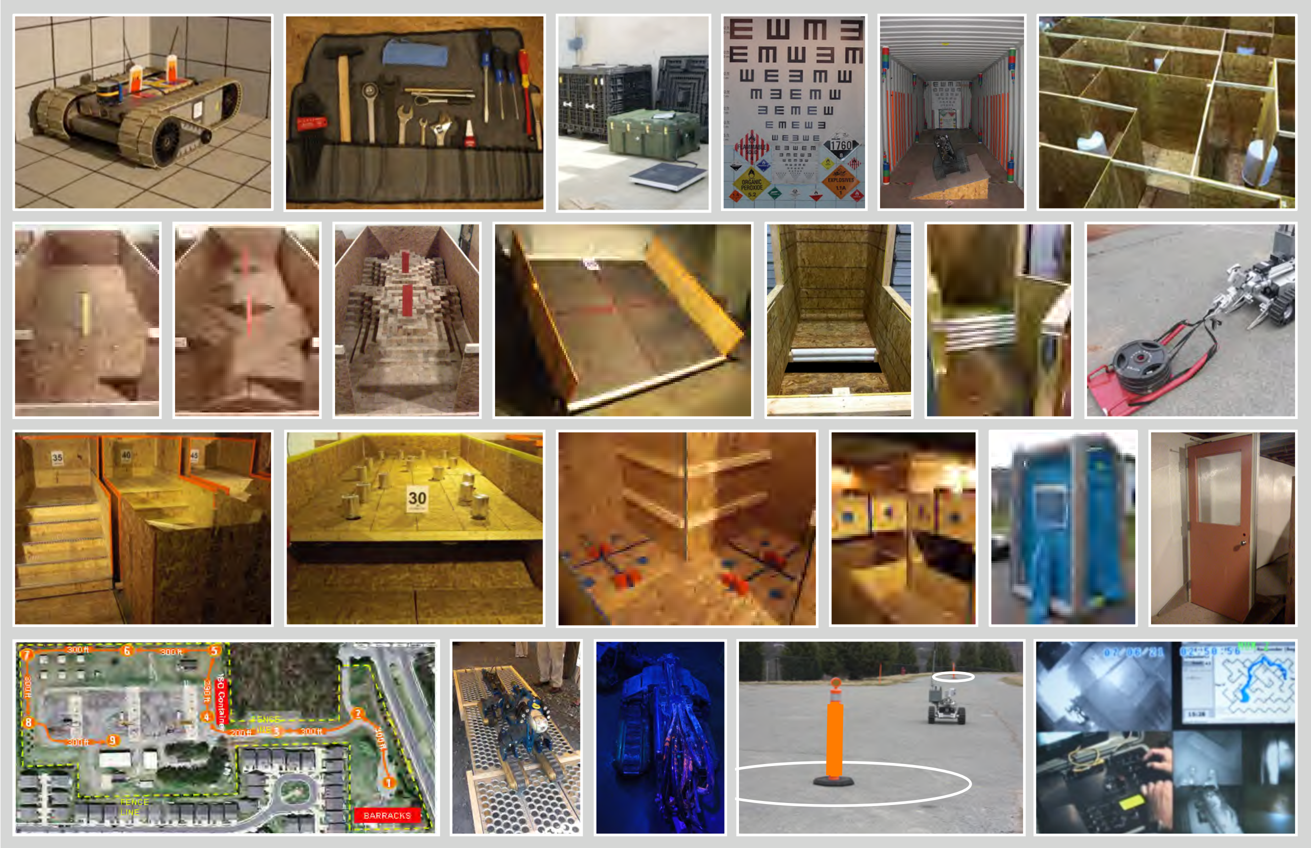
National Institute of Standards and Technology
U.S. Department of Commerce

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011

Forms: v2011.1 Data: A



Sponsors:
Bert Coursey, Phil Mattson
Test & Evaluation and Standards Division
Science and Technology Directorate
Department of Homeland Security
Developing and coordinating the adoption of national standards and appropriate evaluation methods to meet homeland security mission needs.

Bill Billotte, Jennifer Marshall
NIST Office of Law Enforcement Standards
Helping law enforcement, corrections, criminal justice, and public safety agencies ensure that the equipment they purchase and the technologies they use are safe, dependable, and effective.

TEST DIRECTOR:
Adam Jacoff
Intelligent Systems Division
National Institute of Standards and Technology
Gaithersburg, MD 20899

301-975-4235 RobotTestMethods@nist.gov

NIST COLLABORATORS
Elena Messina, Hui-Min Huang
Ann Virts, Anthony Downs
Richard Norcross

Acknowledgements

The Department of Homeland Security sponsored the production of this material under an Interagency Agreement with the National Institute of Standards and Technology

NIST ADMINISTRATORS

Rick Norcross
Bill Rippey
Galen Koepke
Dennis Camell
John Ladbury
Kate Remley
Jean Scholtz
Sal Schipani
Brian Antonishek
Alan Lytle
Kamel Saidi
Nick Scott
Jeremy Swerdlow
Zeid Kootbally
Brian Weiss
Raj Madhaven
Chuck Giauque
Teresa Gutierrez
Brain Marshall

COLLABORATORS (USA)

John Blitch
John Evans
CJ Scrapper
Mark Micire
Chris Rogan
Karl Reichard
Eli Hughes
Bill McBride
Andrew Moore
Joe Herring
Roger Gutierrez
Kevin Alley
Alexander Ferworn
Jenny Burke
Steve Richards
Rolf Lakemper
John Andrews
Steve Holste
Dale Bryan
David Hooper
Scott Ferree
Will Brown
Andy Andrews

COLLABORATORS (INT'L)

Satoshi Tadokoro, Japan
Daniele Nardi, Italy
Andreas Birk, Germany
Johannes Pellenz, Germany
Tetsuya Kimura, Japan
Ehsan Mihankhah, Iran
Jackrit Suthakorn, Thailand
Alexander Kleiner, Germany
Soeren Schwertfeger, Germany

ROBOT DEVELOPERS

Andreas Ciossek
Tom Morehead
Pete Stephens
Don Jones
Brad Bachelor
Mike Cole
Jim Daniels
Patrick Goode
Vito Gambino
Andrew Poulter
Laurie McIntosh
Phillip Gonier
Wayne Russell
Rob Smith
Gary Stair
Ed Duggan
Thomas Meyer
Sean Newsome
Will Pong
Misza Tymowski
Mel Torrie
Roger Andersen
Chris Brown
Blake Douglas
Bill Ross
Jason Seawall
Art Michaud
Mark Donaldson
Len Corasaniti
James Myers
Mike Cardarelli
Richard Bizzari
Eric Peters
Andrew Kavalersky
Bob Christ
David Gustafson
Jeff Conger
David Jones
Karl Steadman
Salvador D'Itri
Ron Cochran
Bob Bean
Ryan Wall

EMERGENCY RESPONDERS

US&R

Lloyd Randall
Tom Haus
Athena Haus
Bill Monahan
Harold Schapelhouman
Roger Miller
Rex Ianson
Steven Morikawa
David Lesh
Todd Fetters
Ford Davies
Richard Leap
Daniel Snyder
Gary Jennings
John Quinn
Kevin Schmidt
Rodney Swanson
Rory Rehbeck
Charles Frost
Craig Radelman
Gregory Barhorst
Robert Hernandez
Sam Stover
Bradford Stocks
Bruce Naslund
Mark Micire
Michael Steed
Lee Turner
Michael Conditt
Vance Behrens
Karl Lee
Mark Kittelson
Paul Bailey
George Hough
Randy Miller
Kevin Clemens
Martin Nevil
Jeffrey Snyder
Robert McKee
Billy Parker
Clint Arnett
Susann Brown
Cathy Farrell
David Vialpando
Jens Lund
Mike Ulibarri
Trevor Tallon
Mark Lucas
Tom Griffin
John Mayers
Buck Best
Teresa Macpherson
Jim Ingledue
Mark Hundley
Parry Boogard
Doug Alexander
Glenn Keller

EOD BOMB TECHS

Sam Hsu
Tom Sharkey
Tom Egger
Kenny Williams
Gregory Kincaid
Paul Freelander
Jerry Swain
Dale Ednock
Don Boyd
Larry Seipp
Scott Kawahara
Shawn Stallworth
Martin Hutchins
Rick Osborn
Greg Stier
Jason Miller
Tom Subject
Wallace Meeks
Jon Sarno

Disclaimer

Policy .

The International System of Units (SI) is used throughout this document. Conversions from SI units to U.S. Customary units are made where possible but approximate equivalents are used to specify materials which are readily available in the domestic market or to avoid excessive fabrication costs of test apparatuses while maintaining repeatability and reproducibility of the test method results

National Institute of Standards and Technology
U.S. Department of Commerce

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

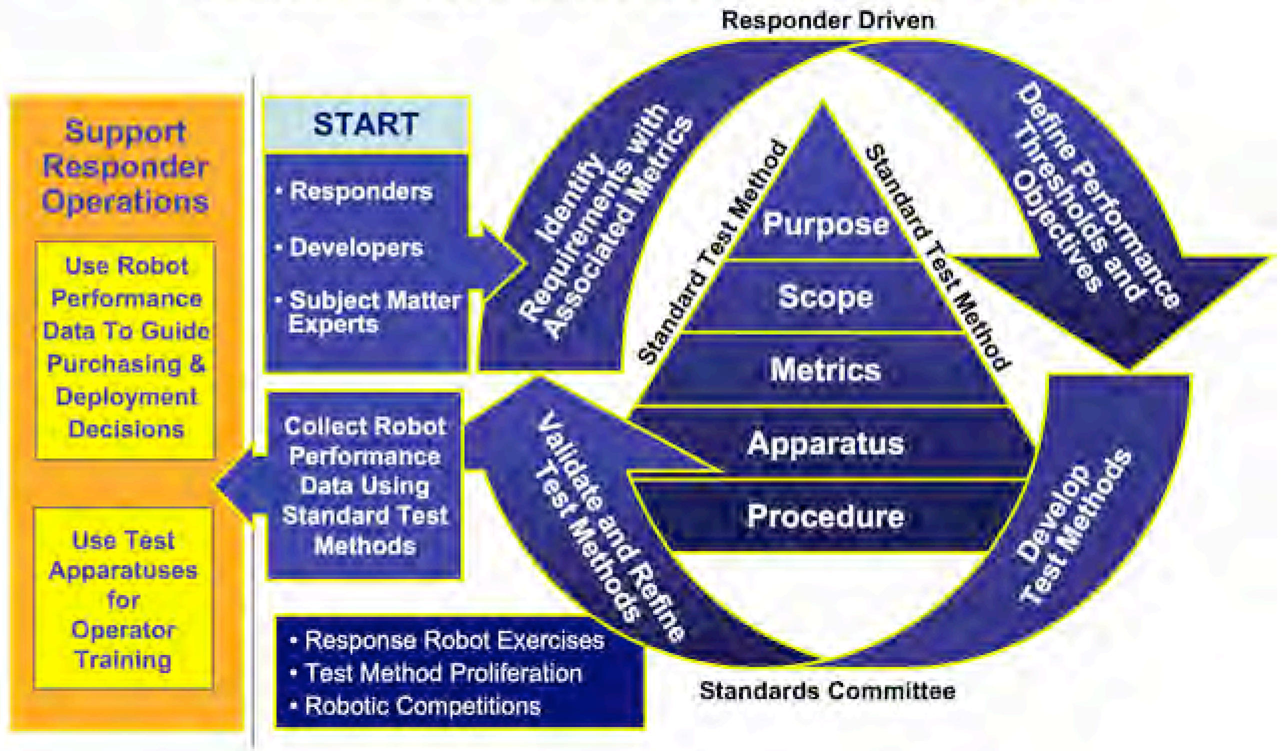
January 2011

Forms: v2011.1 Data: A

Overview

The Intelligent Systems Division of the National Institute of Standards and Technology is conducting an ongoing project, sponsored by the Department of Homeland Security Science and Technology Directorate and the National Institute of Justice, to produce a comprehensive set of standard test methods and associated performance metrics to quantify key capabilities of emergency response robots. These test methods address responder-defined requirements for **robot mobility**, **manipulation**, **sensors**, **energy**, **communications**, **human-robot interfaces**, **logistics** and **safety** for remotely operated ground vehicles, aquatic vehicles, and micro/mini aerial vehicles (under 2 kg/5 lbs) for urban environments. The goal is to facilitate emergency responder comparisons of different robot models based on statistically significant robot performance data captured within the standard test methods to help guide purchasing decisions and understand deployment capabilities. The test methods also support operator proficiency training and foster development and hardening of advanced mobile robot capabilities.

Standard Test Method Developmental Cycle



This document describes the suite of test methods and practices currently standardized or being validated with robot performance data. It contains overviews of test method purposes, metrics, apparatuses, procedures, and associated data collection forms, so It may be used by administrators to conduct testing and capture robot performance data. Additional test methods in the prototype stage are not included in this document.

Development Process

The process used to develop standard test methods begins with specific requirements defined by emergency responders for robotic capabilities that could make their operational deployments more effective, efficient, or safe. Each requirement must have an associated metric along with thresholds of performance below which the responders will not accept. Where such robot requirements already exist, for example bomb squad applications, they may have been used directly. Other responder communities, for example technical search specialists from FEMA urban search and rescue teams, were solicited during the course of this program and have provided over 100 such requirements for 13 different categories of robots.

The requirements are prioritized by responders and prototype test apparatuses are generated to isolate and repeatably test and measure robot performance. Response robot evaluation exercises are hosted in responder training facilities to allow responders to validate the test methods and learn about emerging robotic capabilities. International robot competitions featuring the prototype test apparatuses and tasks are used to leverage robot traffic (over 100 missions per competition) to refine apparatus designs and inspire robot innovations. They also support proliferation of the test methods for practice and provide benchmark comparisons for qualification. Once the apparatus is validated, it is balloted through the ASTM Standards Committee on Homeland Security Applications; Operational Equipment; Robots (E54.08.01).

General Scope

This suite of test methods characterize the capabilities of robots intended to operate in human-scale, complex environments with variable terrains, lighting, temperature, etc. Robots under test shall be teleoperated via a remote operator control unit (OCU), out of sight and sound of the test apparatuses but within communications range (except for the radio communications test methods). The robot configuration as tested shall be specified in detail (manipulators, payloads, batteries, communications, etc) and subjected to the entire suite of test methods. Any variation in robot configuration must be retested across the entire suite of test methods to provide a comprehensive overview of performance characteristics for that particular robot variant. Systems with assistive capabilities or autonomous behaviors should demonstrate improved remote operator/robot performance, efficiency, or survivability of the robot under test. Although these test methods were developed specifically for emergency response robots, they may be applicable to other application domains with modest variations in terrains, targets, or tasks.

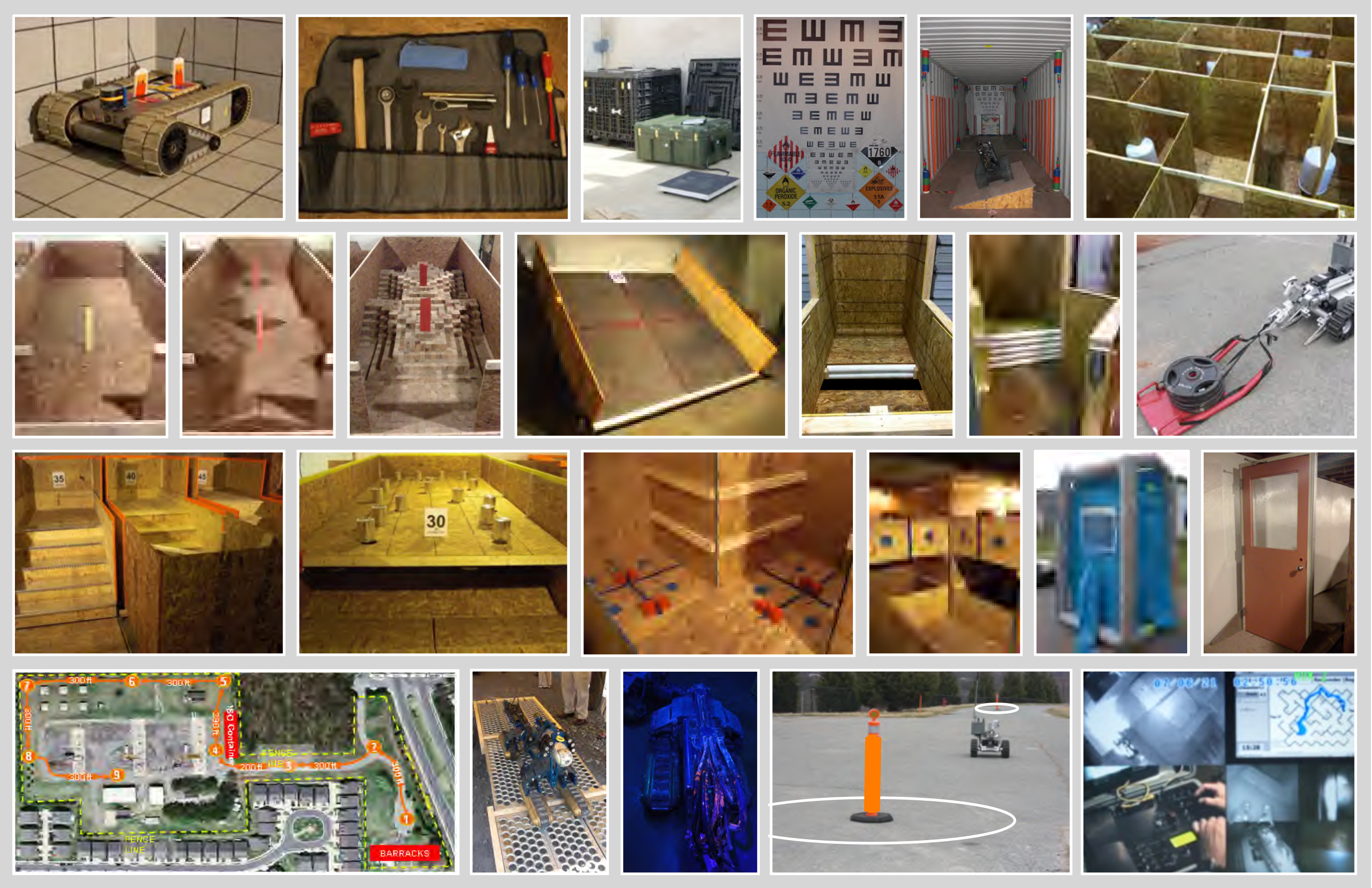
Pointman LRV Applied Research Associates, Inc.
BomBot2 Innovative Response Technologies, Inc.
Matilda II Mesa Robotics, Inc.
Digital Vanguard Allen-Vanguard Corporation

Packbot 510-EFR iRobot Corporation
Talon G4 Foster-Miller, Inc.
Caliber, ICOR Technology Corporation
Andros HD-1J Northrop Grumman Remotec

Robots shown above are typical of the size robot these test methods are intended to evaluate. They are shown in front of a 20 cm (8 inch) metered backdrop used in the *Standard Practice for Establishing the Test Configuration and Associated Cache Packaged Weight and Volume of Emergency Response Robots.* These eight robots provided the first ten robot configurations to be subjected to the entire suite of emerging standard test methods to determine test method "repeatability" within a single apparatus and test method "reproducibility" across different test facilities. Two of the robots also tested either without their manipulator or with an extended manipulator making them new configurations subject to testing across the entire suite of test methods to capture trade-offs in capabilities.

Apparatuses

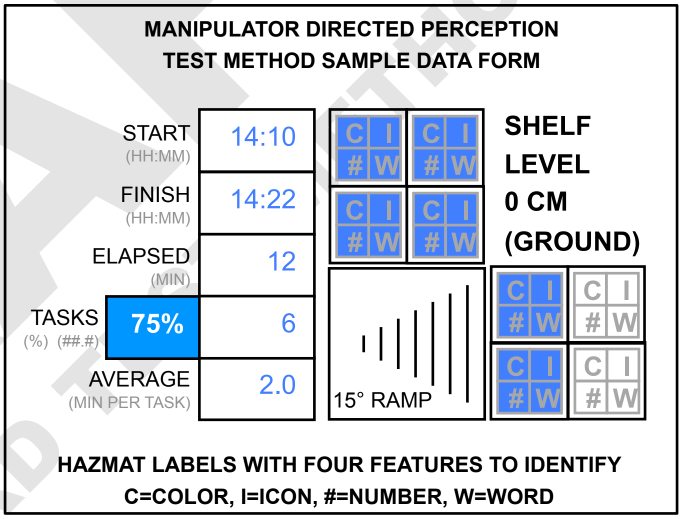
The apparatuses associated with these test methods challenge specific robot capabilities in repeatable ways to facilitate direct comparisons of different robot models and particular configurations of similar robot models. Many of the test apparatuses use terrains, targets, and tasks that are intentionally abstract to facilitate the standardization process which requires capture of repeatable results within a specific test apparatus and reproducible results across different test facilities with replica test apparatuses. They are generally fabricated using readily available materials to facilitate fabrication by robot developers to support system innovation refinement, and hardening, and for emergency responder organizations to support evaluation and training. For example, many test apparatuses are constructed with oriented strand board (OSB) plywood to provide a common friction surface similar to dust covered concrete. The specific terrains, targets, and tasks used can be modified or replaced with more operationally representative examples while using the same apparatuses and procedures to further support training, practice, and comparison of specific system capabilities. These test methods should be considered baseline evaluations and performed prior to more relevant Operational Tasks as defined by responders, although Operational Tasks should leverage a specific set of test methods to pre-qualify particular robot capabilities.



Performance Data Collection

Performance data collections are conducted using the described test methods to capture robot and remote operator performance across a statistically significant number of repetitions. Robots are tested to completion of certain tasks with "expert" operators, as designated by the developer, to capture a task-based capability for a given robot in a given apparatus. The number of repetitions for each test method is determined by ASTM with input from standards committee participants and uses statistical principles while considering test administration practicalities for longer tests, such as the Endurance test method. The duration of each test is typically not included as a metric in the standard test method to de-emphasize speed in favor of task completeness, though the test duration is typically captured secondarily for comparison purposes. Test durations are reported as an average time to perform each repetition, or as an average time to perform a particular sub-task within a test method that can produce varying levels of completeness. For example, in the Manipulation test methods the durations are reported as an average time per task value so that novice operators can quantitatively establish their proficiency as a percentage of “expert” performance within the same test method. The test method forms use graphical representations of the data to provide an intuitive understanding of the test results to facilitate comparisons across different robot configurations.

Quad screen video is one product of the performance testing process. Four simultaneous video feeds show the robot and operator actions along with data such as robot position tracking when appropriate. Clockwise from upper left: robot situation within the random maze test method, robot tracking data with location and orientation of the robot, the operator’s view through the interface, and the operator’s hands to monitor operator intent. This type of display is effective for reviewing robot and remote operator performance after testing is complete.



MANIPULATOR DIRECTED PERCEPTION
TEST METHOD SAMPLE DATA FORM

START (HH:MM)		14:10
FINISH (HH:MM)		14:22
ELAPSED (MIN)		12
TASKS (%) (##.#)	75%	6
AVERAGE (MIN PER TASK)		2.0

SHELF LEVEL 0 CM (GROUND)

15° RAMP

HAZMAT LABELS WITH FOUR FEATURES TO IDENTIFY
C=COLOR, I=ICON, #=NUMBER, W=WORD

This test method apparatus has two adjustable shelves with four recessed targets on each. One shelf is to the front and one to the side of the robot. The robot operates in a 1.2m (4 ft) square confined area with a ramp to induce a 15 degree side roll which forces coordinated manipulator motions to perform the tasks. HAZMAT labels are used as targets in this test method variant. When correctly identified, the letter is colored blue. So if the robot can reach farther in the forward direction than in the side direction, the data graphic may look like that above with 75% of the available tasks completed.

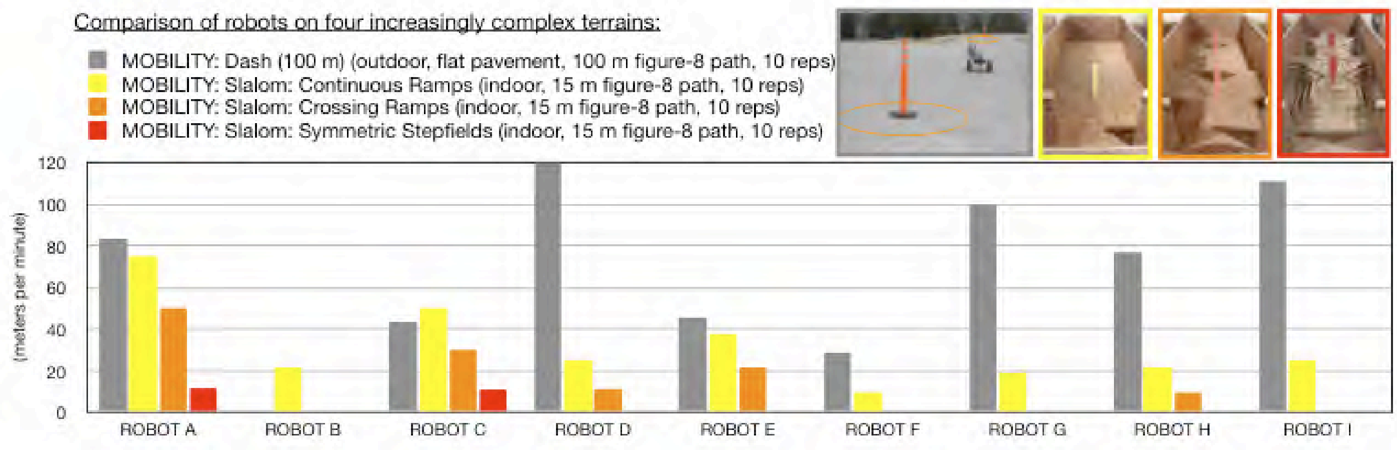
Presentation of Robot Performance Data

Each robot configuration shall be tested in all applicable test methods and may attempt each test as many times as necessary to attain a satisfactory result. Robots may abstain from a particular test method when not applicable or when they may not successfully complete the set of continuous repetitions necessary to get reported in the data. In either instance, the page will be marked as “ABSTAINED” to indicate that the test method was available at test time and the manufacturer acknowledges the omission of performance data. Although some robot implementations are not designed or equipped for particular test methods, (e.g. robots without manipulators in the manipulator test methods) this testing methodology makes no assumptions regarding capabilities. Specifics of particular robot configurations should be considered when the robot has abstained from a given test method. Prototype test methods may be used to capture practice data while the apparatuses are under development. Data for these test methods are clearly marked and not released, but may be used to help refine the apparatus or procedure.

DID NOT COMPLETE TEST
ABSTAINED
OR WILL NOT RELEASE DATA

APPARATUS AND PROCEDURE
PROTOTYPE
UNDER DEVELOPMENT

Test administrators or robot developers may use this document to guide testing events and to capture and store the resulting robot performance data. Although the graphical forms associated with each test method are intended to provide an intuitive understanding of the robot’s capabilities to facilitate side by side comparisons, there are over two dozen individual test methods in the suite and interested users of the data may benefit from comparisons across the entire set of robots. Comparison charts as shown below help identify Best-In-Class robots in specific test methods, and allow initial identification of trade-offs for particular robot configurations. As the set of robots increases, a database will further facilitate searches for key performance capabilities or other robot attributes. In either case, a detailed study of the associated performance data forms is recommended.



Test Site

NIST Research Supporting Mobile Robot Testing and Evaluation
Manufacturing Engineering Laboratory - Intelligent Systems Division

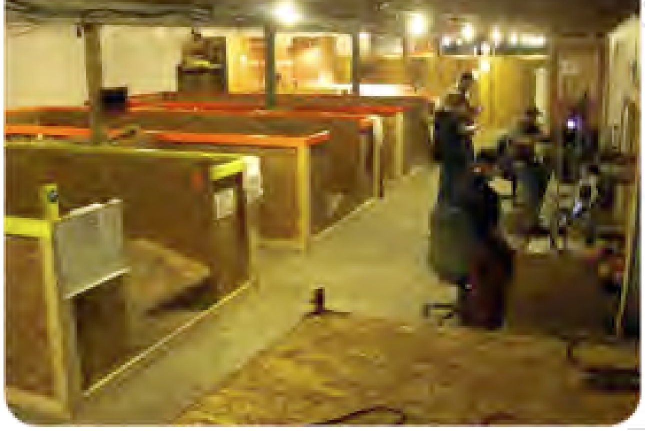
NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

A national resource for industry, universities, and government agencies.

Mission: Facilitate U.S. manufacturing and deployment of advanced robotic systems through performance test methods, measurement capabilities, and standards, with requisite support for emerging sensors, intelligent behaviors, open-architecture controllers, and high-fidelity simulation tools.

NIKE SITE FACILITY, GAITHERSBURG, MD

REPRODUCIBLE TEST METHODS



BARRACKS BUILDING

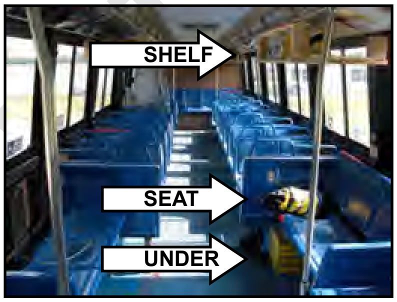
Operational Tasks

These test methods can be considered a baseline performance measure for key capabilities required to perform operational tasks. They can provide a point of comparison for a variety of robot configurations prior to testing in more realistic scenarios. If a robot cannot complete the specific set of standard test methods that represent the requirements of a successful operational task, it is not likely the robot could perform the task in a field test, which is much more expensive to setup and administer. Conversely, if a robot can practice and reliably demonstrate reasonable performance across the set of representative test methods, there is a much greater likelihood that the robot can perform the operational task. Any operational task should be tested to statistical significance, although the repeatability and reproducibility of such setups is necessarily limited, to provide an indication of robotic capabilities that can be expected in an actual deployment. Repeated testing in standard test apparatuses and associated operational tasks can provide essential training and practice opportunities prior to any deployment.

