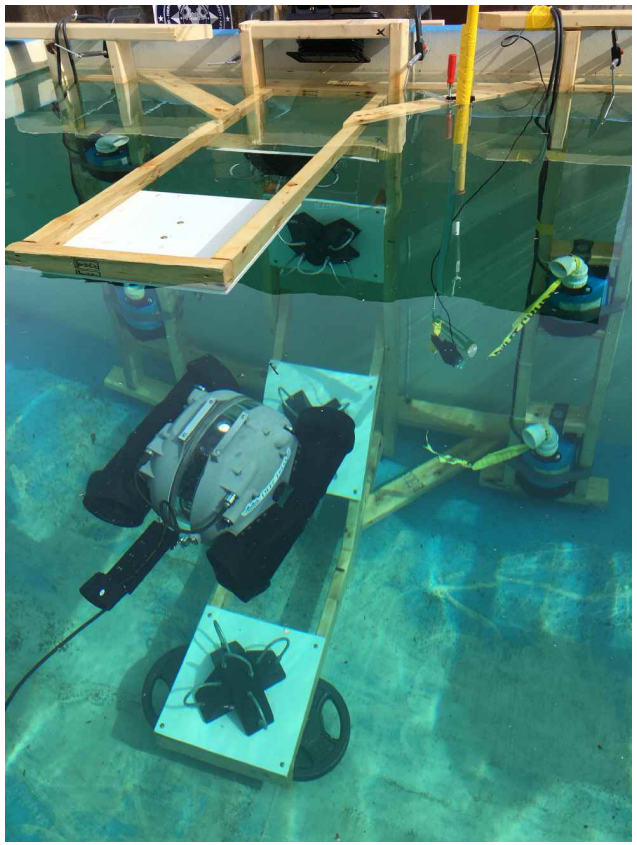




Put a Frac Tank Facility in Your Parking Lot (Rent or Buy)

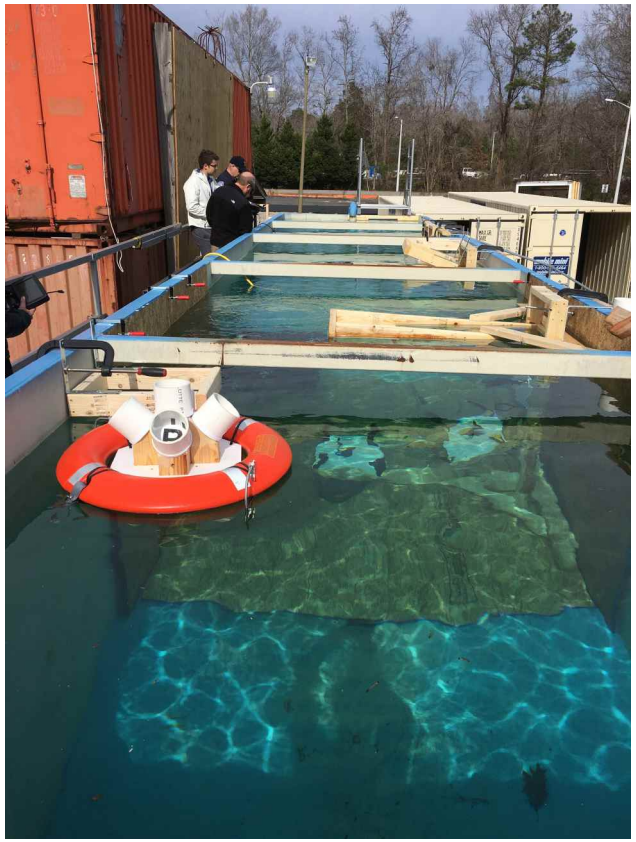
Safety | Capabilities | Proficiency



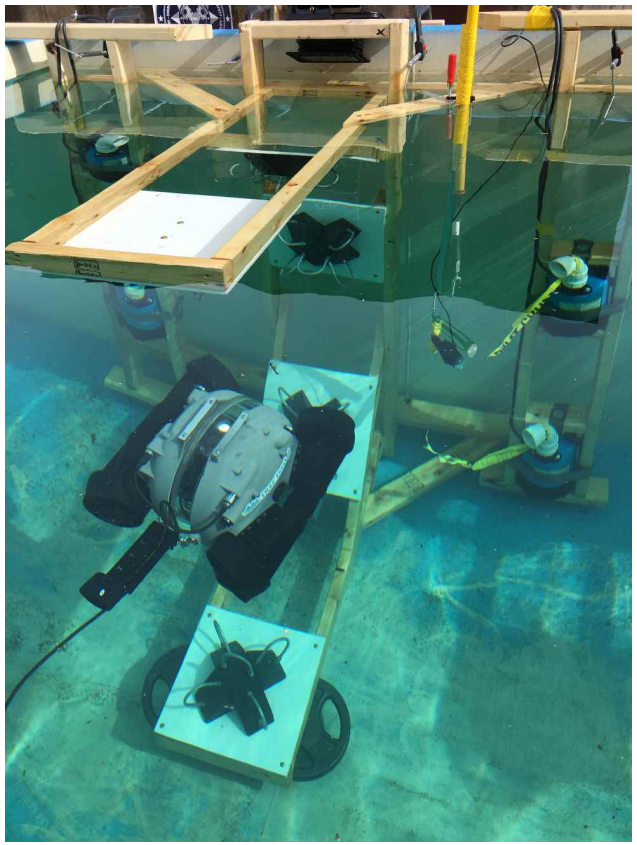


Put a Frac Tank Facility in Your Parking Lot (Rent or Buy)

Safety | Capabilities | Proficiency



Not so hard… get a firefighter to do it!



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