Metrobus Package Removal/Disruption

A bus contains suspicious packages (briefcase with handle, backpack, and box) of varying weights (2kg/5lbs per stripe totaling 5kg/10lbs and 10kg/20lbs), varying locations in the bus (front, middle, and rear) which require different approaches (forward, diagonal, and side), and varying elevations (under seat, on seat, overhead shelf).

Task: The robot must enter the bus from a remote operator location (150m/500ft), remove from the bus the heaviest package possible of each type in each location, deliver to a further remote site (150m/500ft further) for disruption. If a particular type of package cannot be removed from a particular location, the robot should disrupt it in place.



Wide Area and Building Searches with Mapping

An incident involves a building or train with an intact front section and a semi-collapsed rear section which needs to be accessed and searched. The robot should enter the front section via a door or window. Entry into the rear must be after completely searching the intact front section or through direct vertical or horizontal insertion into a breach.

Task: Search and map the area while locating any signs of life (visible shape or motion, audible, thermal) and any suspicious packages, hazardous materials, placards, or labels. All objects of interest should be located on a 2-D map of the area with recognizable navigation features.

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

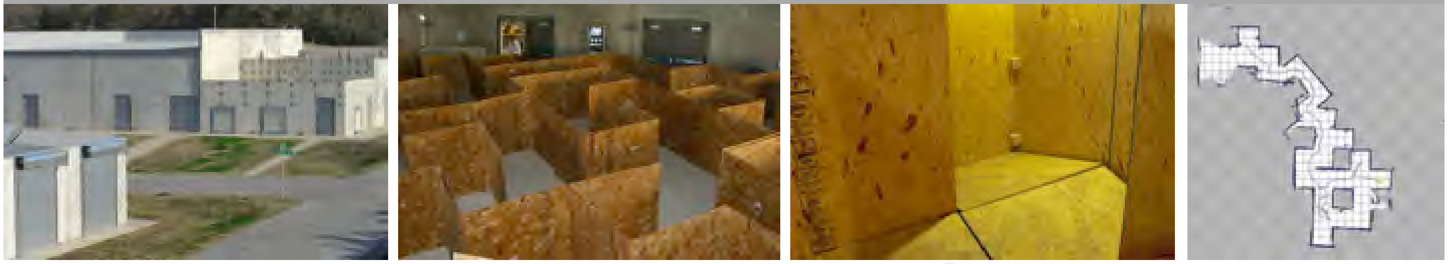
Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

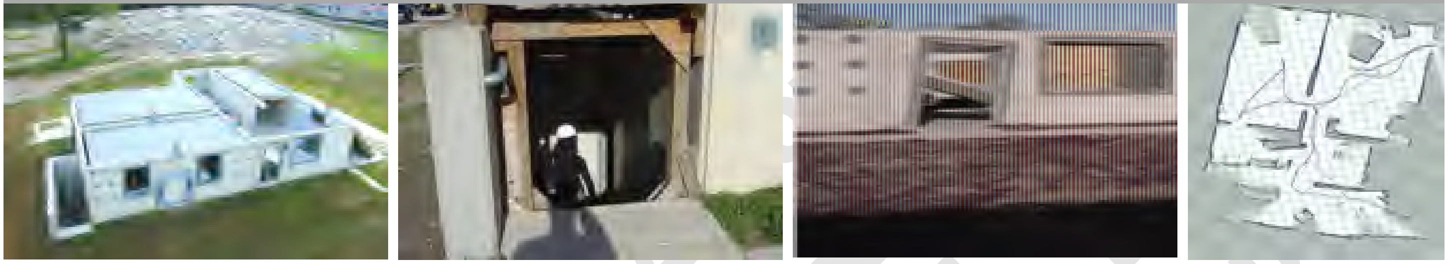
January 2011

Forms: v2011.1 Data: A

SEARCH AND MAP AN INTACT BUILDING WITH RANDOM MAZE TEST METHOD



SEARCH AND MAP A DWELLING WITH BASEMENT



SEARCH AND MAP A SEMI-COLLAPSED STRUCTURE

WIDE AREA SURVEY OF A HAZMAT/PASSENGER TRAIN DERAILMENT WITH OPERATIONAL STAND-OFF

CONFINED SPACE AND RUBBLE PILE SEARCHES

ASTM International Committee on Homeland Security Applications; Operational Equipment; Robots (E54.08.01)

Status Indicators:
Standard (ASTM ####-##), **Balloting (B),** Validating (V), Prototyping (P)

FIGURE A

ADVISORY PANEL OF RESPONDERS

FIGURE B

ADVISORY PANEL OF US&R RESPONDERS

FIGURE C

BOMB TECH TRAINING IN TEST METHOD

FIGURE D

NIST TEAM AT FEMA TRAINING SITE

TERMINOLOGY

Purpose

The purpose of this standard is to identify and standardize the terms necessary to facilitate communication between emergency responders, robot developers, and robot researchers.

Metrics

- Consistency of term definitions among communities.

Apparatus

- None

Procedure

1. Identify terms used in the standard test methods, operational tasks, an emergency response operations.
2. Standardize their definitions through literature search and consensus building, including discussions in the standards committee meetings. Pay particular attention to current emergency response field practices.
3. Publish or reference robot related terms within the ASTM International Committee on Homeland Security Applications; Operational Equipment; Robots (E54.08.01) terminology standard.
4. Forward terms that are applicable wider than robotics to E54.92.
5. Identify and define additional, keywords used in the standard test methods to facilitate standardization process (listed in the next page).

Key Words: Apparatuses

Expert operator: All robot performance data is collected with operators designated by the developer to achieve the best possible performance within a given test method.

Flat terrain element: A flat surface using oriented strand board (OSB) plywood surface with overall dimensions of 1200 cm x 1200 cm (48 in x 48 in) elevated using 10 cm x 10 cm (4 in x 4 in) solid wood posts to form a 10 cm (4 in) thick pallet.

Full ramp terrain element: A ramped OSB surface with overall dimensions of 1200 cm x 1200 cm (48 in x 48 in) typically angled at 15 degree using 10 cm x 10 cm (4 in x 4 in) solid wood posts with angle cuts. These provide some complexity of robot orientation and traction in continuous or crossing configurations.

Half ramp terrain element: A ramped OSB surface with overall dimensions of 600 cm x 1200 cm (24 in x 48 in) typically angled at 15 degree using 10 cm x 10 cm (4 in x 4 in) solid wood posts with angle cuts. These provide some complexity of robot orientation and traction in continuous or crossing configurations.

Operator station: An apparatus set up out of sight and sound of the test apparatuses, but within communications range (except for the radio communications test methods). The robots will be teleoperated via a remote operator control unit (OCU) from this apparatus.

Oriented strand board (OSB) plywood: Readily available building product which provides a frictional surface similar to dust covered concrete. It is commonly available in U.S. in the size of 1200 cm x 2400 cm (48 in x 96 in).

Pick and place object: A 10 cm x 10 cm (4 in x 4 in) blocks or cylinders made from 0.5 kg (1 lb) wood, 3.5 kg (7 lbs) aluminum, or 7 kg (14 lbs) steel embedded into mobile manipulation apparatuses to provide pick and place tasks. The key considerations are:

- **Size:** Fill the gripper to possibly obstruct camera and lighting views
- **Shape:** Require precision placement of gripper for grasping
- **Weight:** Require sufficient gripper force to hold and possibly challenge arm strength and center of gravity at maximum reach

Stepfield terrain element: A discontinuous terrain type using 10 x 10 cm (4 x 4 in) solid wood posts cut to cubic unit lengths of 10 cm, 20 cm, 30 cm, 40 cm, and 50 cm (4 in, 8 in, 12 in, 16 in, 20 in) and arranged in prescribed topologies. These provide continuous terrain complexity for highly mobile robots.

Sensory Identification Target: A feature embedded within the test apparatus used for identification and measurement of capabilities. They may or may not be operationally relevant but could be replaced to support specific operational tasks. Examples of targets may include the following:

- Visual
    - Hazardous Materials (HAZMAT) Label: A standard label with four identifiable features: color, icon, number, and word identifying a particular type of hazardous material.

    - Tumbling E Eye Chart: A standard language-neutral eye chart. Often called a Snellen chart.

    - Shape Totem: A vertical strand of rotationally consistent spheres and cylinders which form vertical patterns in random order ("dot-dash-dot"). Four different size shapes are used: 10 cm, 5 cm, 1 cm , 1 mm (4 in, 2 in, 0.4in, 0.04) to test resolution of sensors. To test color recognition for visual sensors, colored shapes are used: red, blue, green and white. To test grey scale recognition for visual sensors, three varying shades of grey shapes are used.

- Audio
    - Standard rhyming words
    - Full spectrum tones

- Chemical trace (elements are used)
- Biological (simulants may be used)
- Radiological (trace elements are used)
- Explosive (trace elements are used)

Key Words: Procedures

Correct Identification of Target (HAZMAT Label): when three out of the four features: color, word(s), number, and icon are correctly identified by the operator.

Fault Condition: A condition where the current trial of a test method is ended as noted on each test method description. This results in a Maintenance/Repair/Other Event Report form to be filled out and a new trial to start at the operator's discretion.

Remote teleoperation: Operation of the robot through the system's communications and interface components from a location out of sight and sound of the test apparatus. All the test methods are conducted using remote teleoperation.

Repetition: Completion of the test method task from the prescribed start position and return to the original start position. Multiple repetitions establish robot performance to a predefined degree of statistical significance.

General

Test Suite: A collection of test methods that are used, collectively, to evaluate the performance of robot's particular subsystem, namely, mobility, manipulation, sensors, energy, communications, HRI, logistics, safety, and aerial and aquatic maneuvering

Lux: A derived SI unit of measure based on the lumen, which in turn is based on the candela, which describes the illuminance of a scene rather than a light source. Examples include:

Illuminance	Example
0.01 lux	Quarter moon
0.27 lux	Full moon on a clear night
1.0 lux	Full moon overhead at tropical latitudes
3.4 lux	Dark limit of civil twilight for clear skies
50 lux	Family living room
80 lux	Hallway/toilet
100 lux	Dark overcast day
320–500 lux	Office lighting
400 lux	Sunrise or sunset on a clear day
1,000 lux	Overcast day/ TV studio lighting
10,000–25,000 lux	Full daylight (not direct sun)
32,000–130,000 lux	Direct sunlight

Key Words: Performance Data Collection

Position and orientation tracking: A product of the performance testing process which captures 2D position and orientation of the robot operating within a test method. This is only applicable for certain test methods and is not used in the standard metric.

Quad screen video: A product of the performance testing process which captures simultaneous video streams to help remote operators and others understand the successes and failures of different systems, capabilities, and approaches.

This page intentionally left blank.

FIGURE A

FIGURE B

FIGURE C

FIGURE D

LOGISTICS: ROBOT TEST CONFIG AND CACHE PACKAGING

Purpose

The purpose of this practice is to establish the test configuration of a robot subjected to the suite of standard test methods, and to describe the cache packaging and setup attributes of deployable robotic systems to be compatible with transportation and storage systems used by emergency response organizations.

Metrics

- Number and weight of qualified packing containers
- Setup time from packing containers to deployment
- Downrange/testing configuration of robotic system
- Weights and measurements of the robot, operator control unit (OCU), payload, and batteries
- Tools needed for repair and maintenance

Apparatus

- Scales to measure robotic system weights
- Tape measures to measure robotic system dimensions
- Photo backdrop with 20 cm (8 in) grid lines

Procedure

1. Note the number and type of packing containers necessary for the robot to perform the entire suite of test methods. For FEMA US&R Task Force Teams, the packages should include equipment to deploy for 10 days, without re-supply for the first 72 hours.
2. Determine a configuration to perform the tests.
3. Time the setup process from unloading to ready to perform the tests/go down range (prior to the below measuring steps).
4. Weigh the robot and OCU.
5. Measure the robot and OCU.
6. Capture pictures of the robot, including fully retracted and fully extended postures, OCU, and tool set in a metered backdrop for scale.
7. Capture videos of key tasks such as battery changes, track changes, and manipulator removal if applicable.
8. Note the tools needed to perform setup and repair.

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

STATUS: January 20 ASTM E2592-07

Forms: v2011.1 Data: A

LOGISTICS: ROBOT TEST CONFIGURATION AND CACHE PACKAGING

DATE 2010.

FACILITY

LOCATION

EVENT

ROBOT MAKE

ROBOT MODEL

CONFIGURATION

OPERATOR/ORG

RIGHT SIDE VIEW
TYPICAL DRIVING
CONFIGURATION
LANDSCAPE

45 DEGREE VIEW
TYPICAL DRIVING
CONFIGURATION
LANDSCAPE

FRONT VIEW
TYPICAL DRIVING
CONFIGURATION
LANDSCAPE

45 DEGREE VIEW
STOWED
LANDSCAPE

45 DEGREE VIEW
MAX FOOTPRINT
OR
MAX DEGREES OF FREEDOM
LANDSCAPE

45 DEGREE VIEW
MAX HORIZONTAL REACH
(DIAGONAL IF POSSIBLE,
FORWARD IF NOT)
LANDSCAPE

45 DEGREE VIEW
(MAX VERTICAL
REACH)
PORTRAIT

TOP VIEW
OCU PANEL
LANDSCAPE

OCU IN OPERATION
(STANDING/SITTING WITH HANDS ON)
LANDSCAPE

ACCESSORIES
LANDSCAPE

SHIPPING
CONTAINERS
LANDSCAPE

NOTES:

VIDEO FILE NAMING CONVENTION

TEST ADMINISTRATOR NAME/ORGANIZATION:

ROBOTNAME-LOG-CONFIG-IMAGE-TOPSIDEVIEW OR VIDEO-BATTERYCHANGE, TRACKCHANGE XXX

LOGISTICS: ROBOT TEST CONFIGURATION AND CACHE PACKAGING

DATE 2010.________________ **ROBOT MAKE** ________________
FACILITY ________________ **ROBOT MODEL** ________________
LOCATION ________________ **CONFIGURATION** ________________
EVENT ________________ **OPERATOR/ORG** ________________

CONFIGURATION or MAJOR PAYLOAD DESCRITPTION: ____

MOBILITY: ○ WHEELS ○ LEGS ○ TRACKS ○ FLIPPERS (F) ○ FLIPPERS (R) ○ ACKERMAN
BATTERIES: ○ LEAD-ACID ○ NI-CAD ○ LITHIUM ○ FUEL CELL MODEL#:__________
INSTALLED: ______# ______VOLTS ______KG______LBS
MANIP#1: ○ __# DOFS ○ GRIPPER: ○ WEAPON: ○ OTHER MODEL#:__________
COMMS: ○ TETHER ○ RADIO MODEL#:__________

CACHE PACKAGING: CONTAINER TYPES: (**PE**LICAN, **HA**RDIGG, **RO**PACK, **PA**LLET, **SP**ECIFIC TO ROBOT)

CONTAINER 1: TYPE_____; SIZE: _____x_____x_____CM/IN; VOLUME: ______CM³/IN³; WEIGHT: ______KG/LBS
CONTAINER 2: TYPE_____; SIZE: _____x_____x_____CM/IN; VOLUME: ______CM³/IN³; WEIGHT: ______KG/LBS
CONTAINER 3: TYPE_____; SIZE: _____x_____x_____CM/IN; VOLUME: ______CM³/IN³; WEIGHT: ______KG/LBS
CONTAINER 4: TYPE_____; SIZE: _____x_____x_____CM/IN; VOLUME: ______CM³/IN³; WEIGHT: ______KG/LBS
TOTAL: VOLUME: ______CM³/IN³; WEIGHT: ______KG/LBS

SETUP TIME: (10 MIN INCREMENTS): ○ ○ ○ ○ ○ ○ TOTAL: ______ MINUTES

CONFIGURATION WEIGHT AS TESTED:
WEIGHT: _____ KG (_____LB) (INCLUDING MANIPULATOR IF PART OF CONFIGURATION)

MOBILITY BASE DIMENSIONS:
BASE LENGTH (MIN): _____ CM (_____IN) BASE LENGTH (MAX): _____CM (_____IN)
BASE WIDTH (MIN): _____ CM (_____IN) BASE WIDTH (MAX): _____CM (_____IN)
BASE HEIGHT (MIN): _____ CM (_____IN) BASE HEIGHT (MAX): _____CM (_____IN)

MANIPULATOR DIMENSIONS TO CENTER OF GRASPED BLOCK (# ___ DOFS):
FORWARD (MAX): ○ NOT APPLICABLE _____ CM (_____IN)
DIAGONAL (MAX): ○ NOT APPLICABLE _____ CM (_____IN)
SIDE (MAX) ○ NOT APPLICABLE _____ CM (_____IN)
VERTICAL (MAX) ○ NOT APPLICABLE _____ CM (_____IN)

OCU DIMENSIONS:
LENGTH: _____ CM (_____ IN)
WIDTH: _____ CM (_____ IN)
HEIGHT: _____ CM (_____ IN)
WEIGHT: _____ KG (_____ LB)

OTHER SIGNIFICANT PAYLOADS/WEIGHTS: ____________ ____________ ____________ ____________

VIDEO FILE NAMING CONVENTION
ROBOTNAME-LOG-CONFIG

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

LOGISTICS: ROBOT TEST CONFIGURATION AND CACHE PACKAGING

TOOLS AND TIME NEEDED TO PERFORM TASKS:

	VIDEO	NONE	or LIST TOOLS	MINUTES
INITIAL SETUP:	○	○	____________________	______
BATTERY CHANGE:	○	○	____________________	______
TRACK CHANGE:	○	○	____________________	______
MANIP. CHANGE:	○	○	____________________	______

LIGHT KIT (DESCRIBE): ____

____

CAMERAS:

							VIS. ILLUMINATION			I/R ILLUMINATION			FOCUS		WATER
IDENTIFIER	PAN	TILT	ZOOM (OPT/DIG)	COLOR	I/R	B/W	NO	YES	VAR	NO	YES	VAR	FIXED	AUTO	-TIGHT
__________	___°	___°	___X (___X/ ___X)	○	○	○	○	○	○	○	○	○	○	○	○
__________	___°	___°	___X (___X/ ___X)	○	○	○	○	○	○	○	○	○	○	○	○
__________	___°	___°	___X (___X/ ___X)	○	○	○	○	○	○	○	○	○	○	○	○
__________	___°	___°	___X (___X/ ___X)	○	○	○	○	○	○	○	○	○	○	○	○
__________	___°	___°	___X (___X/ ___X)	○	○	○	○	○	○	○	○	○	○	○	○
__________	___°	___°	___X (___X/ ___X)	○	○	○	○	○	○	○	○	○	○	○	○

RADIO COMMUNICATIONS:

					DIGITAL	ANALOG	OMNI
CONTROL:	_____ MHZ	_____ WATTS	ANT: _____	dB	○	○	○
VIDEO:	_____ MHZ	_____ WATTS	ANT: _____	dB	○	○	○
AUDIO TX:	_____ MHZ	_____ WATTS	ANT: _____	dB	○	○	○
AUDIO RX:	_____ MHZ	_____ WATTS	ANT: _____	dB	○	○	○

TETHERS:

POWER:	○ NONE	○ VOLTS ______	○ AMPS______	
SIGNAL:	○ NONE	○ CONTROL	○ VIDEO	○ AUDIO
		○ COPPER	○ COPPER	○ COPPER
		○ FIBER	○ FIBER	○ FIBER

SPOOL:

			ILLUMINATED	GLOW-IN-DARK
LENGTH:	____ M	____ FT		
DIAMETER:	____ CM	____ IN	○ NO	○ NO
WEIGHT:	____ KG	____ LBS	○ YES	○ YES

SENSORS:

- ○ AUDIO: OPERATOR >> ROBOT
- ○ AUDIO: OPERATOR << ROBOT
- ○ INCLINE: PITCH
- ○ INCLINE: ROLL
- ○ COMPASS
- ○ GPS
- ○ RANGE
- ○ THERMAL

CBRNE:

- ○ CHEMICAL
- ○ BIOLOGICAL
- ○ RADIOLOGICAL
- ○ NUCLEAR
- ○ EXPLOSIVE

NOTES:

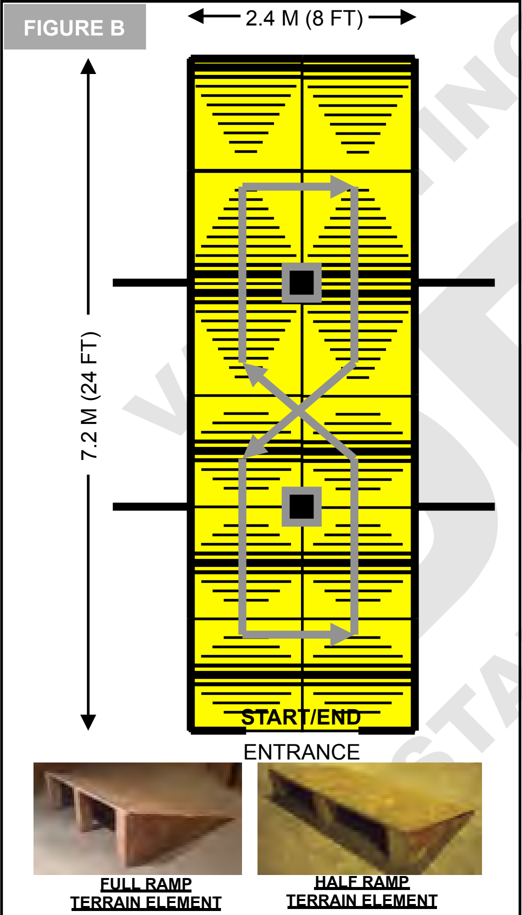
VIDEO FILE NAMING CONVENTION
ROBOTNAME-LOG-CONFIG

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

ENERGY/POWER: ENDURANCE: TERRAINS: PITCH/ROLL RAMPS

FIGURE A

FIGURE B



Purpose

The purpose of this test method is to quantitatively evaluate the battery capacity per charge cycle for a robot while being remotely teleoperated in confined areas with lighted and dark conditions in extreme temperatures.

Metrics

- Distance (m) per charge tested to inoperability (before and after benchtop cycling)
- Time (min) per charge tested to inoperability (before and after benchtop cycling)
- Change in capacity (%) after 100 benchtop battery cycles

Apparatus

- The flooring terrain is continuous **full and half ramp flooring elements** setup according to the design shown (FIGURE A, B).
- The apparatus includes lighting control for testing in lighted and dark conditions.
- **Targets** will be installed to provide for a periodic timed dwell task.
- A beam break sensor can be used to count laps.
- This test apparatus is intended to fit into a 12 m x 2.4 m (40 ft x 8 ft) standard ISO shipping container to allow testing in hot and cold temperature extremes (FIGURE A). It can also be setup as a freestanding apparatus with 1.2 m (4 ft) tall walls with supports.

Procedure

1. Place the robot at starting point with newly conditioned batteries.
2. Start the timer when the robot begins and capture total elapsed time for a complete set of **repetitions.**
3. Traverse the prescribed figure-8 path around the pylons until the batteries are depleted (Figure B).
4. Every 10 laps (150 m (500 ft)) the operator shall dwell at starting point of the test apparatus for 1 minute while identifying **targets** at known locations. Each set of 10 laps will be conducted alternately in lighted conditions (>100 lux) and near darkness (<1 lux).
5. Power/energy data logged over the first 20 laps (300 m (1000 ft)) will be used to perform 100 benchtop depletion cycles unless the battery fails prior to that point.
6. Benchtop cycled batteries will be re-installed into the robot to perform one final battery depletion test.
7. Maintenance and repairs of the robot are allowed, but must be done in-situ within the test apparatus. Elapsed time for the repair will be noted in an event description form and subtracted from the overall test duration. The tools used will also be noted.

Fault Conditions: (Fill out an Event Report)

- Removal of the robot from the apparatus for repair of any type.

ENERGY/POWER: ENDURANCE: TERRAINS: PITCH/ROLL RAMPS

TRIAL ☐

DATE 2010.____________ ROBOT MAKE ____________

FACILITY ____________ ROBOT MODEL ____________

LOCATION ____________ CONFIGURATION ____________

EVENT ____________ OPERATOR/ORG ____________

BATTERY: ○ NEW ○ USED

TEMPERATURE: ○ -20°C ○ 20°C ○ 50°C

START TIME (HH:MM)		END TIME (HH:MM)		ELAPSED (MIN)		DWELLS (MIN)		TOTAL TIME (MIN)		LAPS		METERS PER LAP		DISTANCE (METERS)
☐	–	☐	=	☐	–	☐	=	☐	|	☐	X	< 15 >	=	☐

	TEN LAPS THEN 1 MIN. DWELL		TIME	V^{BOT}	V^{OCU}		LAPS THEN 1 MIN. DWELL		TIME	V^{BOT}	V^{OCU}
0 LIGHT	○○○○○○○○○○	☐	____	____	____	200	○○○○○○○○○○	☐	____	____	____
DARK	○○○○○○○○○○	☐	____	____	____		○○○○○○○○○○	☐	____	____	____
20	○○○○○○○○○○	☐	____	____	____		○○○○○○○○○○	☐	____	____	____
	○○○○○○○○○○	☐	____	____	____		○○○○○○○○○○	☐	____	____	____
	○○○○○○○○○○	☐	____	____	____		○○○○○○○○○○	☐	____	____	____
50	○○○○○○○○○○	☐	____	____	____	250	○○○○○○○○○○	☐	____	____	____
	○○○○○○○○○○	☐	____	____	____		○○○○○○○○○○	☐	____	____	____
	○○○○○○○○○○	☐	____	____	____		○○○○○○○○○○	☐	____	____	____
	○○○○○○○○○○	☐	____	____	____		○○○○○○○○○○	☐	____	____	____
	○○○○○○○○○○	☐	____	____	____		○○○○○○○○○○	☐	____	____	____
100	○○○○○○○○○○	☐	____	____	____	300	○○○○○○○○○○	☐	____	____	____
	○○○○○○○○○○	☐	____	____	____		○○○○○○○○○○	☐	____	____	____
	○○○○○○○○○○	☐	____	____	____		○○○○○○○○○○	☐	____	____	____
	○○○○○○○○○○	☐	____	____	____		○○○○○○○○○○	☐	____	____	____
	○○○○○○○○○○	☐	____	____	____		○○○○○○○○○○	☐	____	____	____
150	○○○○○○○○○○	☐	____	____	____	350	○○○○○○○○○○	☐	____	____	____
	○○○○○○○○○○	☐	____	____	____		○○○○○○○○○○	☐	____	____	____
	○○○○○○○○○○	☐	____	____	____		○○○○○○○○○○	☐	____	____	____
	○○○○○○○○○○	☐	____	____	____		○○○○○○○○○○	☐	____	____	____
200	○○○○○○○○○○	☐	____	____	____	400	○○○○○○○○○○	☐	____	____	____

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-ENE-ENDURANCE

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

MOBILITY: TERRAINS: FLAT/PAVED SURFACES (100 m)

FIGURE A

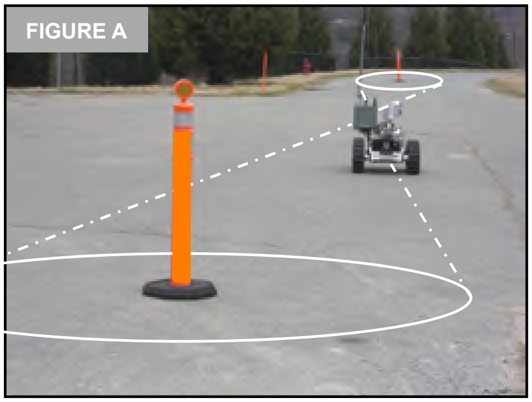
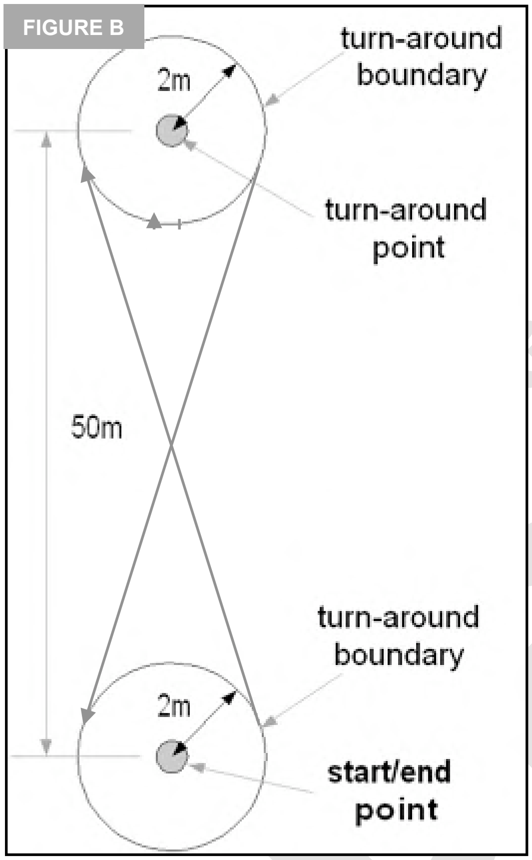


FIGURE B



Purpose

The purpose of this test method is to quantitatively evaluate the sustained speed capabilities of a robot on flat/paved surface terrain while being remotely teleoperated in confined areas.

Metrics

- Completion of 10 figure-8 **repetitions**
- Average time per **repetition**

Apparatus

- This test apparatus is a flat/paved path of 50 m (165 ft) between two pylons.
- Each pylon has a clearly marked turning boundary with a radius of 2 m (6.5 ft) marked by a chalk or paint line.

Procedure

1. Place the robot at the starting position near one pylon turning boundary, straddling the line.
2. Start the timer when the robot begins and capture total elapsed time for a complete set of **repetitions**.
3. Traverse the figure-8 path around the pylons continuously without intervention until all **repetitions** are complete. Maintain at least part of the robot clearly over the marked paths and turning boundaries.
4. Failure to stay over the marked path negates the current lap. Teleoperate the robot to the starting position and continue with the timer running.

Fault Conditions: (Fill out an Event Report)

- Failure to complete 10 continuous **repetitions**

MOBILITY: TERRAINS: FLAT/PAVED SURFACES (100 M)

TRIAL ☐

DATE 2010.__________

FACILITY __________

LOCATION __________

EVENT __________

ROBOT MAKE __________

ROBOT MODEL __________

CONFIGURATION __________

OPERATOR/ORG __________

LIGHTING:
○ >100 LUX ○ <1 LUX

COMMUNICATIONS:
○ TETHER ○ RADIO

TASK DESCRIPTION	START TIME (MIN)	REPETITIONS	END TIME (MIN)		ELAPSED TIME (MIN)		METERS PER MINUTE
					1000 M		
FIGURE-8 LAP (100M/330FT)	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-MOB-TERRAIN-FLATPAVED-100M

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

FIGURE A

MOBILITY: TERRAINS: CONTINUOUS PITCH/ROLL RAMPS (15°)

Purpose

The purpose of this test method is to quantitatively evaluate the mobility capabilities in continuous pitch/roll ramp terrain while being remotely teleoperated in confined areas with lighted and dark conditions.

Metrics

- Completion of 10 figure-8 **repetitions**
- Average time per **repetition**

Apparatus

- The flooring terrain consists of continuous 15 degree **full ramp and half ramp terrain elements** setup as shown (FIGURE A, B).
- Two pylons define the prescribed figure-8 path.
- This test apparatus is intended to fit into a 12 m x 2.4 m (40 ft x 8 ft) standard ISO shipping container (FIGURE A). It can also be setup as a freestanding apparatus with 1.2 m (4 ft) tall walls with supports.

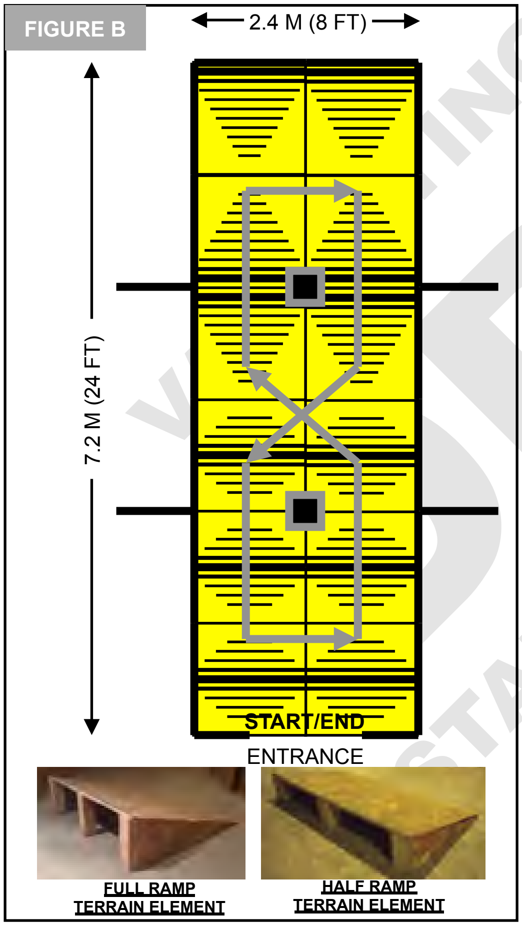
Procedure

1. Place the robot at the starting position near the apparatus entrance.
2. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
3. Start the timer when the robot begins and capture total elapsed time for a complete set of **repetitions**.
4. Traverse the figure-8 path around the pylons continuously without intervention until all **repetitions** are complete.

Fault Conditions: (Fill out an Event Report)

- Failure to complete 10 continuous **repetitions**

FIGURE B



FULL RAMP TERRAIN ELEMENT

HALF RAMP TERRAIN ELEMENT

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011
STATUS: VALIDATING-WK27759

Forms: v2011.1 Data: A

MOBILITY: TERRAINS: CONTINUOUS PITCH/ROLL RAMPS (15°)

TRIAL ☐

DATE 2010.________________

FACILITY ________________

LOCATION ________________

EVENT ________________

ROBOT MAKE ________________

ROBOT MODEL ________________

CONFIGURATION ________________

OPERATOR/ORG ________________

LIGHTING:
○ >100 LUX ○ <1 LUX

COMMUNICATIONS:
○ TETHER ○ RADIO

TASK DESCRIPTION	START TIME (MIN)	REPETITIONS	END TIME (MIN)		ELAPSED TIME (MIN) 150 M		METERS PER MINUTE
FIGURE-8 LAP (15M/50FT)	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐

NOTES:

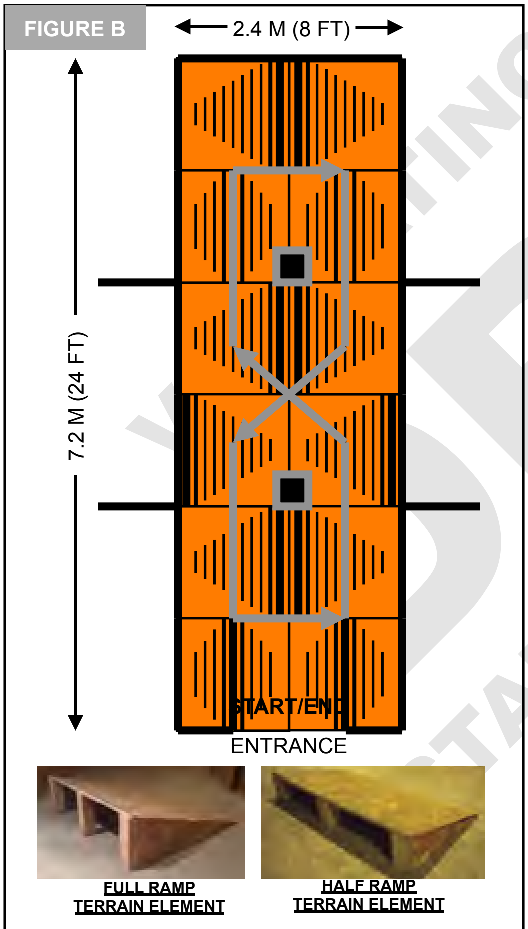
VIDEO FILE NAMING CONVENTION
ROBOTNAME-MOB-TERRAIN-CONTRAMPS

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

MOBILITY: TERRAINS: CROSSING PITCH/ROLL RAMPS (15°)

FIGURE A

FIGURE B



Purpose

The purpose of this test method is to quantitatively evaluate the mobility capabilities in crossing (discontinuous) pitch/roll ramp terrain while being remotely teleoperated in confined areas with lighted and dark conditions.

Metrics

- Completion of 10 figure-8 **repetitions**
- Average time per **repetition**

Apparatus

- The flooring terrain consists of crossing 15 degree **full ramp and half ramp terrain elements** setup as shown (FIGURE A, B).
- Two pylons define the prescribed figure-8 path. They should be made of 10 cm (4 in) PVC pipe with inside end caps fastened to the terrain and the arch above with a single screw to allow rotation to minimize robot tether friction.
- This test apparatus is intended to fit into a 12 m x 2.4 m (40 ft x 8 ft) standard ISO shipping container (FIGURE A). It can also be setup as a freestanding apparatus with 1.2 m (4 ft) tall walls with supports.

Procedure

1. Place the robot at the starting position near the apparatus entrance.
2. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
3. Start the timer when the robot begins and capture total elapsed time for a complete set of **repetitions**.
4. Traverse the figure-8 path around the pylons continuously without intervention until all **repetitions** are complete.

Fault Conditions: (Fill out an Event Report)

- Failure to complete 10 continuous **repetitions**

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

MOBILITY: TERRAINS: CROSSING PITCH/ROLL RAMPS (15°)

TRIAL ☐

DATE 2010.__________

FACILITY __________

LOCATION __________

EVENT __________

ROBOT MAKE __________

ROBOT MODEL __________

CONFIGURATION __________

OPERATOR/ORG __________

LIGHTING:
○ >100 LUX ○ <1 LUX

COMMUNICATIONS:
○ TETHER ○ RADIO

TASK DESCRIPTION	START TIME (MIN)	REPETITIONS	END TIME (MIN)		ELAPSED TIME (MIN)		METERS PER MINUTE
					150 M		
FIGURE-8 LAP (15M/50FT)	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐

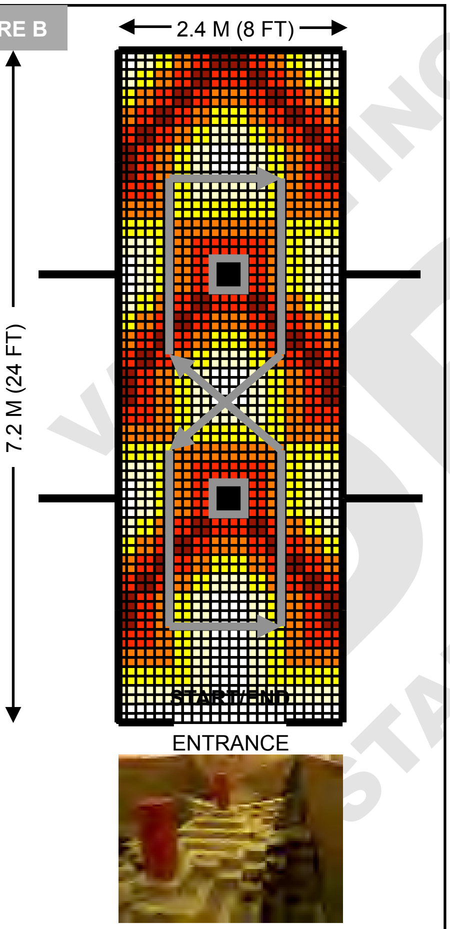
NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-MOB-TERRAIN-CROSSRAMPS

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

FIGURE A

FIGURE B



MOBILITY: TERRAINS: SYMMETRIC STEPFIELDS

Purpose

The purpose of this test method is to quantitatively evaluate the mobility capabilities of a robot in symmetric stepfield terrain while being remotely teleoperated in confined areas with lighted and dark conditions.

Metrics

- Completion of 10 figure-8 **repetitions**
- Average time per **repetition**

Apparatus

- The flooring terrain consists of symmetric **stepfield terrain element** fabricated using 10 cm (4 in) square wood posts cut to prescribed lengths (10 cm, 20 cm, 30 cm, 40 cm, and 50 cm (4 in, 8 in, 12 in, 16 in, and 20 in)) and setup in groups of four posts per step height as shown (FIGURE A, B).
- Two pylons define the prescribed figure-8 path.
- This test apparatus is intended to fit into a 12 m x 2.4 m (40 ft x 8 ft) standard ISO shipping container (FIGURE A). It can also be setup as a freestanding apparatus with 1.2 m (4 ft) tall walls with supports.

Procedure

1. Place the robot at the starting position near the apparatus entrance.
2. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
3. Start the timer when the robot begins and capture total elapsed time for a complete set of **repetitions**.
4. Traverse the figure-8 path around the pylons continuously without intervention until all **repetitions** are complete.

Fault Conditions: (Fill out an Event Report)

- Failure to complete 10 continuous **repetitions**

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011
STATUS: VALIDATING-WK27761

Forms: v2011.1 Data: A

MOBILITY: TERRAINS: SYMMETRIC STEPFIELDS

TRIAL ☐

DATE 2010.__________

FACILITY __________

LOCATION __________

EVENT __________

ROBOT MAKE __________

ROBOT MODEL __________

CONFIGURATION __________

OPERATOR/ORG __________

LIGHTING:
○ >100 LUX ○ <1 LUX

COMMUNICATIONS:
○ TETHER ○ RADIO

TASK DESCRIPTION	START TIME (MIN)	REPETITIONS	END TIME (MIN)		ELAPSED TIME (MIN) 150 M		METERS PER MINUTE
FIGURE-8 LAP (15M/50FT)	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-MOB-TERRAIN-STEPFIELDS

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

FIGURE A

FIGURE B

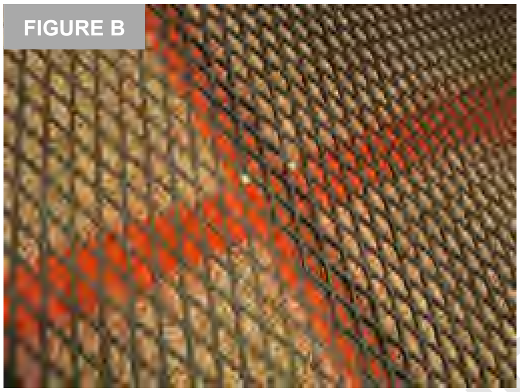
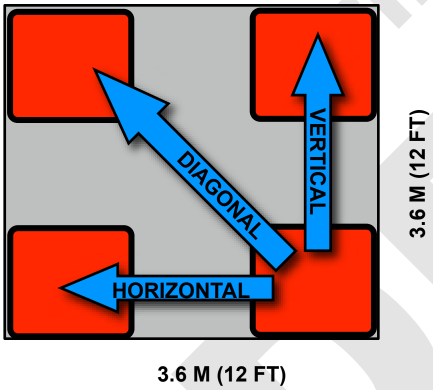


FIGURE C



MOBILITY: OBSTACLES
INCLINED PLANES (0° - 90°)

Purpose

The purpose of this test method is to quantitatively evaluate the incline plane maneuvering capabilities of a robot, including rollover stability and de-tracking prevention on high friction surfaces, while being remotely teleoperated in lighted and dark conditions.

Metrics

- Maximum incline (degrees) while completing 10 **repetitions** each for vertical, diagonal, and horizontal paths
- Average time per **repetition**

Apparatus

- This test apparatus is fabricated to be 3.6 m (12 ft) square using OSB panels covered with a grated friction surface (0.98 coefficient of friction) to provide consistent traction (FIGURE A, B, C).
- The surface has four quadrants in the corners (FIGURE C).
- Side walls are fabricated from 0.6 m (2 ft) tall OSB panels attached to the side of the inclined surface for safety.
- The surface inclines from 0 degrees to 90 degrees in increments of 5 degrees.
- A safety rope belay is routed through an eye bolt in the rear of the apparatus.

Procedure

1. Set the apparatus to the intended testing incline.
2. Place the robot at the starting position in a lower quadrant of the test surface facing up the incline. Robots may perform the task in any orientation. Attach safety rope belay.
3. Start the timer when the robot begins and capture total elapsed time for a complete set of **repetitions**.
4. Traverse a vertical path until the robot is fully contained within the upper quadrant then return to the start position. Repeat continuously without intervention until all **repetitions** are complete.
5. Repeat for diagonal paths and then horizontal paths.
6. Increase the incline until unsuccessful in one of the **repetitions**.
7. Note the maximum incline completed for all **repetitions**.

Fault Conditions: (Fill out an Event Report)

- Intervention via rope belay is required
- Continuous contact with side walls
- Failure to complete 10 continuous **repetitions**

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

Forms: v2011.1 Data: A

MOBILITY: OBSTACLES: INCLINED PLANES (0° - 90°)

TRIAL ☐

DATE 2010.______ **ROBOT MAKE** ______

FACILITY ______ **ROBOT MODEL** ______

LOCATION ______ **CONFIGURATION** ______

EVENT ______ **OPERATOR/ORG** ______

LIGHTING: ○ **>100 LUX** ○ **<1 LUX**

COMMUNICATIONS: ○ **TETHER** ○ **RADIO**

☐ **DEGREE INCLINE**

VIDEO #___	↔	☐	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○	☐	=	☐	=	☐	MIN
VIDEO #___	↘	☐	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○	☐	=	☐	=	☐	MIN
VIDEO #___	↕	☐	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○	☐	=	☐	=	☐	MIN

☐ **DEGREE INCLINE**

VIDEO #___	↔	☐	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○	☐	=	☐	=	☐	MIN
VIDEO #___	↘	☐	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○	☐	=	☐	=	☐	MIN
VIDEO #___	↕	☐	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○	☐	=	☐	=	☐	MIN

☐ **DEGREE INCLINE**

VIDEO #___	↔	☐	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○	☐	=	☐	=	☐	MIN
VIDEO #___	↘	☐	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○	☐	=	☐	=	☐	MIN
VIDEO #___	↕	☐	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○	☐	=	☐	=	☐	MIN

☐ **DEGREE INCLINE**

VIDEO #___	↔	☐	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○	☐	=	☐	=	☐	MIN
VIDEO #___	↘	☐	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○	☐	=	☐	=	☐	MIN
VIDEO #___	↕	☐	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○	☐	=	☐	=	☐	MIN

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-MOB-OBS-INCLINE-##DEG

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

FIGURE A

FIGURE B

MOBILITY: OBSTACLES: GAPS (10 cm to 100 cm)

Purpose

The purpose of this test method is to quantitatively evaluate the horizontal gap traversing capabilities of a robot, including variable chassis configurations and coordinated behaviors, while being remotely teleoperated in confined areas with lighted and dark conditions.

Metrics

- Maximum gap (cm) traversed for 10 **repetitions**
- Average time per **repetition**

Apparatus

- This test apparatus is fabricated from two 1.2 m x 1.2 m (4 ft x 4 ft) OSB **flat floor pallet elements** placed side by side, separated by a controlled gap, with a surrounding containment wall (FIGURE A).
- 10 cm (4 in) diameter pipes are level with the surface of the far edge of the gap and are free to roll to provide an uncertain reach edge on the initial traverse and launch edge on the return.
- The gap can be incremented from 10 cm to 100 cm (4 in to 40 in) in 10 cm (4 in) increments.
- A safety rope belay is routed through an eye bolt in the rear of the apparatus.

Procedure

1. Set the apparatus to the intended testing gap.
2. Place the robot at the starting position on one pallet facing the obstacle. Robots may perform the task in any orientation. Attach safety rope belay.
3. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
4. Start the timer when the robot begins and capture total elapsed time for a complete set of **repetitions**.
5. Traverse the gap fully without touching the bottom surface of the gap until the entire robot is on the opposite platform, then similarly return to the start position. Repeat continuously without intervention until all **repetitions** are complete.
6. Increase the gap until unsuccessful in one of the **repetitions**.
7. Note the maximum gap completed for all **repetitions**.

Fault Conditions: (Fill out an Event Report)

- Intervention via safety rope belay is required
- Touching bottom surface of the gap at any time
- Failure to complete 10 continuous **repetitions**

MOBILITY: OBSTACLES: GAPS (10 cm to 100 cm)

TRIAL ☐

DATE 2010.____________ **ROBOT MAKE** ____________

FACILITY ____________ **ROBOT MODEL** ____________

LOCATION ____________ **CONFIGURATION** ____________

EVENT ____________ **OPERATOR/ORG** ____________

LIGHTING: ○ >100 LUX ○ <1 LUX

COMMUNICATIONS: ○ TETHER ○ RADIO

CONFINED AREA DIVIDER	START TIME (MIN)	REPETITIONS	END TIME (MIN)		ELAPSED TIME (MIN)		AVG TIME (MIN)	
100 CM ○	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN
90 CM ○	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN
80 CM ○	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN
70 CM ○	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN
60 CM ○	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN
50 CM ○	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN
40 CM ○	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN
30 CM ○	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN
20 CM ○	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN
10 CM ○	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-MOB-OBS-GAP-##CM

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

MOBILITY: OBSTACLES: PIPE STEPS (10 cm to 100 cm)

FIGURE A

FIGURE B

Purpose

The purpose of this test method is to quantitatively evaluate the vertical step surmounting capabilities of a robot, including variable chassis configurations and coordinated behaviors, while being remotely teleoperated in confined areas with lighted and dark conditions.

Metrics

- Maximum elevation (cm) surmounted for 10 **repetitions**
- Average time per **repetition**

Apparatus

- This test apparatus is fabricated from two stacks of 1.2 m x 1.2 m (4 ft x 4 ft) OSB **flat floor pallet elements** placed side by side to form a step with a surrounding containment wall (FIGURE A, B).
- The elevated stack can be increased from 10 cm to 100 cm (4 in to 40 in) in 10 cm (4 in) increments.
- Plastic pipes with a diameter of 10 cm (4 in) are stacked along with the each pallet to reduce edge traction.
- The plastic pipes are constrained against the elevated pallets but are free to rotate (FIGURE C).
- A safety rope belay is routed through an eye bolt in the rear wall of the apparatus.

Procedure

1. Set the apparatus to the intended testing elevation.
2. Place the robot at the starting position on one pallet facing the obstacle. Robots may perform the task in any orientation. Attach safety rope belay.
3. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
4. Start the timer when the robot begins and capture total elapsed time for a complete set of **repetitions**.
5. Surmount the pipe step fully so that the entire robot is on the elevated platform with no overhang or contact with the pipes, then return to the start position. Repeat continuously without intervention until all **repetitions** are complete.
6. Increase the pipe step elevation until unsuccessful in one of the **repetitions**.
7. Note the maximum elevation completed for all **repetitions**.

Fault Conditions: (Fill out an Event Report)

- Intervention via safety rope belay is required
- Failure to complete 10 continuous **repetitions**

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

MOBILITY: OBSTACLES: PIPE STEPS (10 cm to 100 cm)

TRIAL ☐

DATE 2010.____________ **ROBOT MAKE** ____________

FACILITY ____________ **ROBOT MODEL** ____________

LOCATION ____________ **CONFIGURATION** ____________

EVENT ____________ **OPERATOR/ORG** ____________

LIGHTING: ○ >100 LUX ○ <1 LUX

COMMUNICATIONS: ○ TETHER ○ RADIO

CONFINED AREA DIVIDER	START TIME (MIN)	REPETITIONS										END TIME (MIN)		ELAPSED TIME (MIN)		AVG TIME (MIN)	
100 CM ○		1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○		=		=		MIN
90 CM ○		1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○		=		=		MIN
80 CM ○		1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○		=		=		MIN
70 CM ○		1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○		=		=		MIN
60 CM ○		1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○		=		=		MIN
50 CM ○		1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○		=		=		MIN
40 CM ○		1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○		=		=		MIN
30 CM ○		1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○		=		=		MIN
20 CM ○		1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○		=		=		MIN
10 CM ○		1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	10 ○		=		=		MIN

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-MOB-OBS-PIPESTEP-##CM

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

FIGURE A

FIGURE B

FIGURE C

MOBILITY: OBSTACLES: STAIRS/ LANDINGS (30°-45°; WOOD/METAL; WET)

Purpose

The purpose of this test method is to quantitatively evaluate the stair ascending/descending capabilities of robot, including variable chassis configurations, coordinated climbing behaviors, and tread surface vulnerabilities, while being remotely teleoperated in confined areas with lighted and dark conditions.

Metrics

- Maximum successful incline (degrees) with a variety of surface conditions for 10 **repetitions**
- Average time per **repetition**

Apparatus

- Four different stair inclines (30°, 35°, 40°, 45°) are available with two different stair tread surfaces, wood and “diamond plate” steel (Figure B, C, D).
- Each apparatus contains five stairs with 20 cm (8 in) risers and 20 cm (8 in) treads with enclosed lower and upper landings made of 1.2 m x 1.2 m (4 ft x 4 ft) OSB (FIGURE A).
- A removable containment wall encloses the lower landing at the start point.
- A shallow basin filled with water is located within the apparatus at the start point one pallet away from the stairs.
- A safety rope belay is routed through an eye bolt in the rear wall of the apparatus.

Procedure

1. Set the apparatus to the intended testing incline and surface.
2. Place the robot at the starting position facing the obstacle. Robots may perform the task in any orientation. Attach safety rope belay. Enclose the robot with the lower landing containment wall
3. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
4. Start the timer when the robot begins and capture total elapsed time for a complete set of **repetitions**.
5. Surmount the stairs fully so that the entire robot is on the elevated landing with no overhang or contact with the stairs, then return to the start position. Repeat continuously without intervention until all **repetitions** are complete.
6. Repeat with other stair tread surfaces.
7. Increase the stair incline until unsuccessful in one of the **repetitions**.
8. Note the maximum incline completed with all surfaces for all **repetitions**.

Fault Conditions: (Fill out an Event Report)

- Intervention via safety rope belay is required
- Failure to complete 10 continuous **repetitions**

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011

STATUS: VALIDATING-WK27758

Forms: v2011.1 Data: A

MOBILITY: OBSTACLES: STAIRS/LANDINGS

TRIAL ☐

DATE 2010.____________

FACILITY ____________

LOCATION ____________

EVENT ____________

ROBOT MAKE ____________

ROBOT MODEL ____________

CONFIGURATION ____________

OPERATOR/ORG ____________

LIGHTING:
○ >100 LUX ○ <1 LUX

COMMUNICATIONS:
○ TETHER ○ RADIO

CONFINED AREA DIVIDER	START TIME (MIN)	REPETITIONS	END TIME (MIN)		ELAPSED TIME (MIN)		AVG TIME (MIN)	
45 DEGREE STAIRS								
WOOD ○	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐	MIN
STEEL ○	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐	MIN
40 DEGREE STAIRS								
WOOD ○	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐	MIN
STEEL ○	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐	MIN
35 DEGREE STAIRS								
WOOD ○	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐	MIN
STEEL ○	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐	MIN
30 DEGREE STAIRS								
WOOD ○	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐	MIN
STEEL ○	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐	MIN

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-MOB-OBS-STAIRS-##DEG-WOOD/METAL

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

MOBILITY: OBSTACLES: CONFINED SPACE VOIDS

FIGURE A

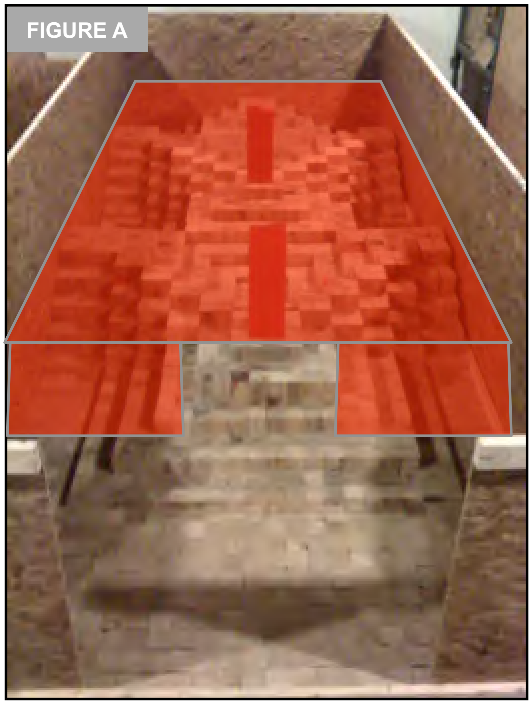
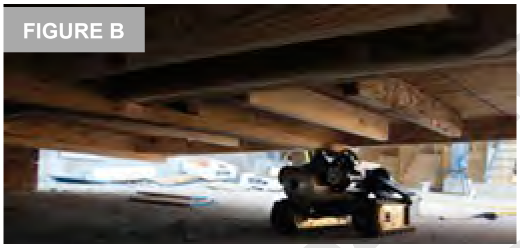


FIGURE B



Purpose

The purpose of this test method is to quantitatively evaluate the confined space maneuvering capabilities of a robot while being remotely teleoperated in complex terrain with lighted and dark conditions.

Metrics

- Completion of 10 figure-8 **repetitions**
- Average time per **repetition**

Apparatus

- The flooring terrain consists of symmetric **stepfield terrain element** fabricated using 10 cm (4 in) square wood posts cut to prescribed lengths (10 cm, 20 cm, 30 cm, 40 cm, and 50 cm (4 in, 8 in, 12 in, 16 in, and 20 in)) and setup in groups of four posts per step height as shown (FIGURE A, B).
- Two pylons define the prescribed figure-8 path.
- This test apparatus is intended to fit into a 12 m x 2.4 m (40 ft x 8 ft) standard ISO shipping container (FIGURE A). It can also be setup as a freestanding apparatus with 1.2 m (4 ft) tall walls with supports.
- A descending ceiling element with stalactites is used to narrow the vertical access dimension in 10 cm (4 in) increments. The pattern of stalactites is inverted from the flooring terrain so that ceiling features fill the valley features of the flooring terrain.

Procedure

1. Place the robot at the starting position near the apparatus entrance.
2. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
3. Start the timer when the robot begins and capture total elapsed time for a complete set of **repetitions**.
4. Traverse the figure-8 path around the pylons continuously without intervention until all **repetitions** are complete.

Fault Conditions: (Fill out an Event Report)

- Failure to complete 10 continuous **repetitions**

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011 STATUS: VALIDATING

Forms: v2011.1 Data: A

MOBILITY: OBSTACLES: CONFINED SPACE VOIDS

TRIAL ☐

DATE 2010.____________

FACILITY ____________

LOCATION ____________

EVENT ____________

ROBOT MAKE ____________

ROBOT MODEL ____________

CONFIGURATION ____________

OPERATOR/ORG ____________

LIGHTING:
○ >100 LUX ○ <1 LUX

COMMUNICATIONS:
○ TETHER ○ RADIO

AVGERAGE CEILING HEIGHT (CM)	START TIME (MIN)	REPETITIONS	END TIME (MIN)		ELAPSED TIME (MIN)		METERS PER MINUTE
50 CM	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐ 150 M	=	☐
40 CM	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐ 150 M	=	☐
30 CM	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐ 150 M	=	☐
20 CM	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐ 150 M	=	☐
10 CM	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐ 15		

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-MOB-OBS-CONFINED

NAME/ORGANIZATION:
XXX

FIGURE A

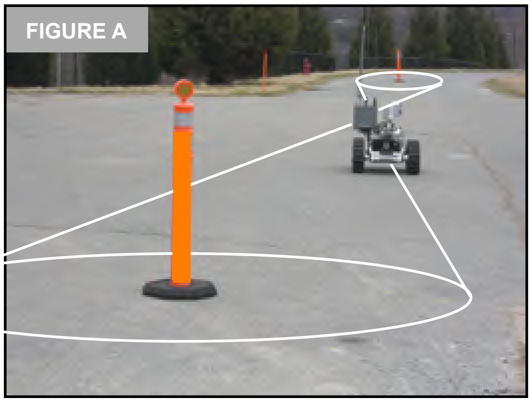


FIGURE B

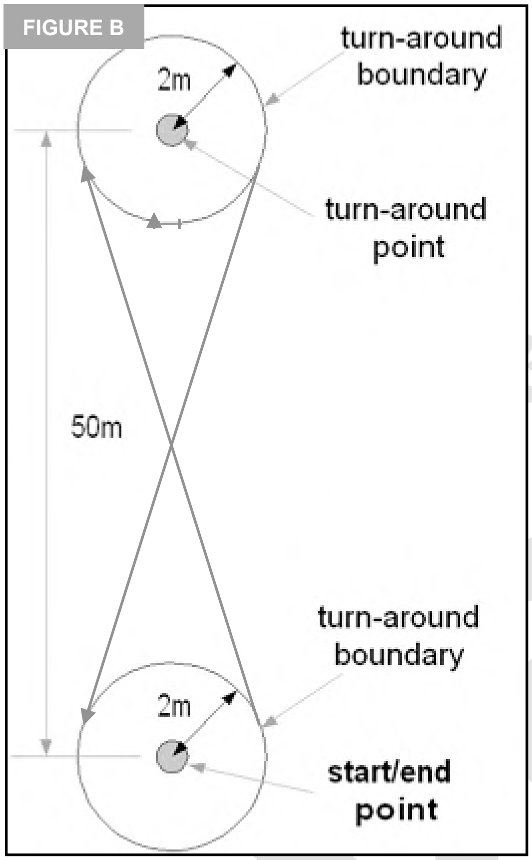


FIGURE C

MOBILITY: TOWING: GRASPED SLEDS (100 M)

Purpose

The purpose of this test method is to quantitatively evaluate the grasped towing capabilities for a remotely teleoperated robot operating on a flat/paved surface with confined area turns.

Metrics

- Maximum weight dragged (kg) for 10 **repetitions**
- Average time per **repetition**

Apparatus

- This test apparatus is a flat, straight, paved path of 50 m (165 ft) between two pylons (FIGURE A).
- Each pylon has a clearly marked turning boundary with a radius of 2 m (6.5 ft) marked by a chalk or paint line (FIGURE B).
- A drag sled with a knotted handle is used for towing (FIGURE C).
- A set of standard weights of 2 kg (5 lbs) and 11 kg (25 lbs) are available to load the sled.
- A set of backpacks weighing 5 kg (10 lbs) and 9 kg (20 lbs) can also be used for drag weights less than the sled itself.

Procedure

1. Place the robot at the starting position near one pylon within the turning boundary.
2. Place the drag sled also within the turning boundary, but not attached to the robot in any way. The operator may select the initial drag weight.
3. Start the timer when the robot begins and capture total elapsed time for a complete set of **repetitions**.
4. Remotely teleoperate the robot to grasp the sled in any convenient manner.
5. Traverse the figure-8 path around the pylons continuously without intervention until all **repetitions** are complete. Maintain at least part of the robot clearly over the marked path including the turning boundaries.
6. Failure to stay over the marked path negates the current lap. Teleoperate the robot to the starting position and continue with the timer running.
7. Increase the drag weight according to the operator's chosen increment and repeat until unsuccessful in one of the **repetitions** or the operator is content with the last successful drag weight.
8. Note the maximum drag weight completed for all **repetitions.**

Fault Conditions: (Fill out an Event Report)

- Failure to complete 10 continuous **repetitions**

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011 STATUS: VALIDATING-WK27763

Forms: v2011.1 Data: A

MOBILITY: TOWING: GRASPED SLEDS (100 M)

TRIAL ☐

DATE 2010.__________

ROBOT MAKE __________

FACILITY __________

ROBOT MODEL __________

LOCATION __________

CONFIGURATION __________

EVENT __________

OPERATOR/ORG __________

LIGHTING:
○ **>100 LUX** ○ **<1 LUX**

COMMUNICATIONS:
○ **TETHER** ○ **RADIO**

LOAD (KGS/LBS)	START TIME (MIN)	REPETITIONS	END TIME (MIN)		ELAPSED TIME (MIN)		AVG TIME (MIN)	
☐	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN
☐	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN
☐	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN
☐	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN

EMPTY SLED (15 KG/ 30 LBS)

WEIGHTED BACKPACK

10kg / 20lb	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN
5kg / 10lb	☐	1 2 3 4 5 6 7 8 9 10 ○ ○ ○ ○ ○ ○ ○ ○ ○ ○	☐	=	☐	=	☐	MIN

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-MOB-TOW-GRASP-##KG

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

FIGURE A

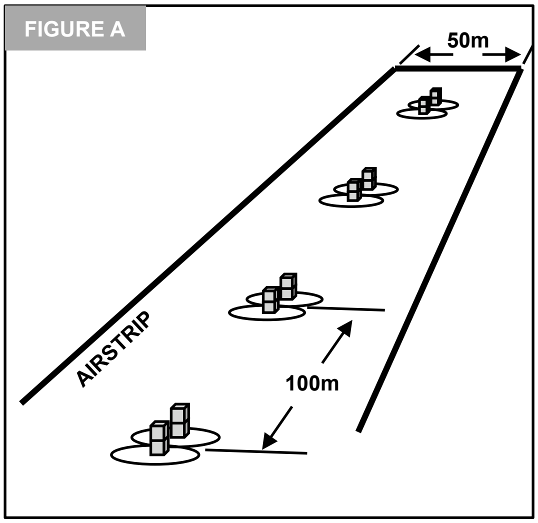


FIGURE B

FIGURE C

RADIO COMMS: LINE-OF-SIGHT ENVIRONMENTS

Purpose

The purpose of this test method is to quantitatively evaluate the line of sight (LOS) radio communications range for a remotely teleoperated robot.

Metrics

- Maximum distance (m) downrange at which the robot completes tasks to verify the functionality of control, video, and audio transmissions.

Apparatus

- The test apparatus for the LOS test is a straight flat section of airstrip, roadway or similar surface at least 1 km (0.6 mi) long (longer if possible). The surface shall be consistent (e.g. asphalt or concrete) and be free of reflective objects at least 50 m (164 ft) on either side of the centerline (FIGURE A).
- A figure-8 path with two 2 m (6.5 ft) radius lobes and 4 targets, facing four directions, shall be located at test distances of 50 m, 100 m, 200 m, 300 m (165 ft, 330 ft, 660 ft, 990 ft)... through the entire range of the test course (FIGURE A).
- Operator station antennas shall be limited to a maximum of 2 m (6.5 ft) elevation above the ground.

Procedure

1. Place the robot in the start position near the operator station.
2. Traverse downrange to the next test station.
3. The control signal is tested by following the curved line. The video signal is tested by identifying hazmat labels. The two-way audio is tested by an endless loop playing a predetermined set of keywords with the operator and administrator at each end identifying the words heard.
4. Upon arrival at a test station, center the robot wheels/tracks on the figure-8 path and follow the curve while maintaining line between tracks until directly in view of a recessed **target** placed at the center of the figure-8. Turn the robot towards the target and use any forward-facing sensor to identify the **target**. Panning of sensors is not allowed. Driving towards the **target** is allowed, but contact with the **target** is not. Return to the figure-8 path and continue around to next **target** until all four **target** are identified.
5. Repeat until a station is reached at which the control, video or audio transmissions fail. Report the last successful station range.

Fault Conditions: (Fill out an Event Report)

- Deviating from prescribed figure-8 path while traversing between **targets** within a station.
- Touching the **targets** while attempting identification.

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011
STATUS: VALIDATING-WK14437

Forms: v2011.1 Data: A

RADIO COMMS: LINE-OF-SIGHT ENVIRONMENTS

TRIAL ☐

DATE 2010.__________
FACILITY __________
LOCATION __________
EVENT __________

ROBOT MAKE __________
ROBOT MODEL __________
CONFIGURATION __________
OPERATOR/ORG __________

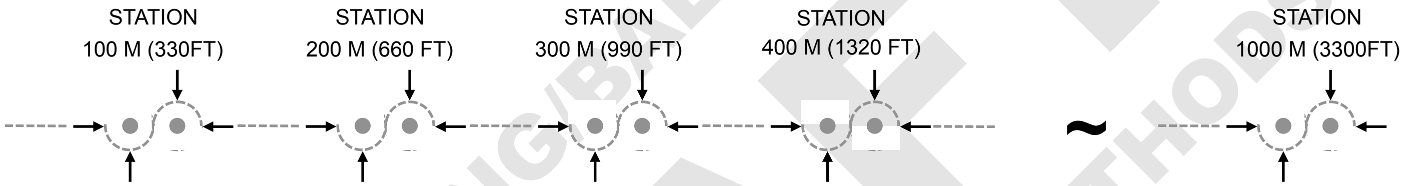
LIGHTING:
○ **>100 LUX** ○ **<1 LUX**

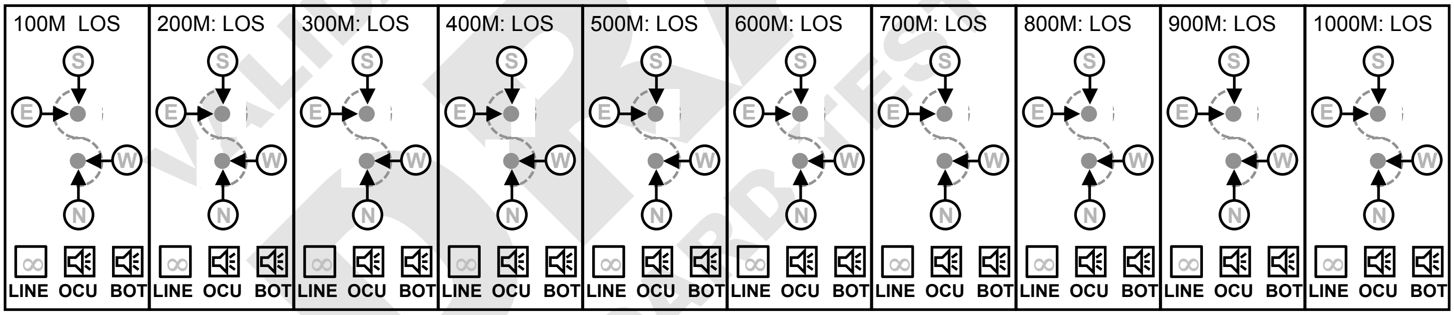
COMMUNICATIONS:
○ **TETHER** ○ **RADIO**

RADIO COMMUNICATION DESCRIPTION:					**DIGITAL**	**ANALOG**	**OMNI**
CONTROL:	____ MHZ	____ WATTS	ANT:____	dB	○	○	○
VIDEO:	____ MHZ	____ WATTS	ANT:____	dB	○	○	○
AUDIO TX:	____ MHZ	____ WATTS	ANT:____	dB	○	○	○
AUDIO RX:	____ MHZ	____ WATTS	ANT:____	dB	○	○	○


LINE OF SIGHT STATIONS


TARGETS





LEGEND: ∞ CONTROL COMMS / LINE FOLLOWING 🔊 AUDIO COMMS

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-COM-LOS-TXTF1

XXX

TEST ADMINISTRATOR NAME/ORGANIZATION:

FIGURE A

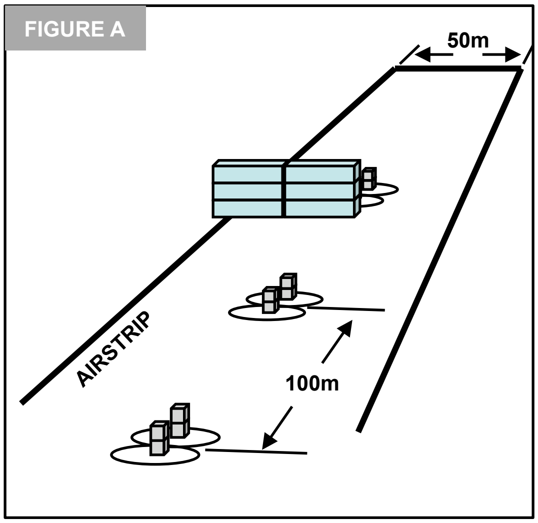


FIGURE B

LINE OF SIGHT STATIONS

FIGURE C

BEHIND THE ISO CONTAINER WALL

FIGURE D

RADIO COMMS: NON-LINE-OF-SIGHT ENVIRONMENTS

Purpose

The purpose of this test method is to quantitatively evaluate the non-line-of-sight (NLOS) radio communications range for a remotely teleoperated robot.

Metrics

- Maximum distance (m) behind a downrange metal monolith at which the robot completes tasks to verify the functionality of control, video, and audio transmissions.

Apparatus

- The test apparatus for the NLOS test is identical to the LOS except at a distance of 500 m (1640 ft) there is a wall constructed of standard ISO shipping containers (7.3 m high x 24.4 m wide (24 ft high x 80 ft wide)) with one edge aligned with the test course centerline and the long face perpendicular to the direction of robot travel (FIGURE A).
- Three additional figure-8 paths are located behind and tangent to the metal wall to test robot operations in the radio shadow.
- Operator station antennas shall be limited to a maximum of 2 m (6.5 ft) elevation above the ground.

Procedure

1. Determine standoff distance of operator station from metal wall based on half the robot's LOS performance data.
2. Place the robot in the start position near the operator station.
3. Traverse downrange to the next test station.
4. The control signal is tested by following the curved line. The video signal is tested by identifying hazmat labels. The two-way audio is tested by an endless loop playing a predetermined set of keywords with the operator and administrator at each end identifying the words heard.
5. Upon arrival at a test station, center the robot wheels/tracks on the figure-8 path and follow the curve while maintaining line between tracks until directly in view of a recessed **target** placed at the center of the figure-8. Turn the robot towards the target and use any forward-facing sensor to identify the **target**. Panning of sensors is not allowed. Driving towards the **target** is allowed, but contact with the **target** is not. Return to the figure-8 path and continue around to next **target** until all four **target** are identified.
6. Upon arrival at the ISO container monolith the robot should turn behind the container and proceed to a figure-8 test at 2 m (6.5 ft), 5 m (16.5 ft), and 12 m (40 ft) from the corner.
7. Repeat until a station is reached at which the control, video or audio transmissions fail. Report the last successful station range.

Fault Conditions: (Fill out an Event Report)

- Deviating from prescribed figure-8 path while traversing between **targets** within a station.
- Touching the **targets** while attempting identification.

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

RADIO COMMS: NON-LINE-OF-SIGHT ENVIRONMENTS

TRIAL ____

DATE 2010.__________ **ROBOT MAKE** __________

FACILITY __________ **ROBOT MODEL** __________

LOCATION __________ **CONFIGURATION** __________

EVENT __________ **OPERATOR/ORG** __________

LIGHTING:
○ >100 LUX ○ <1 LUX

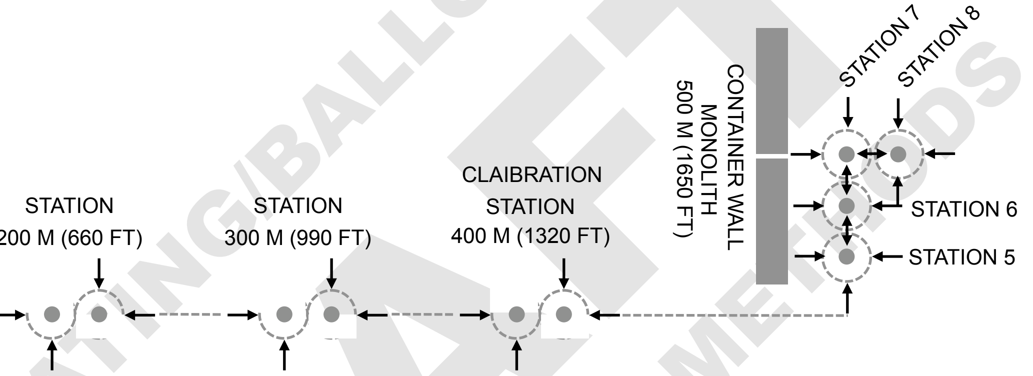
COMMUNICATIONS:
○ TETHER ○ RADIO

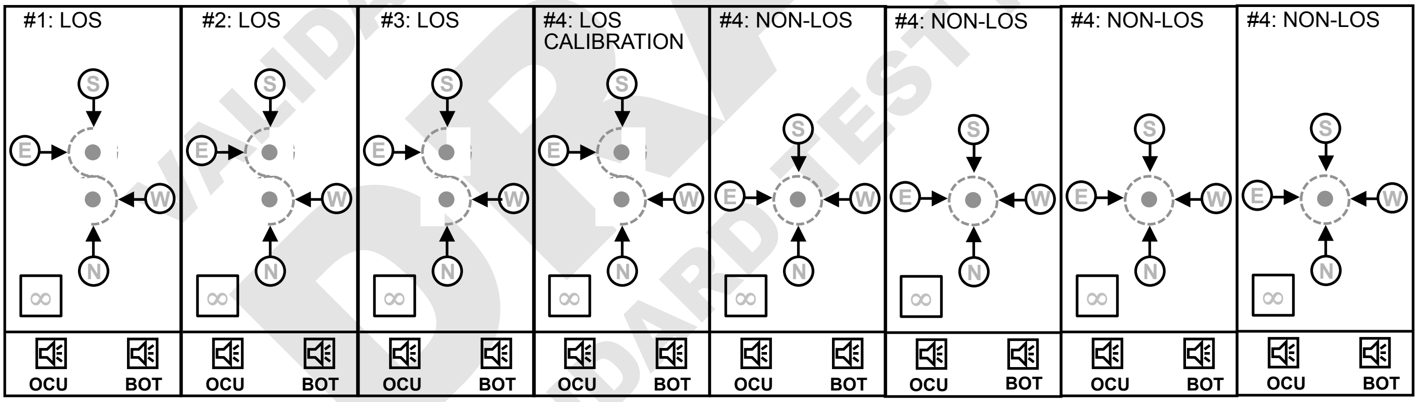
RADIO COMMUNICATION DESCRIPTION:					DIGITAL	ANALOG	OMNI
CONTROL:	____ MHZ	____ WATTS	ANT: ____ dB		○	○	○
VIDEO:	____ MHZ	____ WATTS	ANT: ____ dB		○	○	○
AUDIO TX:	____ MHZ	____ WATTS	ANT: ____ dB		○	○	○
AUDIO RX:	____ MHZ	____ WATTS	ANT: ____ dB		○	○	○


BEHIND THE CONNEX WALL


LINE OF SIGHT STATIONS

STATION
100 M (330FT)





LEGEND: ∞ CONTROL COMMS / LINE FOLLOWING 🔈 AUDIO COMMS

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-COM-NLOS-TXTF1

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

MANIPULATION: DIRECTED PERCEPTION TASKS: OPEN ACCESS

FIGURE A

FIGURE B

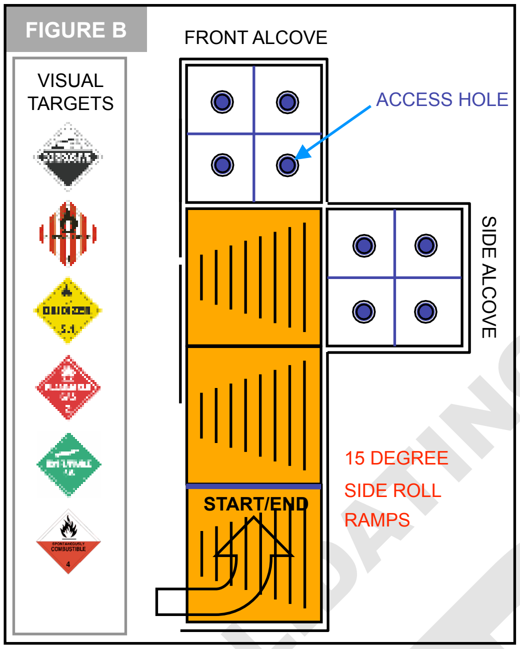
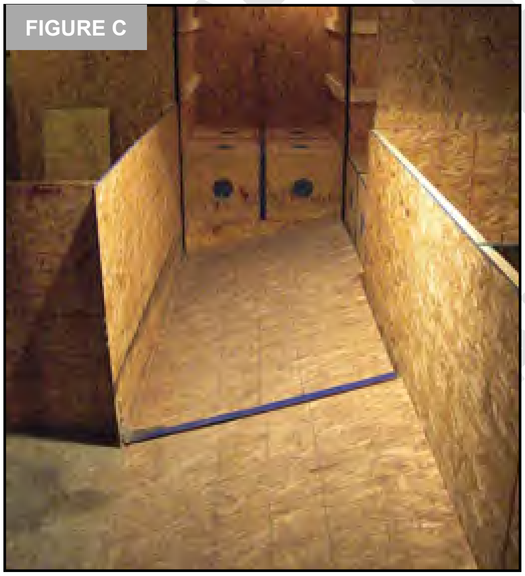


FIGURE C



Purpose

The purpose of this test method is to quantitatively evaluate the manipulator positioning capabilities of a robot on increasingly complex terrain while being remotely teleoperated in confined areas with lighted and dark conditions.

Metrics

- Number of correctly identified **targets** within sub-divided cells at various proximities and elevations relative to the robot
- Average time per task

Apparatus

- The apparatus for this test method contains two alcoves which sub-divide the work volume to the front and side of the robot into roughly cubic cells in which **targets** are placed to be identified.
- Each alcove allows shelf placement at prescribed elevations (0 cm to 200 cm (0 in to 80 in) in 50 cm (20 in) increments).
- Each shelf is sub-divided into four cells.
- The cells are accessible via circular holes of 15 cm (6 in) diameter with hinged doors and magnetic closures (FIGURE A).
- Ground level (0 cm (0 in)) cells have no front holes.
- **Full ramp terrain elements** or symmetric **stepfields terrain elements**, provide complexity in robot orientation and mobility.
- The start/end line is two terrain elements away from the front alcove (FIGURES B, C).

Procedure

1. Set the shelves to the intended testing elevation. Close cell doors.
2. Place the robot outside the start/end line facing the alcoves.
3. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
4. Start the timer when the robot crosses the start/end line to capture total elapsed time for a complete shelf elevation, ending when the robot exits past the start/end line.
5. Open each reachable cell access door with the manipulator tool tip and identify the **target** within. Bumping the apparatus to open doors is not allowed.
6. Repeat at the next higher shelf elevation until all elevations have been tested or the robot is no longer able to reach the cells.
7. Repeat all shelf elevations with other flooring options.
8. Robots may exit past the start/end line for maintenance or repairs.

Fault Conditions: (Fill out an Event Report)

- Failure to return past the start/end line

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

MANIPULATION: DIRECTED PERCEPTION: OPEN ACCESS

TRIAL ☐

DATE ____________ **ROBOT MAKE** ____________

FACILITY ____________ **ROBOT MODEL** ____________

LOCATION ____________ **CONFIGURATION** ____________

EVENT ____________ **OPERATOR/ORG** ____________

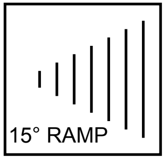
LIGHTING: ○ >100 LUX ○ <1 LUX

COMMUNICATIONS: ○ TETHER ○ RADIO

SHELF LEVEL 100 CM

START (HH:MM) ☐
FINISH (HH:MM) ☐
ELAPSED (MIN) ☐
CORRECT (##.#) ☐
AVERAGE (MIN PER TASK) ☐
% TASKS (%) %

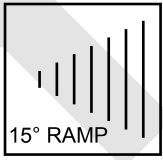
C I # W (×12)



SHELF LEVEL 200 CM

START (HH:MM) ☐
FINISH (HH:MM) ☐
ELAPSED (MIN) ☐
CORRECT (##.#) ☐
AVERAGE (MIN PER TASK) ☐
% TASKS (%) %

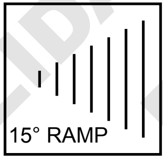
C I # W (×12)



SHELF LEVEL 50 CM

START (HH:MM) ☐
FINISH (HH:MM) ☐
ELAPSED (MIN) ☐
CORRECT (##.#) ☐
AVERAGE (MIN PER TASK) ☐
% TASKS (%) %

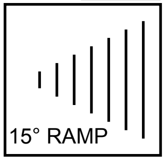
C I # W (×12)



SHELF LEVEL 150 CM

START (HH:MM) ☐
FINISH (HH:MM) ☐
ELAPSED (MIN) ☐
CORRECT (##.#) ☐
AVERAGE (MIN PER TASK) ☐
% TASKS (%) %

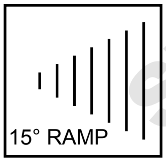
C I # W (×12)



SHELF LEVEL 0 CM (GROUND)

START (HH:MM) ☐
FINISH (HH:MM) ☐
ELAPSED (MIN) ☐
CORRECT (##.#) ☐
AVERAGE (MIN PER TASK) ☐
% TASKS (%) %

C I # W (×8)



NOTES:

LEGEND: CORRECTLY INDENTIFY 3 OF 4 VISUAL INDICATORS
COLOR(C) , ICON (I), NUMBER (#), WORD (W)

VIDEO FILE NAMING CONVENTION
ROBOTNAME-MANIP-PER-##CM

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

MANIPULATION: DIRECTED PERCEPTION TASKS: REACH OVER

FIGURE A

FIGURE B

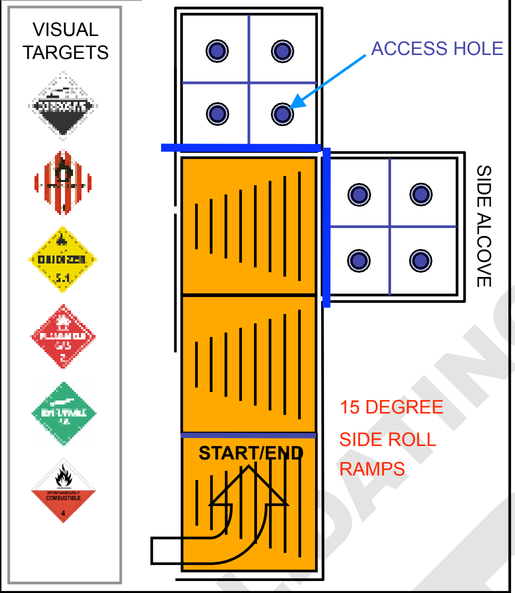
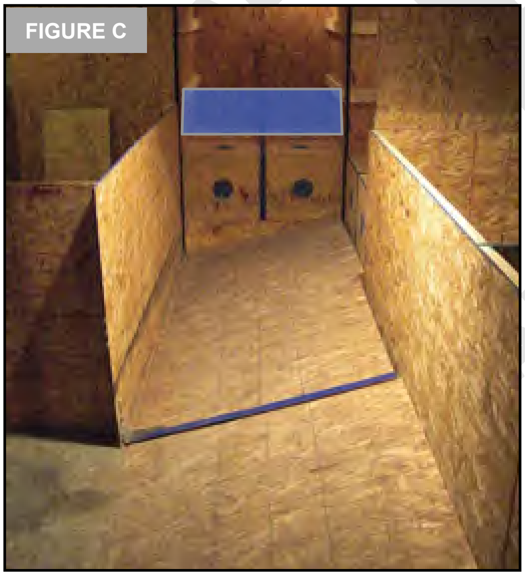


FIGURE C



Purpose

The purpose of this test method is to quantitatively evaluate the manipulator positioning capabilities of a robot on increasingly complex terrain while being remotely teleoperated in confined areas with lighted and dark conditions.

Metrics

- Number of correctly identified **targets** within sub-divided cells at various proximities and elevations relative to the robot
- Average time per task

Apparatus

- The apparatus for this test method contains two alcoves which sub-divide the work volume to the front and side of the robot into roughly cubic cells in which **targets** are placed to be identified.
- Each alcove allows shelf placement at prescribed elevations (0 cm to 200 cm (0 in to 80 in) in 50 cm (20 in) increments).
- Each shelf is sub-divided into four cells.
- The cells are accessible via circular holes of 15 cm (6 in) diameter with hinged doors and magnetic closures (FIGURE A).
- A vertical 50 cm (20 in) OSB blockage is flush with the front edge.
- Ground level (0 cm (0 in)) cells have no front holes.
- **Full ramp terrain elements** or symmetric **stepfields terrain elements**, provide complexity in robot orientation and mobility.
- The start/end line is two terrain elements away from the front alcove (FIGURES B, C).

Procedure

1. Set the shelves to the intended testing elevation. Close cell doors.
2. Place the robot outside the start/end line facing the alcoves.
3. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
4. Start the timer when the robot crosses the start/end line to capture total elapsed time for a complete shelf elevation, ending when the robot exits past the start/end line.
5. Open each reachable cell access door with the manipulator tool tip and identify the **target** within. Bumping the apparatus to open doors is not allowed.
6. Repeat at the next higher shelf elevation until all elevations have been tested or the robot is no longer able to reach the cells.
7. Repeat all shelf elevations with other flooring options.
8. Robots may exit past the start/end line for maintenance or repairs.

Fault Conditions: (Fill out an Event Report)

- Failure to return past the start/end line

MANIPULATION: DIRECTED PERCEPTION: REACH OVER

TRIAL ____

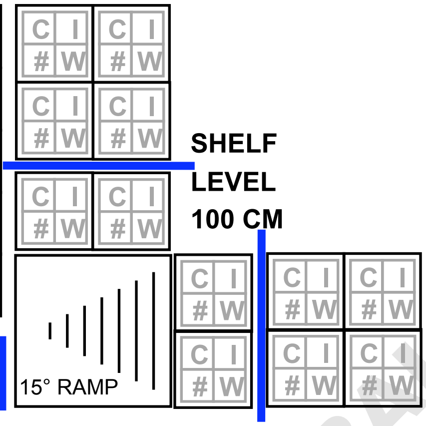
DATE ____
FACILITY ____
LOCATION ____
EVENT ____

ROBOT MAKE ____
ROBOT MODEL ____
CONFIGURATION ____
OPERATOR/ORG ____

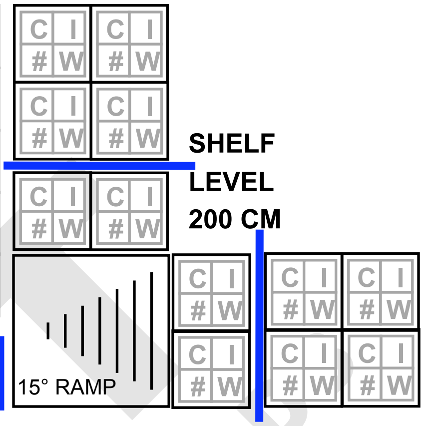
LIGHTING:
○ >100 LUX ○ <1 LUX

COMMUNICATIONS:
○ TETHER ○ RADIO

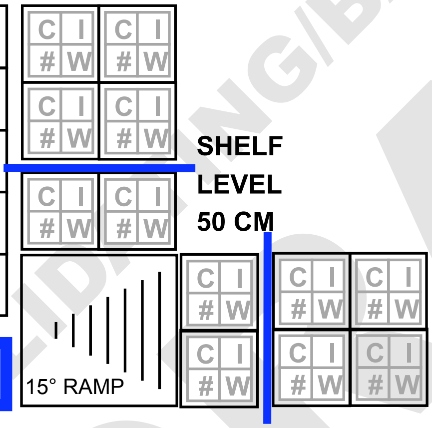
START (HH:MM) ____
FINISH (HH:MM) ____
ELAPSED (MIN) ____
CORRECT (##.#) ____
AVERAGE (MIN PER TASK) ____
% TASKS (%) ____ %



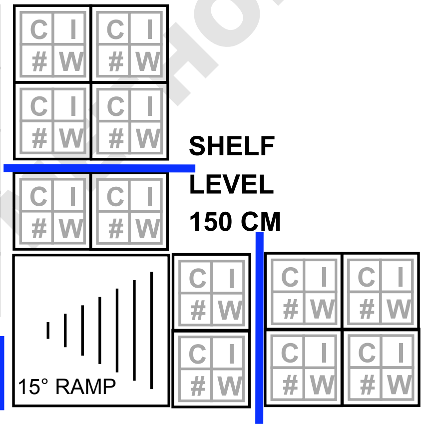
START (HH:MM) ____
FINISH (HH:MM) ____
ELAPSED (MIN) ____
CORRECT (##.#) ____
AVERAGE (MIN PER TASK) ____
% TASKS (%) ____ %



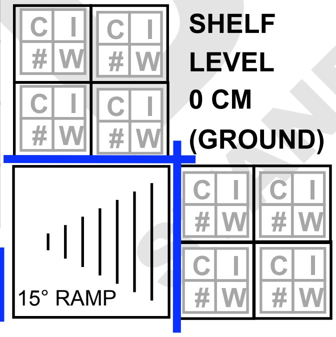
START (HH:MM) ____
FINISH (HH:MM) ____
ELAPSED (MIN) ____
CORRECT (##.#) ____
AVERAGE (MIN PER TASK) ____
% TASKS (%) ____ %



START (HH:MM) ____
FINISH (HH:MM) ____
ELAPSED (MIN) ____
CORRECT (##.#) ____
AVERAGE (MIN PER TASK) ____
% TASKS (%) ____ %



START (HH:MM) ____
FINISH (HH:MM) ____
ELAPSED (MIN) ____
CORRECT (##.#) ____
AVERAGE (MIN PER TASK) ____
% TASKS (%) ____ %



NOTES:

LEGEND: CORRECTLY INDENTIFY 3 OF 4 VISUAL INDICATORS
COLOR(C) , ICON (I), NUMBER (#), WORD (W)

VIDEO FILE NAMING CONVENTION
ROBOTNAME-MANIP-PER-##CM

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

FIGURE A

FIGURE B

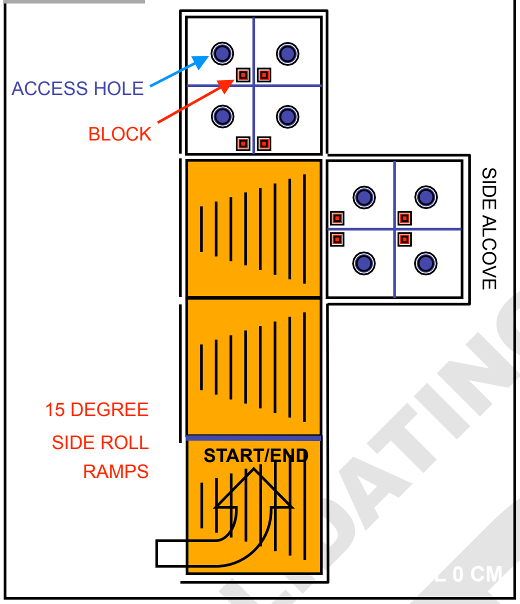


FIGURE C

MANIPULATION: GRASPING DEXTERITY TASKS: OPEN ACCESS

Purpose

The purpose of this test method is to quantitatively evaluate the the manipulator grasping and placement capabilities of a robot on increasingly complex terrain while being remotely teleoperated in confined areas with lighted and dark conditions.

Metrics

- Number of grasped **pick and place objects** within sub-divided cells at various proximities and elevations relative to the robot
- Average time per task

Apparatus

- The apparatus for this test method contains two alcoves which sub-divide the work volume to the front and side of the robot into roughly cubic cells in which pick and place tasks are performed.
- Each alcove allows shelf placement at prescribed elevations (0 cm, 50 cm, 100 cm, 150 cm, 200 cm (0 in, 20 in, 40 in, 60 in, 80 in)).
- Each shelf is sub-divided into four cells with 10 cm (4 in) **pick and place objects** placed on pegs in the near corner (shown as red in FIGURE A) and circular holes of 15 cm (6 in) diameter with hinged doors and magnetic closures (shown as blue in FIGURE A).
- Ground level (0 cm (0 in)) cells have no front holes.
- Non-flat flooring conditions, either **full ramp terrain elements** or symmetric **stepfield terrain elements**, provide complexity in robot orientation and mobility.
- The start/end line is two terrain elements away from the front alcove (FIGURE B, C).

Procedure

1. Set the shelves to the intended testing elevation. Close cell doors. Place the **pick and place object**s on their appropriate pegs.
2. Place the robot outside the start/end line facing the alcoves.
3. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
4. Start the timer when the robot crosses the start/end line to capture total elapsed time for a complete shelf elevation, ending when the robot exits past the start/end line.
5. Grasp each reachable **pick and place object** with the manipulator tool tip, remove from its recessed peg mount, and place through the corresponding cell access door.
6. Repeat at the next higher shelf elevation until all elevations have been tested or the robot is no longer able to reach the cells.
7. Repeat all shelf elevations with other flooring options.
8. Robots may exit past the start/end line for maintenance or repairs.

Fault Conditions: (Fill out an Event Report)

- Failure to return past the start/end line

MANIPULATION: GRASPING DEXTERITY: OPEN ACCESS

TRIAL ☐

DATE 2010.____________

FACILITY ____________

LOCATION ____________

EVENT ____________

ROBOT MAKE ____________

ROBOT MODEL ____________

CONFIGURATION ____________

OPERATOR/ORG ____________

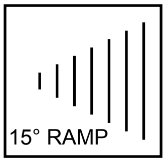
LIGHTING:
○ **>100 LUX** ○ **<1 LUX**

COMMUNICATIONS:
○ **TETHER** ○ **RADIO**

START (HH:MM)
FINISH (HH:MM)
ELAPSED (MIN)
CORRECT (##.#)
AVERAGE (MIN PER TASK)
% TASKS (%) %

☐ ☐
☐ ☐

SHELF LEVEL 100 CM

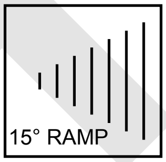


☐ ☐
☐ ☐

START (HH:MM)
FINISH (HH:MM)
ELAPSED (MIN)
CORRECT (##.#)
AVERAGE (MIN PER TASK)
% TASKS (%) %

☐ ☐
☐ ☐

SHELF LEVEL 200 CM

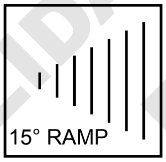


☐ ☐
☐ ☐

START (HH:MM)
FINISH (HH:MM)
ELAPSED (MIN)
CORRECT (##.#)
AVERAGE (MIN PER TASK)
% TASKS (%) %

☐ ☐
☐ ☐

SHELF LEVEL 50 CM

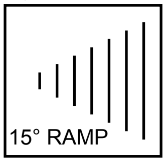


☐ ☐
☐ ☐

START (HH:MM)
FINISH (HH:MM)
ELAPSED (MIN)
CORRECT (##.#)
AVERAGE (MIN PER TASK)
% TASKS (%) %

☐ ☐
☐ ☐

SHELF LEVEL 150 CM

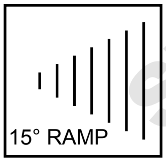


☐ ☐
☐ ☐

START (HH:MM)
FINISH (HH:MM)
ELAPSED (MIN)
CORRECT (##.#)
AVERAGE (MIN PER TASK)
% TASKS (%) %

☐ ☐
☐ ☐

SHELF LEVEL 0 CM (GROUND)



☐ ☐
☐ ☐

NOTES:

LEGEND: ▨ 0.5 KG / 1 LBS 🟦 4 KG / 10 LBS ■ 8 KG / 20 LBS

🟦	TASK 1: BLOCK REMOVED FROM PEG
🟦	TASK 2: BLOCK PLACED COMPETELY INTO CELL

VIDEO FILE NAMING CONVENTION
ROBOTNAME-MANIP-DEX-##CM

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

MANIPULATION: GRASPING DEXTERITY TASKS: REACH OVER

FIGURE A

FIGURE B

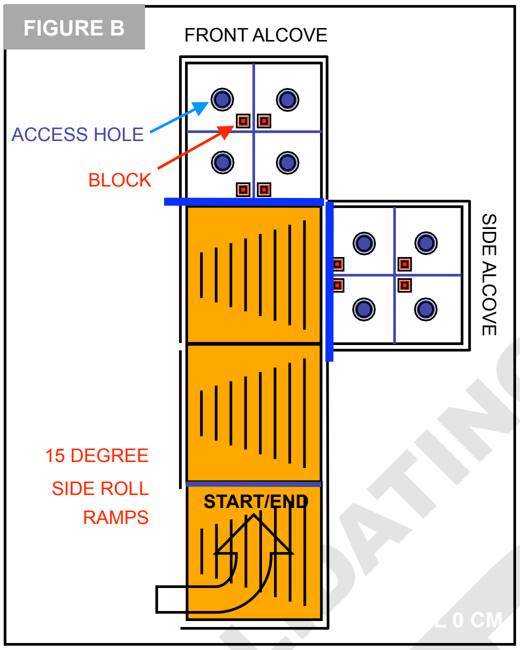
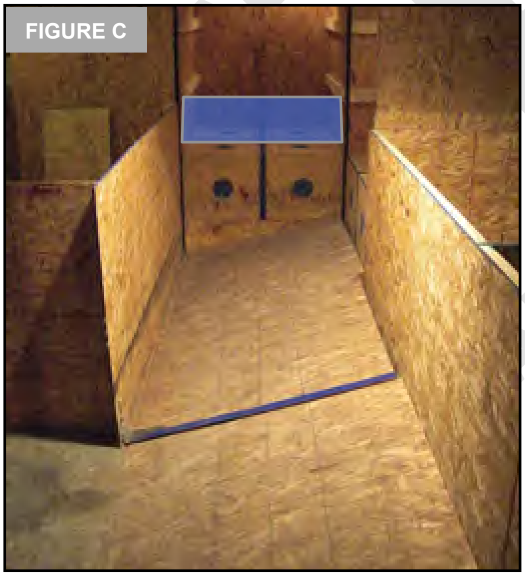


FIGURE C



Purpose

The purpose of this test method is to quantitatively evaluate the the manipulator grasping and placement capabilities of a robot on increasingly complex terrain while being remotely teleoperated in confined areas with lighted and dark conditions.

Metrics

- Number of grasped **pick and place objects** within sub-divided cells at various proximities and elevations relative to the robot
- Average time per task

Apparatus

- The apparatus for this test method contains two alcoves which sub-divide the work volume to the front and side of the robot into roughly cubic cells in which pick and place tasks are performed.
- Each alcove allows shelf placement at prescribed elevations (0 cm, 50 cm, 100 cm, 150 cm, 200 cm (0 in, 20 in, 40 in, 60 in, 80 in)).
- Each shelf is sub-divided into four cells with 10 cm (4 in) **pick and place objects** placed on pegs in the near corner (shown as red in FIGURE A) and circular holes of 15 cm (6 in) diameter with hinged doors and magnetic closures (shown as blue in FIGURE A).
- A vertical 50 cm (20 in) OSB blockage is flush with the front edge.
- Ground level (0 cm (0 in)) cells have no front holes.
- Non-flat flooring conditions, either **full ramp terrain elements** or symmetric **stepfield terrain elements**, provide complexity in robot orientation and mobility.
- The start/end line is two terrain elements away from the front alcove (FIGURE A).

Procedure

1. Set the shelves to the intended testing elevation. Close cell doors. Place the **pick and place object**s on their appropriate pegs.
2. Place the robot outside the start/end line facing the alcoves.
3. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
4. Start the timer when the robot crosses the start/end line to capture total elapsed time for a complete shelf elevation, ending when the robot exits past the start/end line.
5. Grasp each reachable **pick and place object** with the manipulator tool tip, remove from its recessed peg mount, and place through the corresponding cell access door.
6. Repeat at the next higher shelf elevation until all elevations have been tested or the robot is no longer able to reach the cells.
7. Repeat all shelf elevations with other flooring options.
8. Robots may exit past the start/end line for maintenance or repairs.

Fault Conditions: (Fill out an Event Report)

- Failure to return past the start/end line

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

MANIPULATION: GRASPING DEXTERITY: REACH OVER

TRIAL ☐

DATE 2010.____________ **ROBOT MAKE** ____________

FACILITY ____________ **ROBOT MODEL** ____________

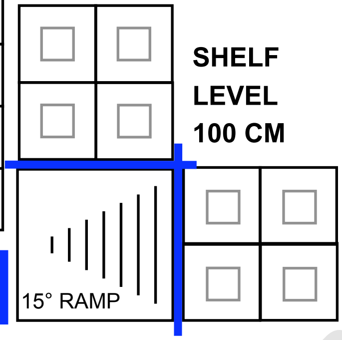
LOCATION ____________ **CONFIGURATION** ____________

EVENT ____________ **OPERATOR/ORG** ____________

LIGHTING:
○ **>100 LUX** ○ **<1 LUX**

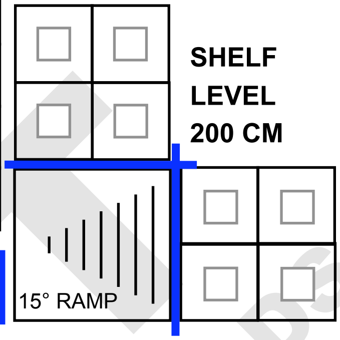
COMMUNICATIONS:
○ **TETHER** ○ **RADIO**

START (HH:MM)	
FINISH (HH:MM)	
ELAPSED (MIN)	
CORRECT (##.#)	
AVERAGE (MIN PER TASK)	
% TASKS (%)	%



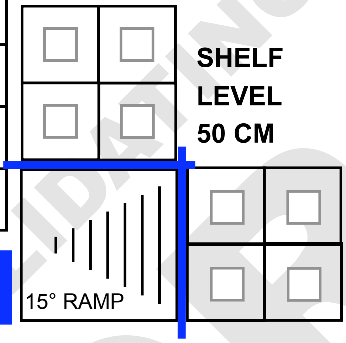
SHELF LEVEL 100 CM

START (HH:MM)	
FINISH (HH:MM)	
ELAPSED (MIN)	
CORRECT (##.#)	
AVERAGE (MIN PER TASK)	
% TASKS (%)	%



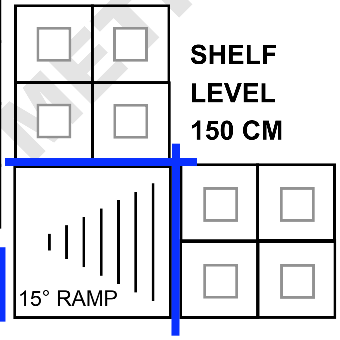
SHELF LEVEL 200 CM

START (HH:MM)	
FINISH (HH:MM)	
ELAPSED (MIN)	
CORRECT (##.#)	
AVERAGE (MIN PER TASK)	
% TASKS (%)	%



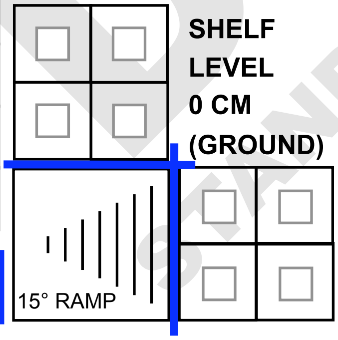
SHELF LEVEL 50 CM

START (HH:MM)	
FINISH (HH:MM)	
ELAPSED (MIN)	
CORRECT (##.#)	
AVERAGE (MIN PER TASK)	
% TASKS (%)	%



SHELF LEVEL 150 CM

START (HH:MM)	
FINISH (HH:MM)	
ELAPSED (MIN)	
CORRECT (##.#)	
AVERAGE (MIN PER TASK)	
% TASKS (%)	%



SHELF LEVEL 0 CM (GROUND)

NOTES:

LEGEND: ▨ 0.5 KG / 1 LBS 🟦 4 KG / 10 LBS ■ 8 KG / 20 LBS

☐ TASK 1: BLOCK REMOVED FROM PEG

🟦 TASK 2: BLOCK PLACED COMPETELY INTO CELL

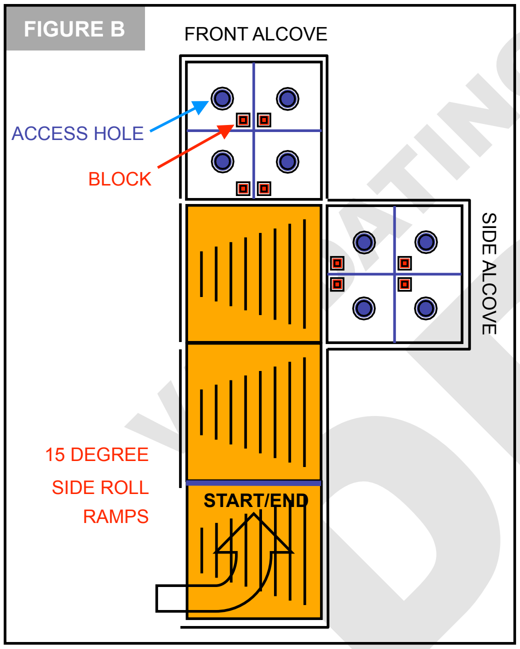
VIDEO FILE NAMING CONVENTION
ROBOTNAME-MANIP-DEX-##CM

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

MANIPULATION: GRASPING DEXTERITY TASKS: WEIGHTED PAYLOADS

FIGURE A

FIGURE B



Purpose

The purpose of this test method is to quantitatively evaluate the the manipulator grasping and placement capabilities of a robot on increasingly complex terrain, including weighted payloads, while being remotely teleoperated in confined areas with lighted and dark conditions.

Metrics

- Number of grasped **pick and place objects** within sub-divided cells at various proximities and elevations relative to the robot
- Average time per task

Apparatus

- The apparatus for this test method contains two alcoves which sub-divide the work volume to the front and side of the robot into roughly cubic cells in which pick and place tasks are performed.
- Each alcove allows shelf placement at prescribed elevations (0 cm, 50 cm, 100 cm, 150 cm, 200 cm (0 in, 20 in, 40 in, 60 in, 80 in)).
- Each shelf is sub-divided into four cells with 10 cm (4 in) diameter cylindrical **pick and place objects** with weights of 0.5kg (1lb), 3kg (7lbs), 7kg (15lbs) placed on pegs in the near corner (shown as red in FIGURE A, B) and circular holes of 15 cm (6 in) diameter.
- Ground level (0 cm (0 in)) cells have no front holes.
- Non-flat flooring conditions, either **full ramp terrain elements** or symmetric **stepfield terrain elements**, provide complexity in robot orientation and mobility.
- The start/end line is two terrain elements away from the front alcove (FIGURE B).

Procedure

1. Set the shelves to the intended testing elevation. Close cell doors. Place the **pick and place objects** on their appropriate pegs.
2. Place the robot outside the start/end line facing the alcoves.
3. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
4. Start the timer when the robot crosses the start/end line to capture total elapsed time for a complete shelf elevation, ending when the robot exits past the start/end line.
5. Grasp each reachable **pick and place object** with the manipulator tool tip, remove from its recessed peg mount, and place through the corresponding cell access door.
6. Repeat at the next higher shelf elevation until all elevations have been tested or the robot is no longer able to reach the cells.
7. Repeat all shelf elevations with other flooring options.
8. Robots may exit past the start/end line for maintenance or repairs.

Fault Conditions: (Fill out an Event Report)

- Failure to return past the start/end line

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

MANIPULATION: GRASPING DEXTERITY: WEIGHTED PAYLOAD

TRIAL ☐

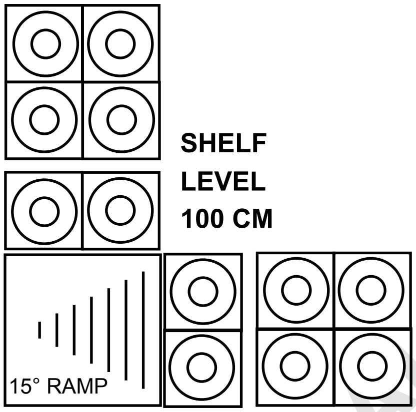
DATE ____________
FACILITY ____________
LOCATION ____________
EVENT ____________

ROBOT MAKE ____________
ROBOT MODEL ____________
CONFIGURATION ____________
OPERATOR/ORG ____________

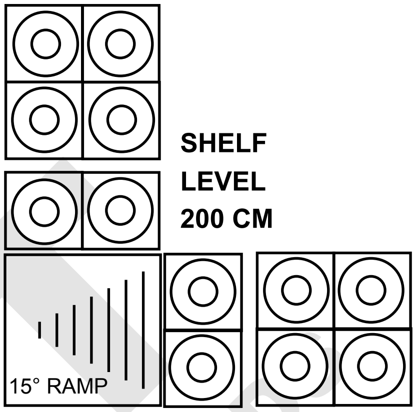
LIGHTING:
○ >100 LUX ○ <1 LUX

COMMUNICATIONS:
○ TETHER ○ RADIO

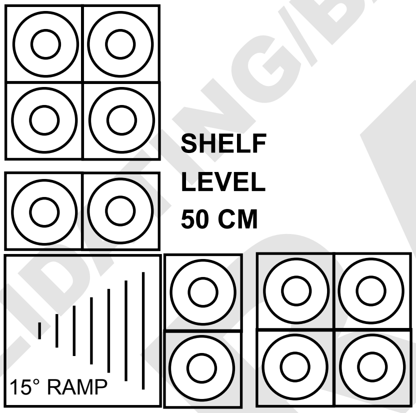
START (HH:MM) ☐
FINISH (HH:MM) ☐
ELAPSED (MIN) ☐
CORRECT (##.#) ☐
AVERAGE (MIN PER TASK) ☐
% TASKS (%) %



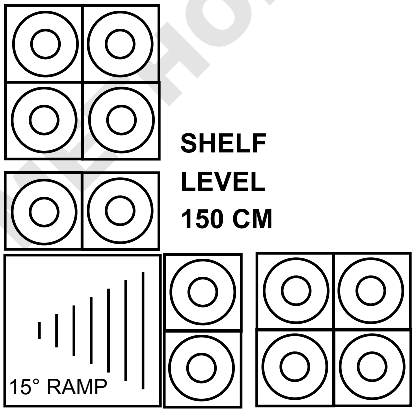
START (HH:MM) ☐
FINISH (HH:MM) ☐
ELAPSED (MIN) ☐
CORRECT (##.#) ☐
AVERAGE (MIN PER TASK) ☐
% TASKS (%) %



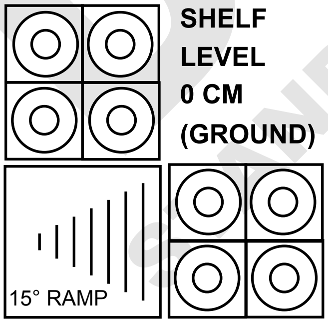
START (HH:MM) ☐
FINISH (HH:MM) ☐
ELAPSED (MIN) ☐
CORRECT (##.#) ☐
AVERAGE (MIN PER TASK) ☐
% TASKS (%) %



START (HH:MM) ☐
FINISH (HH:MM) ☐
ELAPSED (MIN) ☐
CORRECT (##.#) ☐
AVERAGE (MIN PER TASK) ☐
% TASKS (%) %



START (HH:MM) ☐
FINISH (HH:MM) ☐
ELAPSED (MIN) ☐
CORRECT (##.#) ☐
AVERAGE (MIN PER TASK) ☐
% TASKS (%) %



NOTES:

LEGEND: ○ 0.5 KG / 1 LB ● 3 KG / 7 LBS ● 7 KG / 15 LBS

◉ TASK 1: CYLINDER REMOVED FROM PEG

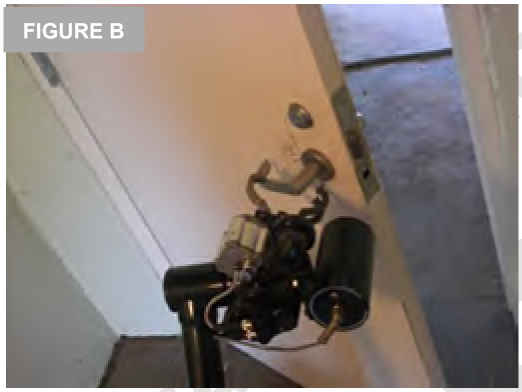
◉ TASK 2: CYLINDER PLACED COMPETELY INTO CELL

VIDEO FILE NAMING CONVENTION
ROBOTNAME-MANIP-DEX-##CM-##KG

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

FIGURE A

FIGURE B



MANIPULATION: DOOR OPENING AND TRAVERSAL TASKS

Purpose

The purpose of this test method is to quantitatively evaluate the door opening capabilities of a robot on increasingly complex terrain while being remotely teleoperated in confined areas with lighted and dark conditions.

Metrics

- Completion of two subtasks: unlatching the door and traversing through
- Average time per **repetition**

Apparatus

- The apparatus for this test method uses a set of common household 90 cm (36 in) entry doors that are installed on frames.
- The doors are to have the following types of handles and locks for opening: lever and knob, push and pull, spring loaded and not, flat and with a step.
- The latches can be on left or right side of the door (FIGURE A).
- The starting line will be marked on the floor at 1.2 m (4 ft) from the door.

Procedure

1. Place the robot at the starting position facing the door. Ensure that the door is latched, but not locked.
2. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
3. Start the timer when the robot begins and capture total elapsed time for a complete set of **repetitions**.
4. Open the door and drive through to the other side so the robot is clear of the door (spring loaded doors should shut). Repeat for 10 continuous **repetitions** without intervention.
5. Repeat the same door from the opposite side for 10 continuous **repetitions** without intervention.
6. Repeat for all other doors handle types and conditions.

Fault Conditions: (Fill out an Event Report)

- Failure to complete 10 continuous **repetitions**

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011
STATUS: VALIDATING-WK27852

Forms: v2011.1 Data: A

MANIPULATION: DOOR OPENING AND TRAVERSAL TASKS

TRIAL ☐

DATE 2010.__________
FACILITY __________
LOCATION __________
EVENT __________

ROBOT MAKE __________
ROBOT MODEL __________
CONFIGURATION __________
OPERATOR/ORG __________

LIGHTING:
○ **>100 LUX** ○ **<1 LUX**

COMMUNICATIONS:
○ **TETHER** ○ **RADIO**

TASK DESCRIPTION	START TIME (MIN)	REPETITIONS	END TIME (MIN)		ELAPSED TIME (MIN)		AVG TIME (MIN)	
HANDLE TYPE: LEVER OPENING BY: PUSH DOOR SPRING LOADED: NO	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐	MIN
HANDLE TYPE: LEVER OPENING BY: PULL DOOR SPRING LOADED: NO	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐	MIN
HANDLE TYPE: KNOB OPENING BY: PUSH DOOR SPRING LOADED: YES	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐	MIN
HANDLE TYPE: KNOB OPENING BY: PULL DOOR SPRING LOADED: YES	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	=	☐	MIN

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-MANIP-DOOR-PUSH/PULL-LEVER/KNOB

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

FIGURE A

FIGURE B

FIGURE C

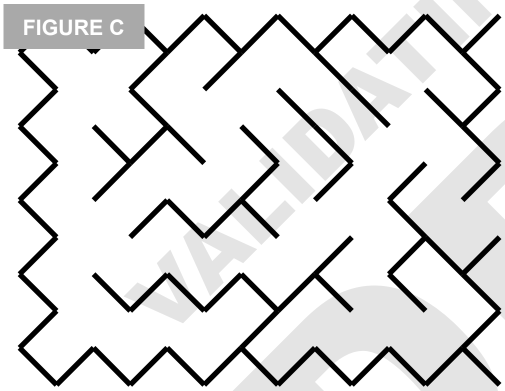
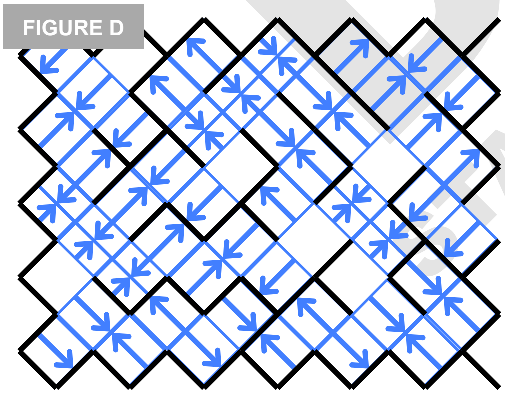


FIGURE D



HUMAN-SYSTEM INTERACTION: NAVIGATION TASKS: RANDOM MAZES

Purpose

The purpose of this test method is to quantitatively evaluate the navigation capabilities of a robot on increasingly complex terrain, while being remotely teleoperated in confined areas with lighted and dark conditions.

Metrics

- Number of **full and half ramp flooring elements** traversed while wall following ("right-hand" or "left-hand") through the maze (complexity measure).
- Completion time.

Apparatus

- This test apparatus is a random maze of 1.2 m (4 ft) wide hallways constructed with 1.2 m x 2.4 m (4 ft x 8 ft) tall OSB walls (FIGURE A, B).
- The overall dimensions are roughly 10 m x 15 m (33 ft x 50 ft) (FIGURE C).
- The flooring is made of continuous **full and half ramp flooring elements** to provide complexity in robot orientation and operator awareness (FIGURE D).
- **Targets** are placed on the far walls of dead-ends only.

Procedure

1. Place the robot at the starting position facing into the apparatus.
2. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
3. Start the timer when the robot begins and capture total elapsed time for a complete negotiation of the maze ending when the robot returns to the start position.
4. Traverse the maze using the prescribed "**right hand**" or "**left hand" wall following** technique to navigate completely through the maze. Contact with the walls is allowed. Flooring pallets in dead-ends must be fully occupied to be counted (touch the **Target** on the far wall).
5. The robot may return to the start point to allow for maintenance and/or repairs during the test. The timer will be paused during maintenance and an Event Report should be generated.
6. The robot must return to the start point at the end of the test.

Fault Conditions: (Fill out an Event Report)

- Failure to return to start point.

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

HSI: NAVIGATION TASKS: RANDOM MAZES

TRIAL ☐

DATE 2010.____________

FACILITY ____________

LOCATION ____________

EVENT ____________

ROBOT MAKE ____________

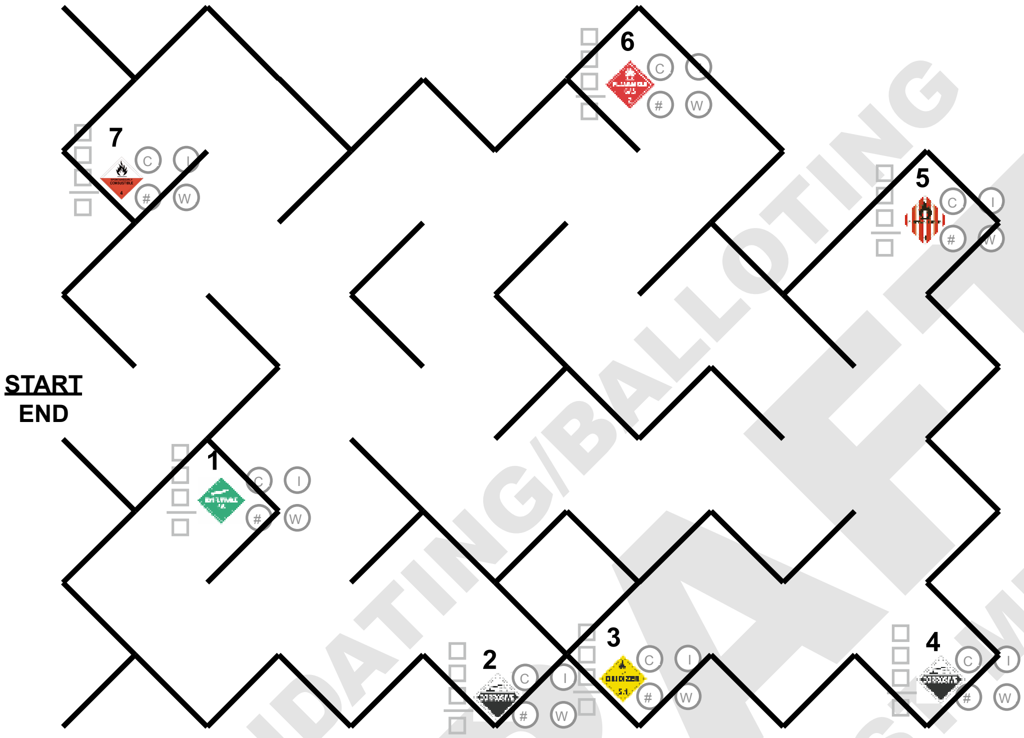
ROBOT MODEL ____________

CONFIGURATION ____________

OPERATOR/ORG ____________

LIGHTING:
○ >100 LUX ○ <1 LUX

COMMUNICATIONS:
○ TETHER ○ RADIO



START TIME (HH:MM) ☐

FINISH TIME (HH:MM) ☐

ELAPSED (MIN) ☐

LEFT ○ **WALL FOLLOWING** ○ **RIGHT**

○ **RETURNED TO START POINT?**

LABEL # :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CORRECT ID:	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
MULTIPLE ID:	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
MISSED:	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

TARGETS PLACED

☐ %

CLEARED

↑

CORRECT ☐

=

☐ **PLACED**

LEGEND: ⊗ PARTIAL ID
● CORRECT ID
🟥 MULTIPLE ID / MISSED

☐☐☐☐ TARGET HEIGHT

COLOR Ⓒ Ⓘ ICON
NUMBER # Ⓦ WORDS

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-HSI-MAZE-SEARCH

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

FIGURE A

FIGURE B

FIGURE C

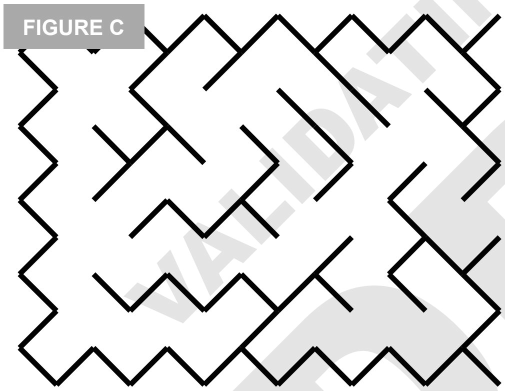
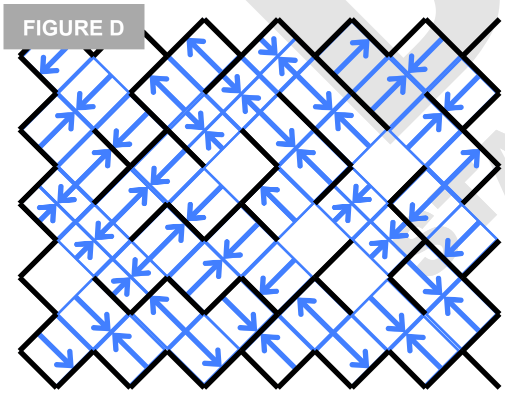


FIGURE D



HUMAN-SYSTEM INTERACTION: SEARCH TASKS: RANDOM MAZES

Purpose

The purpose of this test method is to quantitatively evaluate the search capabilities of a robot on increasingly complex terrain while being remotely teleoperated in confined areas with lighted and dark conditions.

Metrics

- Percentage (%) of **targets** correctly identified, incorrectly identified (visual acuity), multiply identified (loss of spatial awareness), or missed (field of view).
- Completion time.

Apparatus

- This test apparatus is a random maze of 1.2 m (4 ft) wide hallways constructed with 1.2 m x 2.4 m (4 ft x 8 ft) tall OSB walls (FIGURE A, B).
- The overall dimensions are roughly 10 m x 15 m (33 ft x 50 ft) (FIGURE C).
- The flooring is made of continuous **full and half ramp flooring elements** to provide complexity in robot orientation and operator awareness (FIGURE D).
- **Targets** are distributed throughout the maze in quantities unknown to the robot operator.

Procedure

1. Place the robot at the starting position facing into the apparatus.
2. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
3. Start the timer when the robot begins and capture total elapsed time for a complete search ending when the robot returns to the start position.
4. Search the maze to find, identify, and map all **targets**, contact with the walls is allowed.
5. The robot may return to the start point to allow for maintenance and/or repairs during the test. The timer will be paused during maintenance and an Event Report should be generated.
6. The robot must return to the start point at the end of the test.

Fault Conditions: (Fill out an Event Report)

- Failure to return to start point.

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

HSI: SEARCH TASKS: RANDOM MAZES

TRIAL ☐

DATE 2010.__________ **ROBOT MAKE** __________

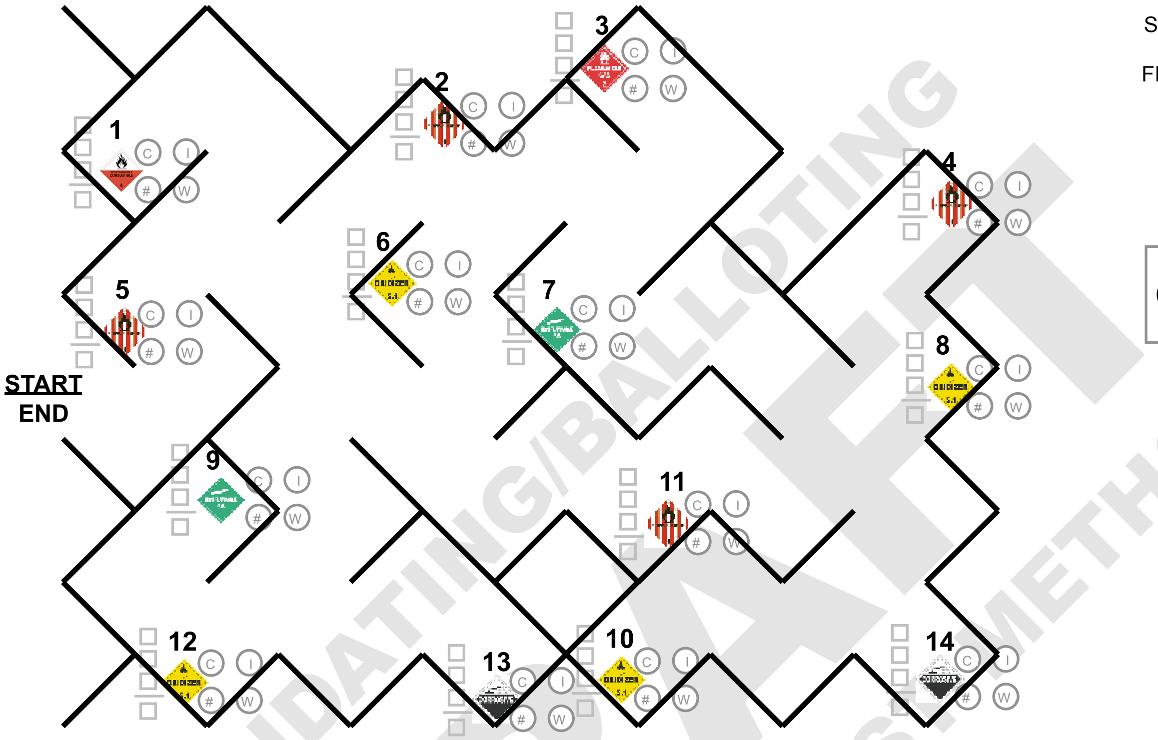
FACILITY __________ **ROBOT MODEL** __________

LOCATION __________ **CONFIGURATION** __________

EVENT __________ **OPERATOR/ORG** __________

LIGHTING:
○ **>100 LUX** ○ **<1 LUX**

COMMUNICATIONS:
○ **TETHER** ○ **RADIO**



START TIME (HH:MM) ☐

FINISH TIME (HH:MM) ☐

ELAPSED (MIN) ☐

○ **RETURNED TO START POINT?**

LABEL # :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CORRECT ID:	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
MULTIPLE ID:	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
MISSED:	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

TARGETS PLACED

☐ %

CLEARED

↑

CORRECT

= ☐

☐

PLACED

LEGEND:	⊗	PARTIAL ID	☐ ☐ ☐ ☐ TARGET ELEVATION	COLOR C	I ICON
	●	CORRECT ID			
	#	MULTIPLE ID / MISSED		NUMBER #	W WORDS

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-HSI-MAZE-SEARCH

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

FIGURE A

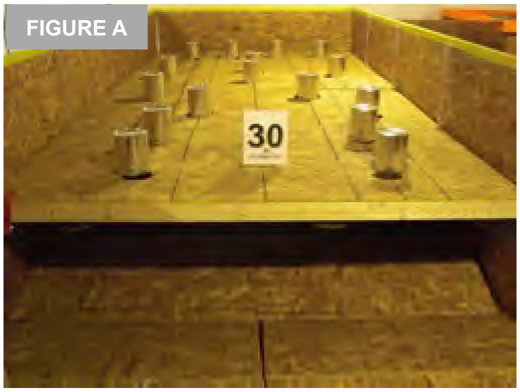


FIGURE B

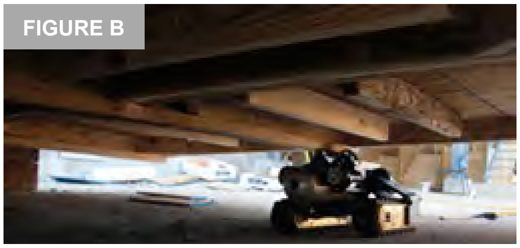


FIGURE C

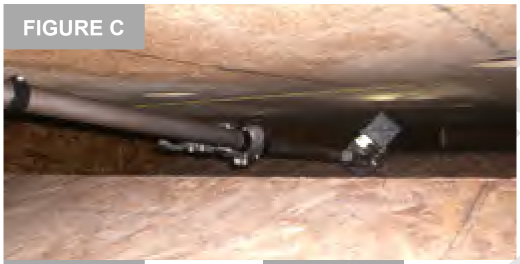


FIGURE D

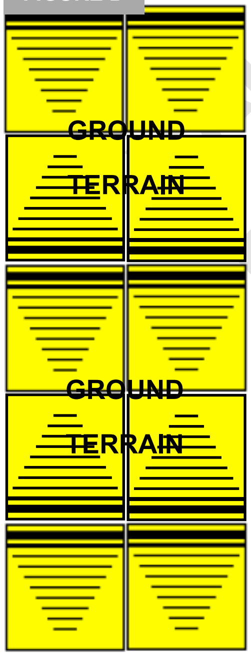
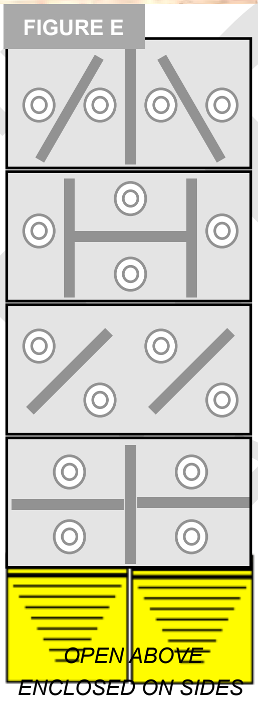


FIGURE E



HUMAN-SYSTEM INTERACTION: SEARCH TASKS: CONFINED SPACE VOIDS

Purpose

The purpose of this test method is to quantitatively evaluate the under-body search capabilities of a robot on increasingly complex terrain while being remotely teleoperated in confined areas with lighted and dark conditions.

Metrics

- Percentage of **targets** successfully identified at each level
- Completion time.

Apparatus

- The flooring terrain consists of continuous **half ramp terrain elements** setup to provide complexity for camera pointing (FIGURE A, D).
- The ceiling consists of five 1.2 m x 2.4 m (4 ft x 8 ft) OSB panels with four 15 cm (6 in) holes cut in the various patterns, and 5 cm x 10 cm (2 in x 4 in) wood ribbing as occlusions (FIGURE E).
- The ceiling panel elevations are adjustable in 10 cm (4 in) increments. This provides variable clearance underneath for different size robots.
- Each hole is covered by an inverted, opaque, 4 liter (1 gallon) can with a **target** inside to provide a recessed inspection task.
- Panels have unique hole locations therefore switching panels changes the hole patterns for the overall test (FIGURE E).
- Not all holes are always fitted with cans and not every can has a **target** inside to identify.
- Empty holes are plugged to limit lighting under the ceiling.
- This test apparatus is intended to fit into a 12 m x 2.4 m (40 ft x 8 ft) standard ISO shipping container. It can also be setup as a freestanding apparatus with 1.2 m (4 ft) tall walls with supports.

Procedure

1. Set the ceiling apparatus to the intended clearance elevation for testing. Note panel placement changes on form.
2. Place the robot at the starting position facing the apparatus.
3. Turn the lights on (>100 lux) or off (<1 lux) if testing in darkness.
4. Start the timer to capture total elapsed time for a complete search, ending when the robot returns to the start position.
5. Search the underpass at the elevation to identify all **targets** then eturn to the start point.
6. Change the **target** locations and/or the ceiling panels. Lower the ceiling one increment of 10 cm (4 in) and repeat.

Fault Conditions: (Fill out an Event Report)

- Failure to return to start point.

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011
STATUS: VALIDATING

Forms: v2011.1 Data: A

HSI: SEARCH TASKS: CONFINED SPACE VOIDS

TRIAL ☐

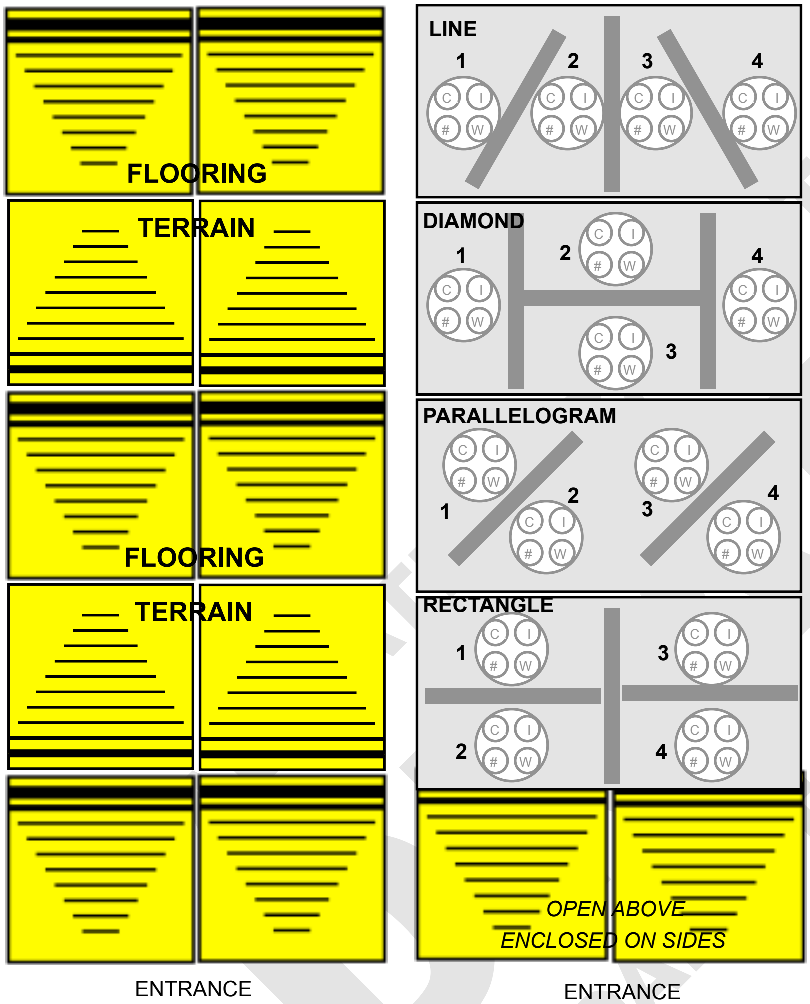
DATE 2010.____________
FACILITY ____________
LOCATION ____________
EVENT ____________

ROBOT MAKE ____________
ROBOT MODEL ____________
CONFIGURATION ____________
OPERATOR/ORG ____________

LIGHTING:
○ **>100 LUX** ○ **<1 LUX**

COMMUNICATIONS:
○ **TETHER** ○ **RADIO**

START TIME (HH:MM) ☐
FINISH TIME (HH:MM) ☐
ELAPSED (MIN) ☐



	1	2	3	4
MULTIPLE ID	☐	☐	☐	☐
MISSED	☐	☐	☐	☐

	1	2	3	4
MULTIPLE ID	☐	☐	☐	☐
MISSED	☐	☐	☐	☐

	1	2	3	4
MULTIPLE ID	☐	☐	☐	☐
MISSED	☐	☐	☐	☐

	1	2	3	4
MULTIPLE ID	☐	☐	☐	☐
MISSED	☐	☐	☐	☐

MINIMUM CEILING ELEVATION
(CM/IN)
☐

CONSIDER FLOORING PEAKS WHEN MEASURING

TARGET POINTS ☐
TARGETS PLACED ☐
= CLEARED ☐ %

LEGEND: 🟥 # MULTIPLE ID / MISSED

BE SURE THIS FORM DRAWING REFLECTS THE ACTUAL APPARATUS PANEL ORDER

COLOR (C) ICON (I)
NUMBER (#) WORDS (W)

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-HSI-UNDERPASS-##CM

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

SENSORS: VIDEO: ACUITY CHARTS and FIELD OF VIEW MEASURES

Purpose

The purpose of this test method is to quantitatively evaluate the color video, visual acuity, field of view, zooming, and variable illumination capabilities of a robot while being remotely teleoperated in lighted and dark conditions.

Metrics

- Color video capability (check)
- Near field acuity (Snellen fraction)
- Far field acuity (Snellen fraction)
- Field of view (degrees)

Apparatus

- This test apparatus is implemented in a 12 m x 2.4 m (40 ft x 8 ft) standard ISO shipping container with a center terrain element.
- No flooring terrain is used.
- Snellen far field eye charts and an assortment of hazmat labels are posted on the wall at the far end of the container, 6 m (20 ft) from the centerline of the container, which is the standard distance for the eye chart usage (FIGURE A).
- A Snellen near field eye chart is placed on a free standing pole which allows elevation adjustments for the eye chart to be aligned at 40 cm (16 in) away from the container center line and at the same level as the individual camera on the robot (FIGURE B).
- The field of view lines are marked on the wall starting at the far end of the container with 5° separation from the point of view of the robot. Each side ranges from 5° to 60° to accommodate a 120° field of view (FIGURE C).

Procedure

1. Note the camera features for each camera on the robot as per the form, and measure the lighting to ensure at least 1000 lux.
2. Place the robot on the terrain element at the center of the container behind the 6 m (20 ft) line. The robot is allowed to move but must remain on the terrain element while viewing.
3. Measure the field of view of the camera by counting orange lines to the widest angle.
4. Read the eye charts from the 6 m (20 ft) distance and circle the decimal equivalent for the smallest correct line read normally and then with the zoom lens if available.
5. Place the near field chart in front of the robot, 40 cm (16 in) from the line and at the same level as the camera being tested. Read the near field chart and circle smallest correct line read normally and with the zoom lens if available.
6. Repeat with the lights out (<1 lux).
7. Repeat for all cameras on the robot.

FIGURE A

FIGURE B

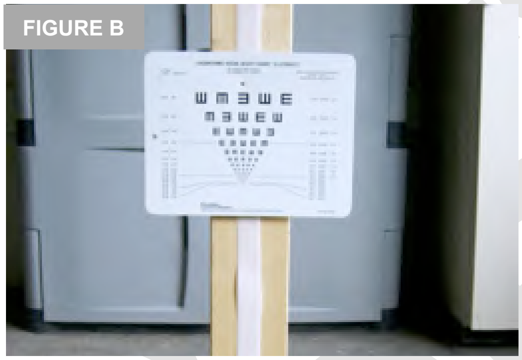


FIGURE C

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 20 STATUS: ASTM E2566-08

Forms: v2011.1 Data: A

SENSORS: VIDEO: ACUITY CHARTS and FIELD OF VIEW

TRIAL ☐

DATE 2010.__________

ROBOT MAKE __________

FACILITY __________

ROBOT MODEL __________

LOCATION __________

CONFIGURATION __________

EVENT __________

OPERATOR/ORG __________

CAMERA NAME ☐

FOV (DEG) ☐

○ COLOR
○ B/W
○ LOW LIGHT

○ ILLUMINATION
○ VARIABLE

PAN (DEG) ☐
TILT (DEG) ☐
ZOOM (X) ☐

START TIME (HH:MM) ☐
FINISH TIME (HH:MM) ☐
ELAPSED (MIN) ☐

FAR FIELD TEST (DISTANCE = 6.0 METERS)

TEST DISTANCE 6 M (20 FT)	LIGHTED CHART (1000 LUX) NORMAL	LIGHTED CHART (1000 LUX) ZOOM	DARK CHART (1 LUX) NORMAL	DARK CHART (1 LUX) ZOOM
AERIAL CHART	NONE	NONE	NONE	NONE
6/150 (20/500)	0.04	0.04	0.04	0.04
6/120 (20/400)	0.05	0.05	0.05	0.05
6/90 (20/300)	0.07	0.07	0.07	0.07
6/70 (20/240)	0.08	0.08	0.08	0.08
6/60 (20/200)	0.10	0.10	0.10	0.10
6/50 (20/160)	0.12	0.12	0.12	0.12
6/40 (20/125)	0.16	0.16	0.16	0.16
FAR FIELD CHART				
6/30 (20/100)	0.20	0.20	0.20	0.20
6/24 (20/80)	0.25	0.25	0.25	0.25
6/18 (20/60)	0.33	0.33	0.33	0.33
6/15 (20/50)	0.40	0.40	0.40	0.40
6/12 (20/40)	0.50	0.50	0.50	0.50
6/9.0 (20/30)	0.67	0.67	0.67	0.67
6/7.5 (20/25)	0.80	0.80	0.80	0.80
6/6.0 (20/20)	1.00	1.00	1.00	1.00
6/4.8 (20/16)	1.25	1.25	1.25	1.25
6/3.8 (20/12)	1.70	1.70	1.70	1.70
6/3.0 (20/10)	2.00	2.00	2.00	2.00
6/2.4 (20/8)	2.50	2.50	2.50	2.50
6/1.7 (20/6)	3.30	3.30	3.30	3.30
6/1.5 (20/5)	4.00	4.00	4.00	4.00
NEAR FIELD CHART	(BOTTOM LINES ADJUSTED TO 6M)			
6/1.25 (20/4)	5.00	5.00	5.00	5.00
6/1.00 (20/3.3)	6.00	6.00	6.00	6.00
6/0.80 (20/2.7)	7.50	7.50	7.50	7.50
6/0.60 (20/2.0)	10.0	10.0	10.0	10.0
6/0.50 (20/1.7)	12.0	12.0	12.0	12.0
6/0.40 (20/1.3)	15.0	15.0	15.0	15.0
6/0.30 (20/1.1)	20.0	20.0	20.0	20.0
6/0.25 (20/.08)	24.0	24.0	24.0	24.0
6/0.20 (20/.07)	30.0	30.0	30.0	30.0

NEAR FIELD TEST (DISTANCE = 0.40 METER)

TEST DISTANCE 0.4M (16 IN)	LIGHTED CHART (1000 LUX) NORMAL	LIGHTED CHART (1000 LUX) ZOOM	DARK CHART (1 LUX) NORMAL	DARK CHART (1 LUX) ZOOM
NEAR FIELD CHART	NONE	NONE	NONE	NONE
6/120 (20/400)	0.05	0.05	0.05	0.05
6/96 (20/320)	0.06	0.06	0.06	0.06
6/75 (20/250)	0.08	0.08	0.08	0.08
6/60 (20/200)	0.10	0.10	0.10	0.10
6/48 (20/160)	0.12	0.12	0.12	0.12
6/38 (20/125)	0.16	0.16	0.16	0.16
6/30 (20/100)	0.20	0.20	0.20	0.20
6/24 (20/80)	0.25	0.25	0.25	0.25
6/19 (20/63)	0.32	0.32	0.32	0.32
6/15 (20/50)	0.40	0.40	0.40	0.40
6/12 (20/40)	0.50	0.50	0.50	0.50
6/9.5 (20/32)	0.63	0.63	0.63	0.63
6/7.5 (20/25)	0.80	0.80	0.80	0.80
6/6.0 (20/20)	1.00	1.00	1.00	1.00
6/4.8 (20/16)	1.25	1.25	1.25	1.25
6/3.8 (20/12)	1.60	1.60	1.60	1.60
6/3.0 (20/10)	2.00	2.00	2.00	2.00

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTMODEL-SEN-VISUAL-ACUITY

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

SENSORS: VIDEO: DIRECTED SEARCH TASKS (DETAILED)

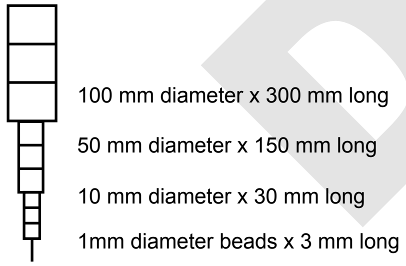
FIGURE A

FIGURE B

GREY SCALE VERSION

COLORED VERSION

Standardized totem: cylinders and spheres with red, green, and blue color in random orders. Also in three grey-scale gradients.



Purpose

The purpose of this test method is to quantitatively evaluate the camera pointing capabilities of a robot on increasingly complex terrain while being remotely teleoperated in lighted and dark conditions.

.

Metrics

- Correct identification of the three colors of the smallest diameter cylinders for each **shape totem**.

Apparatus

- This test apparatus is contained in a 2.4 m x 12 m (8 ft x 40 ft) standard ISO shipping container to allow testing in almost complete darkness (< 1 lux) and environmental complexity such as smoke, rain, etc.
- A **full ramp terrain element** with friction surface is placed at the center of the container to maintain the robot on a side roll orientation relative to the major container axes and provide complexity in camera pointing (FIGURE A).
- Twenty **shape totems** are placed along the edge of the container, equally spaced at five cross-planes from end to end.
- Each totem contains four cylindrical sections of decreasing diameter 100 mm, 50 mm, 10 mm, 1 mm (4 in, 2 in, 0.4 in, 0.04 in) (FIGURE B).
- Each cylinder section is taped in three colors (red, green, and blue) in random order with lengths equal to the cylinder diameter.

Procedure

1. Place the robot on the **full ramp terrain element** in the center of the container. The robot may rotate but must stay on the ramp during the entirety of the test. If the robot falls off the ramp, the robot must return to the ramp before continuing identification of **targets**. Use any available cameras.
2. Identify all **shape totems** by identifying the colors for the smallest visible cylinders. Test administrator will verify over operator's shoulder.
3. Points are given for each diameter cylinder: 1 point for the largest diameter to 4 points for the smallest diameter. Only the smallest correctly identified cylinders are scored for a given **shape totem**.
4. For each of the 5 **targets** (around the **full ramp terrain element** and on the ceiling above the ramp) each identifier is worth 4 point for a total of 20 points available.
5. Repeat with the lights out (<1 lux) if testing in darkness.

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011
STATUS: VALIDATING

Forms: v2011.1 Data: A

SENSORS: VIDEO: DIRECTED SEARCH TASKS (DETAILED)

TRIAL ☐

DATE 2010.__________

FACILITY __________

LOCATION __________

EVENT __________

ROBOT MAKE __________

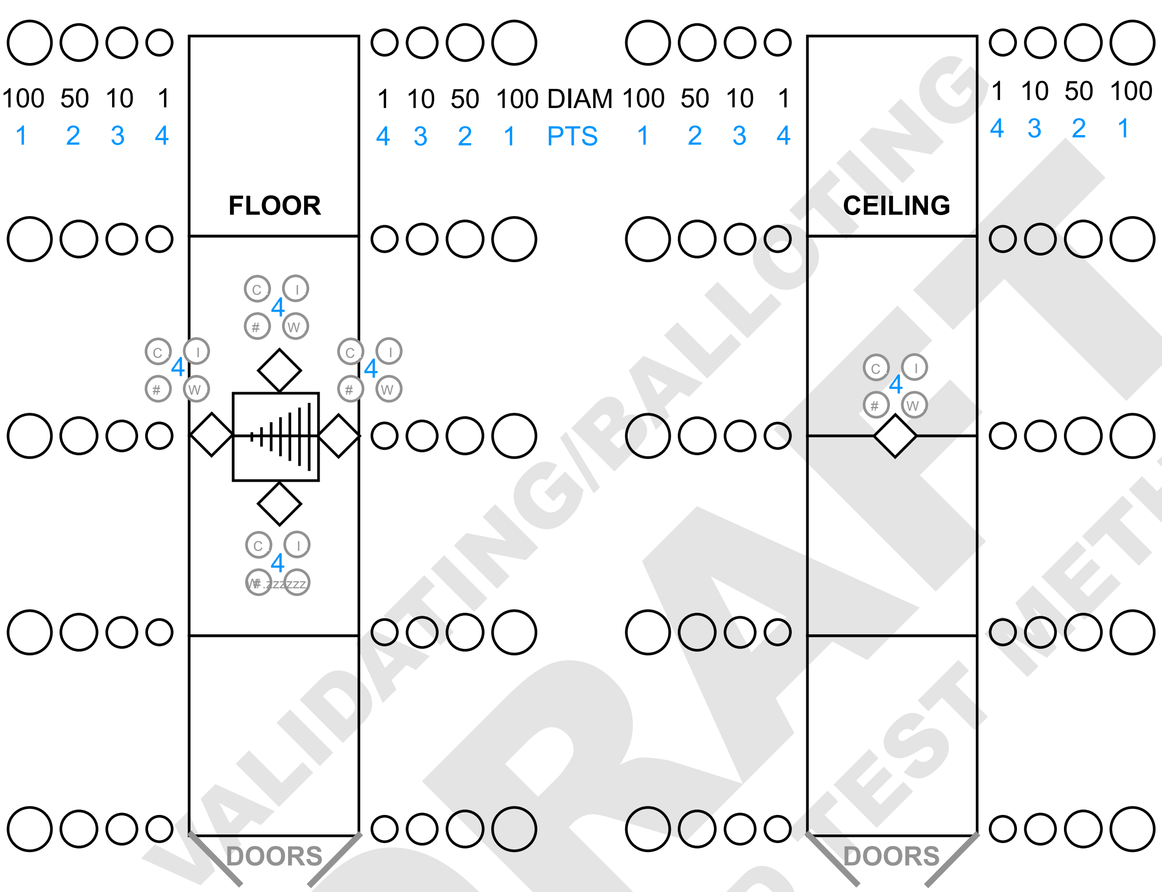
ROBOT MODEL __________

CONFIGURATION __________

OPERATOR/ORG __________

LIGHTING:
○ **>100 LUX** ○ **<1 LUX**

COMMUNICATIONS:
○ **TETHER** ○ **RADIO**



START TIME (HH:MM) ☐

FINISH TIME (HH:MM) ☐

ELAPSED (MIN) ☐

LEGEND:
COLOR ICON
Ⓒ Ⓘ
\# Ⓦ
NUMBER WORDS

NUMBER OF TARGETS IDENTIFIED (SMALLEST):	○	○	○	○	◇	=	**TARGETS** ☐
MULTIPLY TIMES POINTS PER TARGET:	x1	x2	x3	x4	x4		
TOTAL POINTS PER TARGET:	☐ +	☐ +	☐ +	☐ +	☐	=	**POINTS** ☐

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-SEN-VISUAL-DIRSEARCH-DETAIL

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

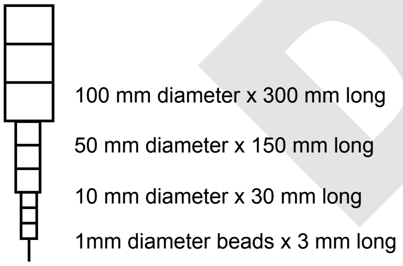
FIGURE A

FIGURE B


GREY SCALE VERSION

COLORED VERSION

Standardized totem: cylinders and spheres with red, green, and blue color in random orders. Also in three grey-scale gradients.



SENSORS: VIDEO: DIRECTED SEARCH TASKS (RAPID)

Purpose

The purpose of this test method is to quantitatively evaluate the camera pointing capabilities of a robot on increasingly complex terrain while being remotely teleoperated in lighted and dark conditions.

Metrics

- Number of **targets** correctly identified.
- Average time per **target**.

Apparatus

- This test apparatus is contained in a 2.4 m x 12 m (8 ft x 40 ft) standard ISO shipping container to allow testing in almost complete darkness (< 1 lux) and environmental complexity such as smoke, rain, etc.
- A **full ramp terrain element** with friction surface is placed at the center of the container to maintain the robot on a side roll orientation relative to the major container axes and provide complexity in camera pointing (FIGURE A).
- Twenty **totems** are placed along the edge of the container, equally spaced at five cross-planes from end to end.
- Each totem contains four cylindrical sections of decreasing diameter (100 mm, 50 mm, 10 mm, 1 mm (4 in, 2 in, 0.4 in, 0.04 in)) (FIGURE B).
- Each cylinder section is taped in three colors (red, green, and blue) in random order with lengths equal to the cylinder diameter.

Procedure

1. Place the robot on the **full ramp terrain element** in the center of the container. The robot may rotate but must stay on the ramp during the entirety of the test. If the robot falls off the ramp, the robot must return to the ramp before continuing identification of **targets**. Use any available cameras.
2. Indicate a sequence of 10 **targets** alternating from floor to ceiling and front to back. The two required **targets** in the mid-plane are the ceiling **target** and one of the four available ramp **targets**. Pick one floor **target** and one ceiling **target** from each of the other four cross-planes.
3. Record the number of **targets** correctly identified and the elapsed time.
4. Repeat with the lights off (<1 lux).

Fault Conditions: (Fill out an Event Report)

- Failure to identify all 10 **targets** indicated

SENSORS: VIDEO: DIRECTED SEARCH TASKS (RAPID)

TRIAL ☐

DATE 2010.

FACILITY

LOCATION

EVENT

ROBOT MAKE

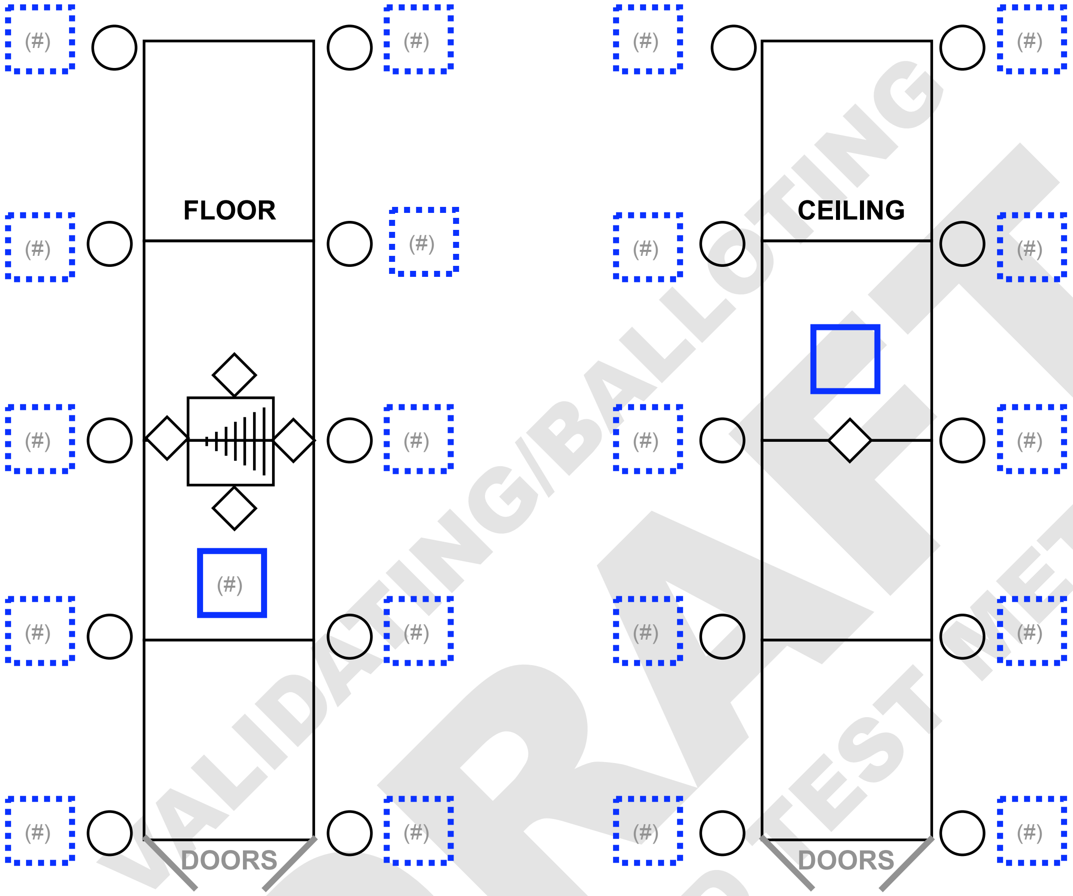
ROBOT MODEL

CONFIGURATION

OPERATOR/ORG

LIGHTING:
○ **>100 LUX** ○ **<1 LUX**

COMMUNICATIONS:
○ **TETHER** ○ **RADIO**



START TIME (HH:MM) ☐

FINISH TIME (HH:MM) ☐

ELAPSED (MIN) ☐

AVERAGE (MIN) ☐

LEGEND: (#) Indicate the order of **targets** chosen prior to test.

NOTES:

FIGURE A

SENSORS: AUDIO: SPEECH INTELLIGIBILITY RHYMING WORDS

Purpose

The purpose of this test method is to quantitatively evaluate the one/two-way speech intelligibility capabilities of a remotely teleoperated robot.

Metric

- Percentage of words correctly identified from lists of standard rhyming words spoken by male and female voices

Apparatus

- This test apparatus is a set of pre-recorded audio pronunciations from male and female voices speaking standard rhyming words [ANSI S3.2 1999/ASA 85-1989], or other designated words /number sets.
- A computer or portable player is need to play randomly select words through a speaker system with a subwoofer.
- The speakers are initially placed 3 m (10 ft) in front of the remote robot the operator to identify at the operator station.
- Then the system is reversed so the speakers play words at the operator station microphone for the operator to identify at the robot.
- Then the speakers are placed at the operator station.

Procedure

1. Measure the background audio to ensure it is less than 50 dB.
2. Place the robot at the start point facing the speakers.
3. To test the system from ROBOT TO OPERATOR, play an alternating list of 12 male and 12 female words through the speakers in front of the robot. The words should be randomly generated and equally distributed between male and female. The robot operator should circle the word heard through the OCU on a list of all possible words provided. Headphones are allowed.
4. Reverse the system to test from OPERATOR TO ROBOT by switching the location of the speakers to the OCU and move the operator to the the position 3 m (10 ft) in front of the remote robot.
5. Play a different alternating male and female list of 24 words through the speakers into the OCU microphone. The words should be randomly generated and equally distributed between male and female. The operator should circle the word heard through the robot speaker(s) on a list of all possible words provided.

FIGURE A

FIGURE B

SAFETY/ENVIRONMENT: WASHDOWN/ DECONTAMINATION PRACTICE

Purpose

The purpose of this practice is to qualitatively evaluate a robot's washdown vulnerabilities and identify specific design issues that may hinder complete decontamination.

Metric

- Best practice, involves no metric

Apparatus

- This test uses a simulated contaminant applied consistently over the robot that is invisible in normal lighting, but glows in ultra -violet.
- The apparatus consists of an elevated platform in a washdown tub, a similar elevated platform in a rinsing tub, and an adjoining bridge.
- A low pressure water supply is used along with a set of typical brushes and additional tools used by the emergency responder community.
- A hand-held ultra-violet light source (black light) is also used.

Procedure

1. Contaminate the robot with powder and/or liquid simulants in a controlled area.
2. Drive the robot onto the elevated platform in the washdown tub.
3. Operator decontaminate the robot using water and/or brushes for 5 minutes.
4. Administrator uses the black light to examine for the existence of contaminants out of sight of operator.
5. Repeat steps 3-4 until the robot is free of contaminants or 50 minutes of decontamination elapse.

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011 STATUS: VALIDATING

Forms: v2011.1 Data: A

SAFETY/ENVIRONMENT: WASHDOWN/DECONTAMINATION

TRIAL ☐

DATE 2010.__________

FACILITY __________

LOCATION __________

EVENT __________

ROBOT MAKE __________

ROBOT MODEL __________

CONFIGURATION __________

OPERATOR/ORG __________

LIGHTING:
○ **>100 LUX** ○ **<1 LUX**

COMMUNICATIONS:
○ **TETHER** ○ **RADIO**

TASK DESCRIPTION	START TIME (MIN)	5 MINUTE INCREMENTS	END TIME (MIN)		ELAPSED TIME (MIN)	

○ INFRARED PICTURES TAKEN FROM ALL ANGLES IN NEAR DARKNESS

WASH DOWN	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	MIN

○ INFRARED PICTURES TAKEN FROM ALL ANGLES IN NEAR DARKNESS

WASH DOWN	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	MIN

○ INFRARED PICTURES TAKEN FROM ALL ANGLES IN NEAR DARKNESS

WASH DOWN	☐	1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○	☐	=	☐	MIN

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-SAFETY-DECON

NAME/ORGANIZATION:
XXX

FIGURE A

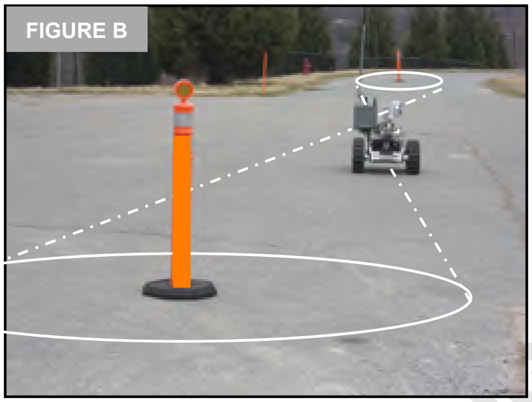


FIGURE B

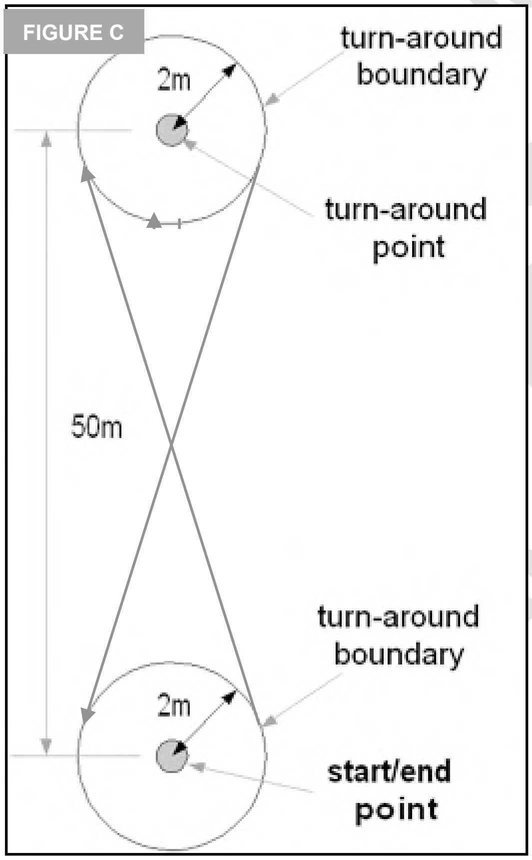


FIGURE C

AERIAL: sUAS (GROUP I) VTOL ENDURANCE

Purpose

The purpose of this test method is to quantitatively evaluate the aerial endurance capabilities of a small unmanned aircraft system (sUAS) with vertical take-off and landing flight operations while being remotely teleoperated in lighted and dark conditions. This test method is intended for Group I sUAS systems defined by the FAA Aviation Rulemaking Committee as having less than 2kg (4.4.bs) gross take-off weight, under 30 knots air speed at full power in level flight, and made in a frangible manner.

Metrics

- Average of smallest correctly read lines via remote video display (an optional still image capture) while hovering near each eye chart for 10 **repetitions**
- Average time per **repetition**

Apparatus

- Five sets of eye charts and hazmat placards and labels (for reference size and color only) FIGURE B.
- Set the targets 5 meters apart to form a square with one at the center FIGURE C.
- Targets should be mounted on a vertical wall and on the ground separately to test forward and downward facing sensors.

Procedure

1. The test should be conducted indoors to control for wind and lighting. However, if conducted outdoors, note the average wind speed and any wind gusts that disrupt target identification stand-offs.
2. Place the robot at the starting position near the operator station 10 meters from the apparatus.
3. Start the timer when the robot begins and capture total elapsed time for a complete set of **repetitions** at all the available targets identified twice.
4. The targets may be identified in any order, but never the same target sequentially. Robots should maintain a stand-off 2 meters from the target for 20 continuous seconds while identifying
5. Note the average minimum line sizes for all **repetitions**.
6. (Additional capabilities can also be noted by capturing high-resolution still images for evaluation)

Fault Conditions: (Fill out an Event Report)

- Failure to complete 10 continuous **repetitions**

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

AERIAL: sUAS (GROUP I) VTOL ENDURANCE

TRIAL ☐

DATE 2010.__________ **ROBOT MAKE** __________

FACILITY __________ **ROBOT MODEL** __________

LOCATION __________ **CONFIGURATION** __________

EVENT __________ **OPERATOR/ORG** __________

LIGHTING:
○ **>100 LUX** ○ **<1 LUX**

COMMUNICATIONS:
○ **TETHER** ○ **RADIO**

BATTERY: ○ NEW ○ USED

TEMPERATURE: ○ -20°C ○ 20°C ○ 50°C

WIND SPEED: ☐ KM/HR ☐ KNOTS

REPETITIONS (#)		METERS PER LAP		TOTAL DISTANCE (METERS)
☐	–	100	=	☐

START TIME (HH:MM)		END TIME (HH:MM)		ELAPSED (MIN)		1 MIN DWELLS (MIN)		TOTAL TIME (MIN)
☐	–	☐	=	☐	–	☐	=	☐

REPETITIONS: FIGURE-8 LAPS (100M/330FT)

AVERAGE SPEED (METERS / MIN)
☐

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**DWELL**
○	○	○	○	○	○	○	○	○	○	☐
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
○	○	○	○	○	○	○	○	○	○	☐
21	**2**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	
○	○	○	○	○	○	○	○	○	○	☐
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	
○	○	○	○	○	○	○	○	○	○	☐
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	
○	○	○	○	○	○	○	○	○	○	☐

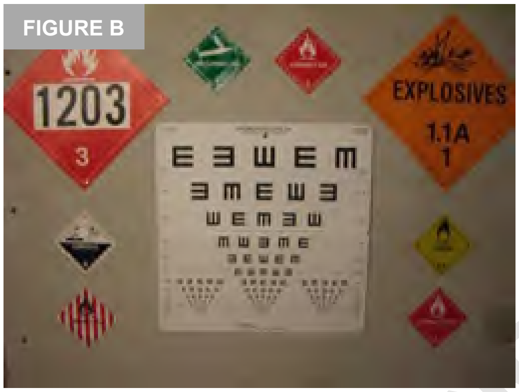
NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-SAFETY-DECON

NAME/ORGANIZATION:
XXX

FIGURE A

FIGURE B



AERIAL: sUAS (GROUP I) VTOL STATION-KEEPING

Purpose

The purpose of this test method is to quantitatively evaluate the aerial station-keeping capabilities of a small unmanned aircraft system (sUAS) with vertical take-off and landing flight operations, including visual acuity and obstacle avoidance/interaction, while being remotely teleoperated in lighted and dark conditions. This test method is intended for Group I sUAS systems defined by the FAA Aviation Rulemaking Committee as having less than 2kg (4.4.bs) gross take-off weight, under 30 knots air speed at full power in level flight, and made in a frangible manner.

Metrics

- Average of smallest correctly read lines via remote video display (an optional still image capture) while hovering near each eye chart for 10 **repetitions**
- Average time per **repetition**

Apparatus

- Five sets of eye charts and hazmat placards and labels (for reference size and color only) FIGURE B.
- Set the targets 5 meters apart to form a square with one at the center FIGURE C.
- Targets should be mounted on a vertical wall and on the ground separately to test forward and downward facing sensors.

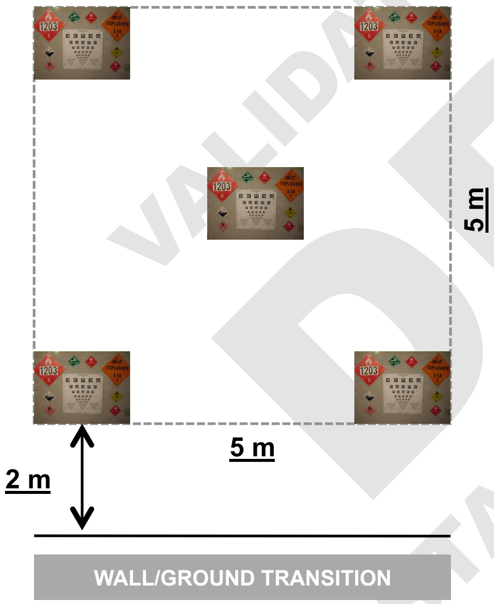
Procedure

1. The test should be conducted indoors to control for wind and lighting. However, if conducted outdoors, note average wind speed and any wind gusts that disrupt target identification.
2. Place the robot at the starting position near the operator station 10 meters from the apparatus.
3. Start the timer when the robot begins and capture total elapsed time for a complete set of **repetitions** at all the available targets identified twice.
4. The targets may be identified in any order, but never the same target sequentially. Robots should maintain a stand-off 2 meters from the target for 20 continuous seconds while identifying
5. Note the average minimum line sizes for all **repetitions**.
6. (Additional capabilities can also be noted by capturing high -resolution still images for evaluation)

Fault Conditions: (Fill out an Event Report)

- Failure to complete 10 continuous **repetitions**

FIGURE C



NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011
STATUS: VALIDATING

Forms: v2011.1 Data: A

AERIAL: sUAS (GROUP I) VTOL STATION-KEEPING

TRIAL ☐

DATE 2010.________

FACILITY ________

LOCATION ________

EVENT ________

ROBOT MAKE ________

ROBOT MODEL ________

CONFIGURATION ________

OPERATOR/ORG ________

LIGHTING:
○ **>100 LUX** ○ **<1 LUX**

COMMUNICATIONS:
○ **TETHER** ○ **RADIO**

WIND SPEED:
☐ KM/HR
☐ KNOTS

CONTINUOUS OPERATIONS WITH HORIZONTAL TO VERTICAL TRANSITION?
(IF SO FILL IN DOT. IF NOT USE SECOND FORM)

○

START TIME (HH:MM) ☐
FINISH TIME (HH:MM) ☐
ELAPSED (MIN) ☐
AVERAGE (MIN) ☐

VERTICAL TARGETS

LINE#: USE DECIMAL EQUIVELENTS

SMALLEST LINE #

VIDEO	IMAGE
☐	☐
☐	☐

SMALLEST LINE #

VIDEO	IMAGE
☐	☐
☐	☐

SMALLEST LINE #

VIDEO	IMAGE
☐	☐
☐	☐

SMALLEST LINE #

VIDEO	IMAGE
☐	☐
☐	☐

SMALLEST LINE #

VIDEO	IMAGE
☐	☐
☐	☐

GROUND

TOTAL VIDEO ☐ / REPETITIONS 10 = ☐ AVERAGE VIDEO

TOTAL STILL ☐ / REPETITIONS 10 = ☐ AVERAGE STILL

NOTES:

HORIZONTAL TARGETS

LINE#: USE DECIMAL EQUIVELENTS

WALL

SMALLEST LINE #

VIDEO	IMAGE
☐	☐
☐	☐

SMALLEST LINE #

VIDEO	IMAGE
☐	☐
☐	☐

SMALLEST LINE #

VIDEO	IMAGE
☐	☐
☐	☐

SMALLEST LINE #

VIDEO	IMAGE
☐	☐
☐	☐

SMALLEST LINE #

VIDEO	IMAGE
☐	☐
☐	☐

TOTAL VIDEO ☐ / REPETITIONS 10 = ☐ AVERA

TOTAL STILL ☐ / REPETITIONS 10 = ☐

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-SAFETY-DECON

NAME/ORGANIZATION:
XXX

FIGURE A

FIGURE B

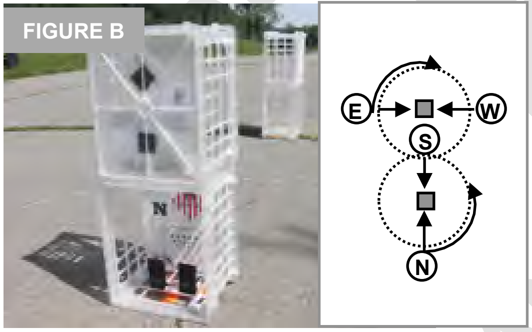


FIGURE C

OPERATIONAL TASK: RADIO COMMS: NIKE SITE

Purpose

The purpose of this operational task is to quantitatively evaluate the radio communications range of a robot, including line of sight (LOS) and non line of sight (NLOS) environments, for a remotely teleoperated robot.

Metrics

- Percent of available stations completed for each task.

Apparatus

- The test apparatus for the NIKE Site Radio Comms test is a series of stations placed approximately 100 m (300 ft) from each other along a specified course around the NIKE Site (FIGURE A). Each station contains figure-8 paths surrounding **targets** (FIGURE B).
- Operator station antennas shall be limited to a maximum of 2 m (6.5 ft) elevation above the ground.

Procedure

1. Place the robot in the start position near the operator station.
2. Traverse downrange to the next test station.
3. Center robot tracks on the figure-8 path and follow the curve, while maintaining line between tracks, until directly in view of a recessed **target** placed at the center of the figure-8. Turn the robot towards the target and use any forward-facing sensor to identify the **target**. Panning of sensors is not allowed. Driving towards the **target** is allowed, but contact with the **target** is not. Return to the figure-8 path and continue around to next **target**.
4. Repeat steps 2 & 3 until a station is reached at which the video or control fails.
5. The radio systems shall be evaluated indirectly by monitoring video and control system relative to a reference LOS distance of 50 m (164 ft).
6. Two-way audio will be tested by an endless loop playing a predetermined set of keywords. Operator will note the line number and which words were audible.

Fault Conditions: (Fill out an Event Report)

- While traversing between **targets** within a station, deviating from prescribed figure-8 path. If robot leaves the line due to latency or other reason, the test is ended at that station.
- Touching the **targets** while attempting identification.

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011 STATUS: VALIDATING-WK14437

Forms: v2011.1 Data: A

OPERATIONAL TASK: RADIO COMMS: NIKE SITE

TRIAL ☐

DATE 2010.

FACILITY

LOCATION

EVENT

ROBOT MAKE

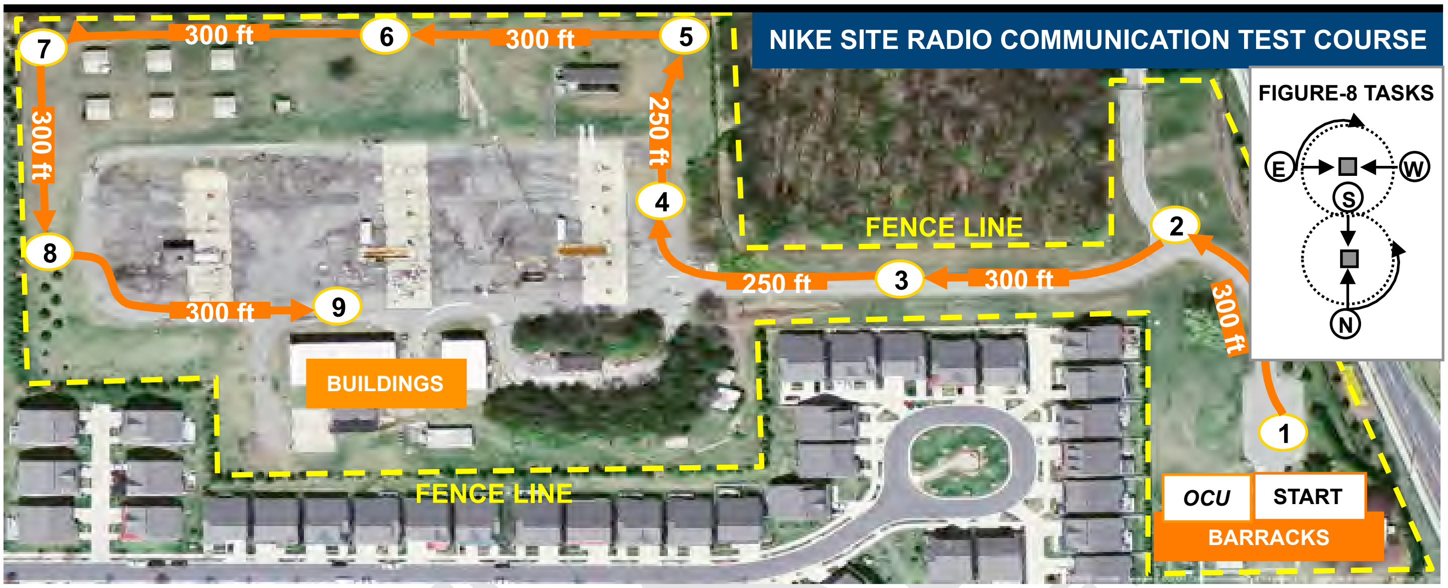
ROBOT MODEL

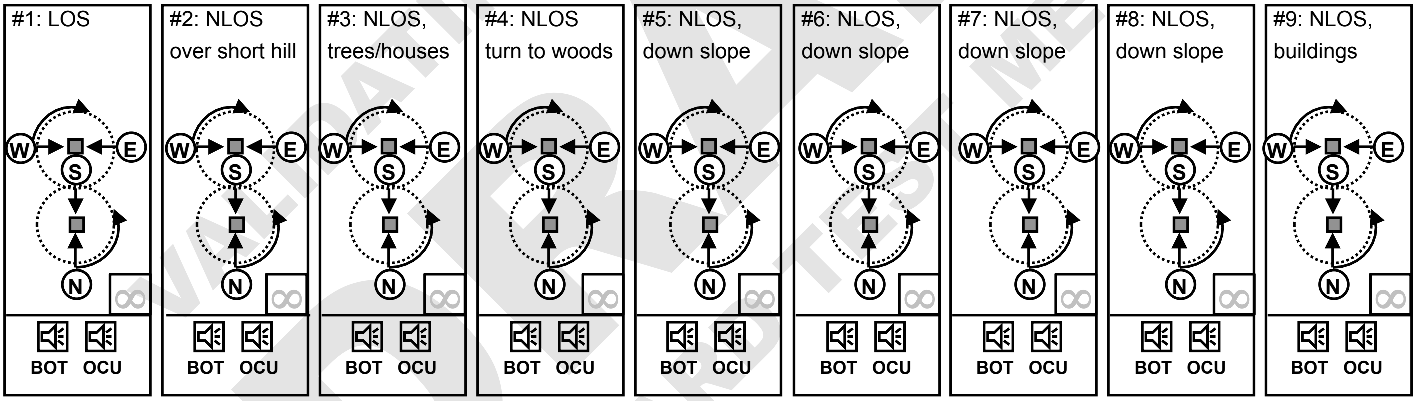
CONFIGURATION

OPERATOR/ORG

LIGHTING:
○ >100 LUX ○ <1 LUX

COMMUNICATIONS:
○ TETHER ○ RADIO





LEGEND: ∞ Control Comms 🔊 Audio Comms

NOTES:

VIDEO FILE NAMING CONVENTION

ROBOTNAME-COM-NIKE

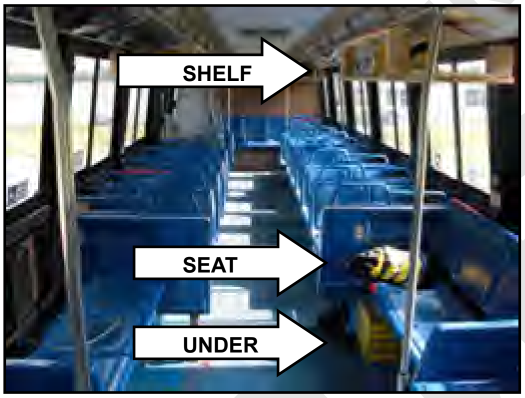
TEST ADMINISTRATOR NAME/ORGANIZATION:

XXX

OPERATIONAL TASK: METROBUS PACKAGE REMOVAL/DISRUPTION

FIGURE A

FIGURE B



Purpose

The purpose of this operational task is to evaluate several elemental test methods within an operational context to perform specified tasks.

Metrics

- Successful removal or disruption of targets.

Apparatus

- Metrobus with seating and overhead shelves.
- The Metrobus is populated with cases/backpacks weighing 4.5 kg (10 lbs) and 9 kg (20 lbs), and small/large boxes.
- All packages lay flat with handles, if any, facing the seat front, or facing the aisle if located on the shelf and flush with the shelf edge.

Procedure

1. Operator is located in **operator station**.
2. Robot starts 100 m (328 ft) from bus and can be outfitted with trailers or other such payloads to accomplish the task.
3. Task 1 is to remove targets with handles from all possible locations on the bus, transporting them to a location 100 m (328 ft) from the bus.
4. Task 2 is to disrupt in place any targets that cannot be removed from the bus.
5. Locations include: front (wide aisle which allows diagonal approach), mid-bus (narrow aisle which requires working to the side of the robot), and back (wide aisle which allows diagonal approach but with occluded features and farther reach).
6. Elevations include: under seat which is 0 cm to 20 cm (0 in to 8 in), on seat, which is 50 cm to 70 cm (20 in to 28 in), and overhead shelf which is 160 cm to 178 cm (63 in to 70 in).

FIGURE C

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011
STATUS: PROTOTYPE

Forms: v2011.1 Data: A

OPERATIONAL TASK: METROBUS PACKAGE REMOVAL/DISRUPTION

DATE 2010.____________

FACILITY ____________

LOCATION ____________

EVENT ____________

ROBOT MAKE ____________

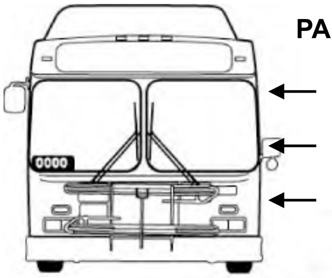
ROBOT MODEL ____________

CONFIGURATION ____________

OPERATOR/ORG ____________

LIGHTING:
○ >100 LUX ○ <1 LUX

COMMUNICATIONS:
○ TETHER ○ RADIO



PACKAGE LOCATIONS

OVERHEAD SHELF 160 CM TO 178 CM (63 IN TO 70 IN)

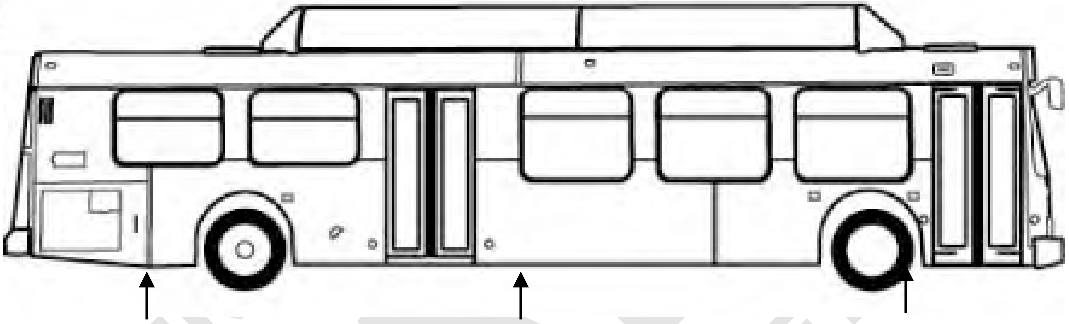
ON SEAT 50 CM TO 70 CM (20 IN TO 28 IN)

UNDER SEAT 0 CM TO 20 CM (0 IN TO 8 IN)

START TIME (HH:MM) ☐

FINISH TIME (HH:MM) ☐

ELAPSED (MIN) ☐



BACK
WIDE AISLE
DIAGONAL APPROACH
NARROW ACCESS, FARTHER REACH

MID-BUS
NARROW AISLE
MUST REACH TO SIDE

FRONT
WIDE AISLE
DIAGONAL APPROACH

	REMOVE	DISRUPT	REMOVE	DISRUPT	REMOVE	DISRUPT
OVERHEAD SHELF	◎	☐	◎	☐	◎	☐
ON SEAT	◎	☐	◎	☐	◎	☐
UNDER SEAT	◎	☐	◎	☐	◎	☐

LEGEND:

◉ PACKAGE WEIGHT 4.5 KG (10 LB)

● PACKAGE WEIGHT 9 KG (20 LB)

🟦 DISRUPTOR AIMING

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-XXX-METROBUS

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

OPERATIONAL TASK: PASSENGER TRAIN SEARCH, THREAT REMOVAL

Purpose

The purpose of this operational task is to evaluate several elemental test methods within an operational context to perform specified tasks.

Metrics

- Successful identification of signs of life and/or successful removal of targets/threats

Apparatus

- Passenger train with seating and overhead shelves.
- The train is populated with simulated victims and cases, backpacks, and IEDs weighing 4.5 kg (10 lbs) and 9 k.
- All packages lay flat with handles, if any, facing the seat front, or facing the aisle if located on the shelf and flush with the shelf edge.
- Some targets/threats are located in closed compartments.

Procedure

1. Operator is located in **operator station**.
2. Robot starts 100 m (328 ft) from bus and can be outfitted with trailers or other such payloads to accomplish the task.
3. Task 1 is to search the train car, locate and assess any simulated victims with thermal sensors, motion sensors, or other sensors.
4. Task 2 is to remove targets from all possible locations, transporting them to a location 100 m (328 ft) from the site.
5. Task 3 open compartments to identify threat or clear.
6. Task 4 is to disrupt in place any targets that cannot be removed from the bus.
7. Locations include: front (wide aisle which allows diagonal approach), mid (narrow aisle which requires working to the side of the robot), and back (wide aisle which allows diagonal approach but with occluded features and farther reach).
8. Elevations include: under seat which is 0 cm to 20 cm (0 in to 8 in), on seat, which is 50 cm to 70 cm (20 in to 28 in), and overhead shelf which is 160 cm to 178 cm (63 in to 70 in).

FIGURE A

FIGURE B

FIGURE C

FIGURE D

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

STATUS: PROTOTYPE

Forms: v2011.1 Data: A

OPERATIONAL TASK: PASS. TRAIN SEARCH / PACKAGE REMOVAL

DATE 2010.__________ **ROBOT MAKE** __________

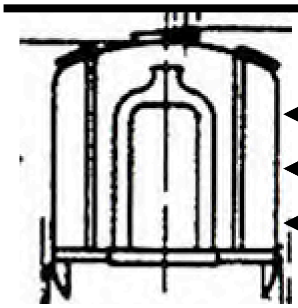
FACILITY __________ **ROBOT MODEL** __________

LOCATION __________ **CONFIGURATION** __________

EVENT __________ **OPERATOR/ORG** __________

LIGHTING:
○ **>100 LUX** ○ **<1 LUX**

COMMUNICATIONS:
○ **TETHER** ○ **RADIO**



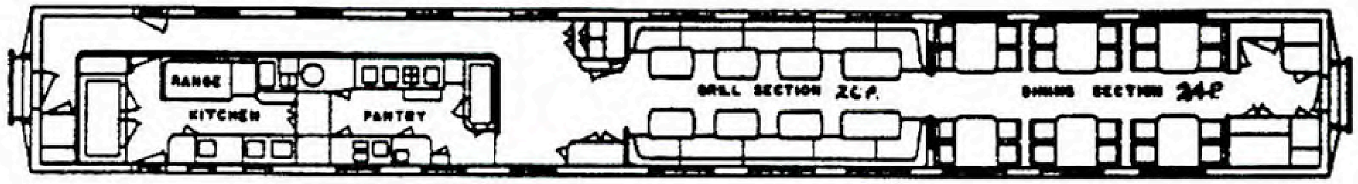
PACKAGE LOCATIONS

← OVERHEAD SHELF 160 CM TO 178 CM (63 IN TO 70 IN)

← ON SEAT 50 CM TO 70 CM (20 IN TO 28 IN)

← UNDER SEAT 0 CM TO 20 CM (0 IN TO 8 IN)

START TIME (HH:MM)	☐
FINISH TIME (HH:MM)	☐
ELAPSED (MIN)	☐



↑ BACK
WIDE AISLE
DIAGONAL APPROACH
NARROW ACCESS, FARTHER REACH

↑ MID
NARROW AISLE
MUST REACH TO SIDE

↑ FRONT
WIDE AISLE
DIAGONAL APPROACH

	BACK REMOVE	BACK DISRUPT	MID REMOVE	MID DISRUPT	FRONT REMOVE	FRONT DISRUPT
OVERHEAD SHELF	◎	☐	◎	☐	◎	☐
ON SEAT	◎	☐	◎	☐	◎	☐
UNDER SEAT	◎	☐	◎	☐	◎	☐

LEGEND:

◉ PACKAGE WEIGHT 4.5 KG (10 LB)	● PACKAGE WEIGHT 9 KG (20 LB)	🟦 DISRUPTOR AIMING

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-XXX-PASSTRAIN

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

OPERATIONAL TASK: HAZMAT TRAIN RECONAISSANCE AND RETRIEVAL

Purpose

The purpose of this operational task is to evaluate several elemental test methods within an operational context to perform specified tasks.

Metrics

- Successful identification of signs of life and/or successful removal of targets.

Apparatus

- Hazardous materials train with tankers and other rail cars.
- The train is populated hazmat placards, targets, and grasping targets weighing 4.5 kg (10 lbs) and 9 k.

Procedure

1. Operator is located in **operator station**.
2. Robot starts 200 m (660 ft) from train and can be outfitted with trailers or other such payloads to accomplish the task.
3. Task 1 is to search the train perimeter, locate hazmat targets.
4. Task 2 is to remove targets from all possible locations, transporting them to a location 100 m (328 ft) from the site.
5. Elevations include: 0 cm to 50 cm (0 in to 20 in), 50 cm to 100 cm (20 in to 40 in), 100 cm to 150 cm (40 in to 60 in), and 150 cm to 200 cm (60 in to 80 in).

FIGURE A

FIGURE B

FIGURE C

FIGURE D

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

OPERATIONAL TASK: HAZMAT TRAIN RECON / RETRIEVAL

DATE 2010.____________

FACILITY ____________

LOCATION ____________

EVENT ____________

ROBOT MAKE ____________

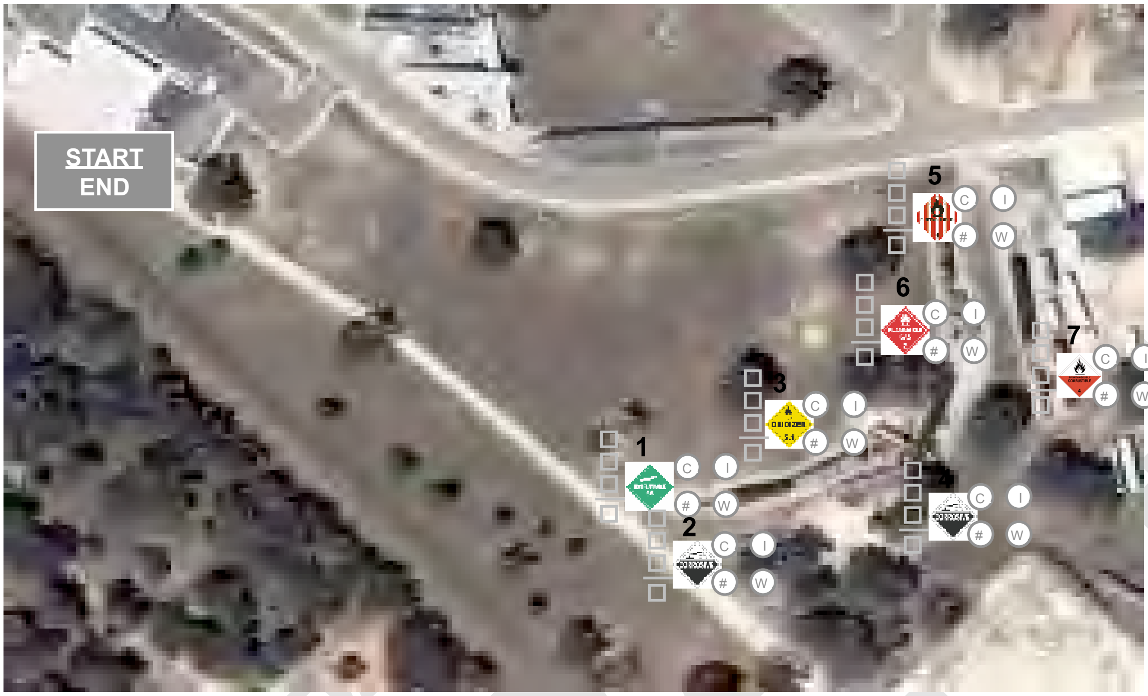
ROBOT MODEL ____________

CONFIGURATION ____________

OPERATOR/ORG ____________

LIGHTING: ○ >100 LUX ○ <1 LUX

COMMUNICATIONS: ○ TETHER ○ RADIO



TASK LOCATIONS

START TIME (HH:MM)	☐
FINISH TIME (HH:MM)	☐
ELAPSED (MIN)	☐

○ **RETURNED TO START POINT?**

LABEL # :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
CORRECT ID:	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
MULTIPLE ID:	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
MISSED:	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

TARGETS PLACED

☐ %

CLEARED

↑

CORRECT

= ☐ / ☐

PLACED

LEGEND:

◉ PACKAGE WEIGHT 4.5 KG (10 LB)

● PACKAGE WEIGHT 9 KG (20 LB)

■ DISRUPTOR AIMING

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-XXX-PASSTRAIN

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

FIGURE A

FIGURE B

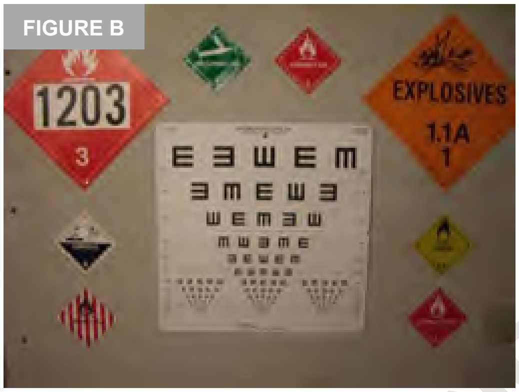
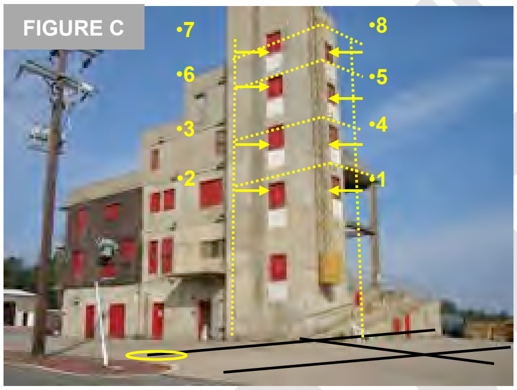


FIGURE C



OPERATIONAL TASK: sUAS (GROUP I) VOTL EXTERIOR BUILDING RECON:

Purpose

The purpose of this operational task is to evaluate the aerial search capabilities of a small unmanned aircraft system (sUAS) with vertical take-off and landing flight operations, including station-keeping, visual acuity, and obstacle avoidance /interaction, while being remotely teleoperated around a multi -story building in lighted and dark conditions. This test method is intended for Group I sUAS systems defined by the FAA Aviation Rulemaking Committee as having less than 2kg (4.4.bs) gross take-off weight, under 30 knots air speed at full power in level flight, and made in a frangible manner.

Metrics

- Successful identification of targets in specified windows.

Apparatus

- Multi-story building with three or more floors and some openable windows, preferably on two sides of a building corner to include wind effects. Roof access can provide additional upward-facing target locations.
- Targets within each window should consist of visual acuity charts and hazmat placards (large) and labels (small).
- Four different target viewing conditions should be setup:
  - Open window, flush mounted
  - Open window, recessed 2-meters inside
  - Closed window, flush mounted
  - Closed window, recessed 2-meters inside

Procedure

1. Operator is located in **operator station** 50 meters from building.
2. Robot starts at the designated start position near the operator station.
3. Locate and search each window in the path shown to correctly identify the smallest visual targets possible in as many windows as possible before returning to the the start position to land.

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

OPERATIONAL TASK: sUAS (GROUP I) VTOL BUILDING RECON:

TRIAL ☐

DATE 2010.____________

FACILITY ____________

LOCATION ____________

EVENT ____________

ROBOT MAKE ____________

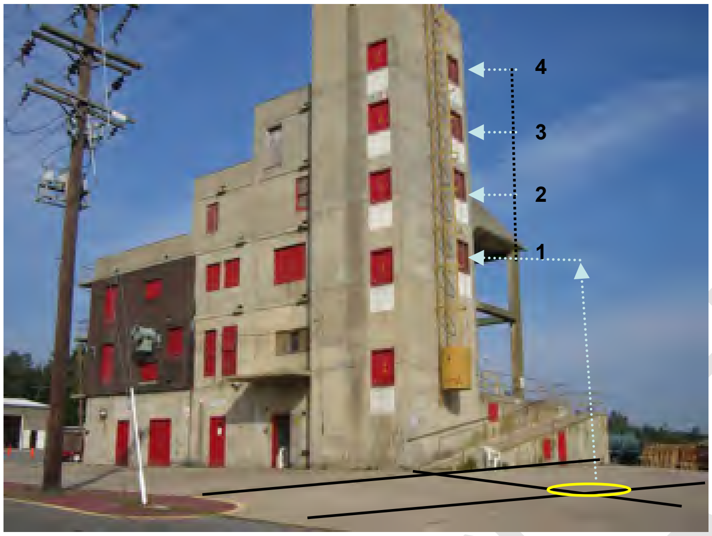
ROBOT MODEL ____________

CONFIGURATION ____________

OPERATOR/ORG ____________

LIGHTING:
○ >100 LUX ○ <1 LUX

COMMUNICATIONS:
○ TETHER ○ RADIO



WIND SPEED:
____km/hr ____knots

4 LINE _____

3 LINE _____

2 LINE _____

1 LINE _____

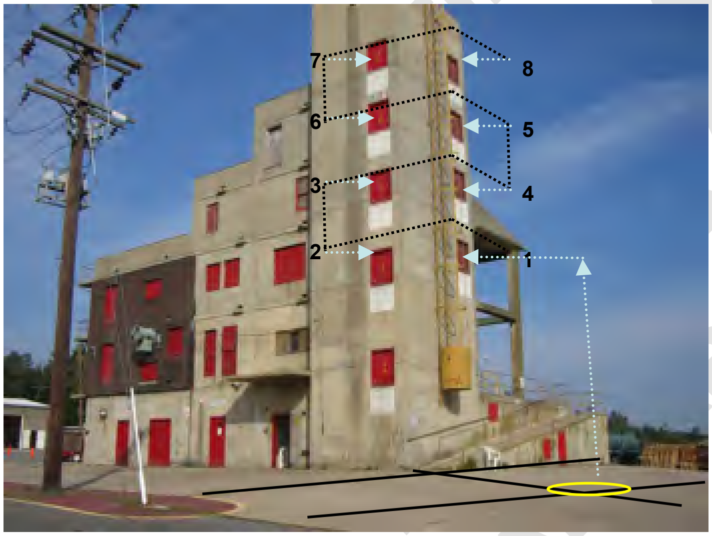
START TIME (HH:MM) ☐

FINISH TIME (HH:MM) ☐

ELAPSED (MIN) ☐

AVERAGE (MIN) ☐

AVERAGE VISUAL ACUITY LINE ☐



WIND SPEED:
____km/hr ____knots

7 LINE _____ **8 LINE** _____

6 LINE _____ **5 LINE** _____

3 LINE _____ **4 LINE** _____

2 LINE _____ **1 LINE** _____

START TIME (HH:MM) ☐

FINISH TIME (HH:MM) ☐

ELAPSED (MIN) ☐

AVERAGE (MIN) ☐

AVERAGE VISUAL ACUITY LINE ☐

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-XXX-VTOLBUILDINGSEARCH

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

FIGURE A

FIGURE B

OPERATIONAL TASK: sUUV RECON

Purpose

The purpose of this operational task is to evaluate the underwater search capabilities of a small unmanned underwater vehicle (sUUV), including station-keeping, visual acuity, and obstacle avoidance/interaction, while being remotely teleoperated around submerged underwater targets.

Metrics

- Successful identification of targets in specified locations.

Apparatus

- Submerged vehicle with simulated victim, simulated explosive device, and other targets of interest. Targets within each window should consist of visual acuity charts and hazmat placards (large) and labels (small).
- Submerged culverts with markings on exterior and interior surfaces to identify.
- Submerged weights to grasp, lift and move.
- Submerged dowel rods ranging from 25mm (1 in) and under to cut.
- Submerged ropes ranging from 25mm (1 in) and under to cut.
- Submerged array of paint cans with targets inside to identify

Procedure

1. Operator is located in **operator station** 50 meters from lake edge.
2. Robot starts at the designated start position near the operator station.
3. Locate and search the scenario and interact or perform tasks as capable.

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011
STATUS: VALIDATING

Forms: v2011.1 Data: A

OPERATIONAL TASK: sUUV RECON:

TRIAL ☐

DATE 2010.__________

FACILITY __________

LOCATION __________

EVENT __________

ROBOT MAKE __________

ROBOT MODEL __________

CONFIGURATION __________

OPERATOR/ORG __________

LIGHTING:
○ **>100 LUX** ○ **<1 LUX**

COMMUNICATIONS:
○ **TETHER** ○ **RADIO**

START TIME (HH:MM) ☐
FINISH TIME (HH:MM) ☐
ELAPSED (MIN) ☐
AVERAGE (MIN) ☐

☐

START TIME (HH:MM) ☐
FINISH TIME (HH:MM) ☐
ELAPSED (MIN) ☐
AVERAGE (MIN) ☐

☐

NOTES:

VIDEO FILE NAMING CONVENTION
ROBOTNAME-XXX-WATERSEARCH

TEST ADMINISTRATOR NAME/ORGANIZATION:
XXX

NIST
National Institute of
Standards and Technology
U.S. Department of Commerce

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011

Forms: v2011.1 Data: A

Maintenance/Repair/Other Event Report: A trial is ended prior to completion any time the operator (or representative) must leave the operator station to visually inspect, adjust, or fix any part of the robot. This includes battery changes. All such events inspire an event report below.

Test Method: ☐ **Trial:** ☐ **Date:** 2010/___/___

Start Time: ☐ **End Time:** ☐ **Elapsed Time:** ☐

Indicators: ☐

Tools: ○ None ○ List: ____

Remedy: ☐

Test Method: ☐ **Trial:** ☐ **Date:** 2010/___/___

Start Time: ☐ **End Time:** ☐ **Elapsed Time:** ☐

Indicators: ☐

Tools: ○ None ○ List: ____

Remedy: ☐

Test Method: ☐ **Trial:** ☐ **Date:** 2010/___/___

Start Time: ☐ **End Time:** ☐ **Elapsed Time:** ☐

Indicators: ☐

Tools: ○ None ○ List: ____

Remedy: ☐

This page intentionally left blank.

Standard Test Methods For Response Robots

ASTM International Committee on Homeland Security Applications;
Operational Equipment; Robots (E54.08.01)

January 2011
Date: XXXXXXX

Forms: v2011.1 Data: A

Response Robot Evaluations Using Emerging Standard Test Methods

RIGHT SIDE VIEW TYPICAL DRIVING CONFIGURATION	**45 DEGREE VIEW** TYPICAL DRIVING CONFIGURATION	**FRONT VIEW** TYPICAL DRIVING CONFIGURATION

RobotName, OrganizationName

LOGO

Prepared for:

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

LOGO

Sponsored by:

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

TEST DIRECTOR:

Adam Jacoff
Program Manager
Intelligent Systems Division
National Institute of Standards and Technology

301-975-4235
adam.jacoff@nist.gov,RobotTestMethods@nist.gov

SPONSOR CONTACT:

XXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXX
XXXXXXXXXXXXXXX
XXXXXXXXXXXXXXX

XXX-XXX-XXXX
XXXXXXXX@XXXXXXX.XXX

Elena Messina, Hui-Min Huang, Anthony Downs, Ann Virts, Christopher Scrapper
National Institute of Standards and Technology

For Official Use Only

PINE TEMPLATE

NIST

LOGO

LOGO

RobotName, Organization Name

Response Robot Evaluations using Standard Test Methods

Metrotech National Capital Regional Bomb Squad Working Group

NIST

LOGO

LOGO

RobotName, Organization Name

Response Robot Evaluations using Standard Test Methods

Metrotech National Capital Regional Bomb Squad Working Group

DID NOT PERFORM TEST

ABSTAINED

OR WILL NOT RELEASE DATA

APPARATUS AND PROCEDURE

PROTOTYPE

UNDER DEVELOPMENT