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

Standard Test Methods for Emergency Response Robots

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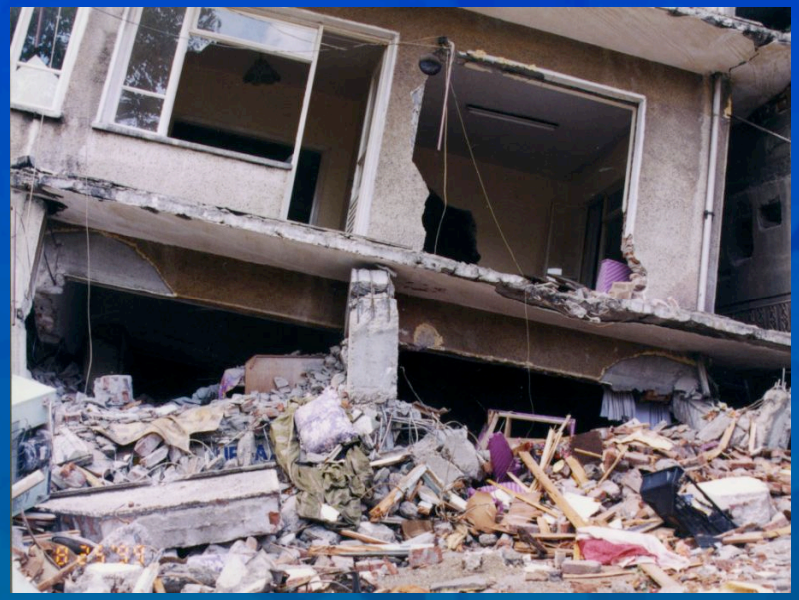
What Must Response Robots Do?

(mobility, power, sensors, communications, operator interfaces)



What are the requirements?
How can we quantify robot performance in specific areas?
How can we abstract domain challenges?
How can we make them reproducible, repeatable?

Performance Evaluation of Mobile Robots

Requires knowledge of robot technologies and application domain

Provides researchers with concrete development goals

Multi-disciplinary

Collaboration
Maximize coverage, redundancy, efficiency among(heterogeneous) robot teams
High level human/robot interactions

Autonomy
Mixed-initiative modes to limit human interactions, improve robot survivability

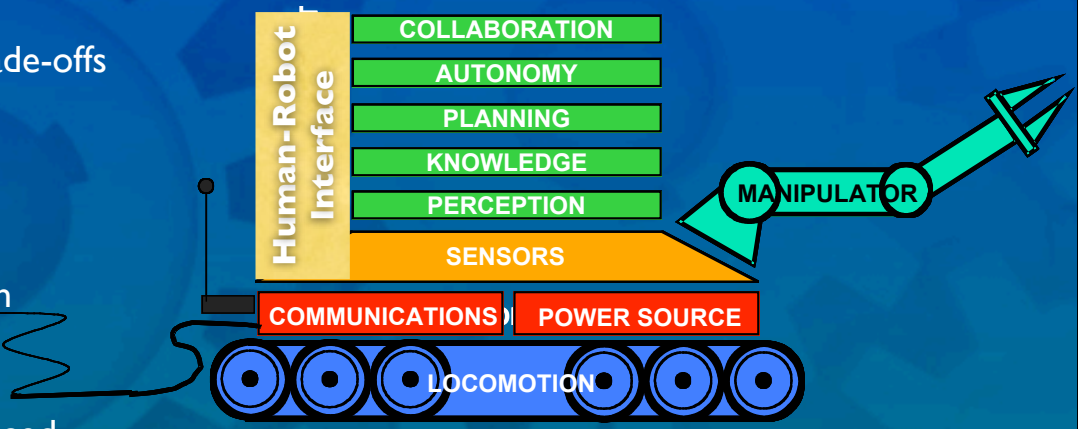
Mapping and Planning
Negotiate obstacles, time-critical decisions, trade-offs

Knowledge Representation
A priori knowledge/skills (traversability)
Gained information (3-D spatial maps)

Sensory Perception
Navigation, hazard detection, goal identification
Sensor fusion to provide robust performance

Human-Robot Interaction
Remote situational awareness, operator workload, management of multiple-robots, interface standardization

Locomotion
Types/Limits of mobility, negotiation of unstructured environment



Toward Performance Standards for US&R and EOD Robots

Requirements from FEMA Teams and Bomb Squads → Test Methods & Performance Data → "Consumer's Guide"

Response Robot Evaluation Exercises

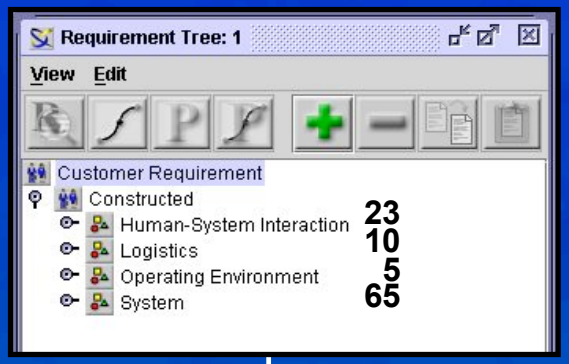
Number:	96
Type:	SENSING
Sub-Type:	REAL-TIME COLOR VIDEO
Requirement:	SYSTEM ACUITY - NEAR
Metric:	MILLIMETERS
Description:	This requirement captures the responders' expectation to use video for key tasks such as maneuvering (hence the real-time emphasis), object identification (hence the color emphasis), and detailed inspection (hence the emphasis on short-range system acuity). The responders noted the need to consider the entire system, including possible communications signal degradation and display quality, when testing this capability. They also noted that this requirement is closely tied to the need for adjustable illumination to avoid washing out the image of close objects. The responders made no distinction regarding tethered or wireless implementations to address this requirement.
Test Method:	SEE REAL-TIME VISION SYSTEM ACUITY TEST

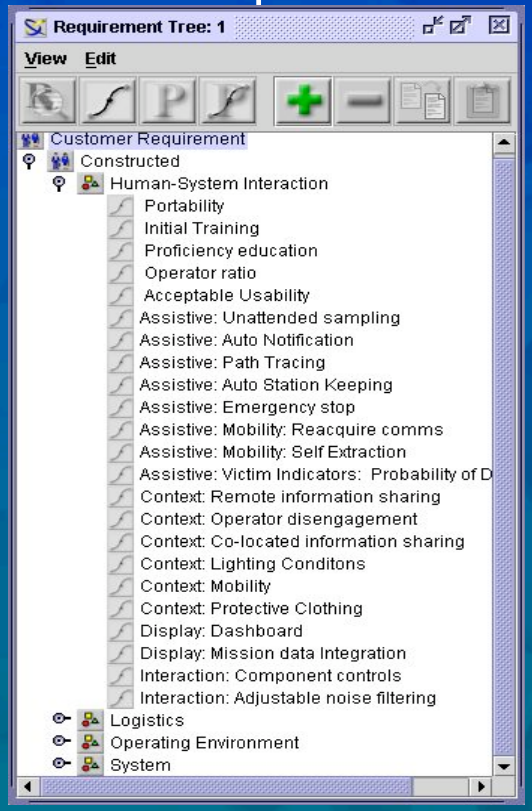
Robot Requirements Capture Process

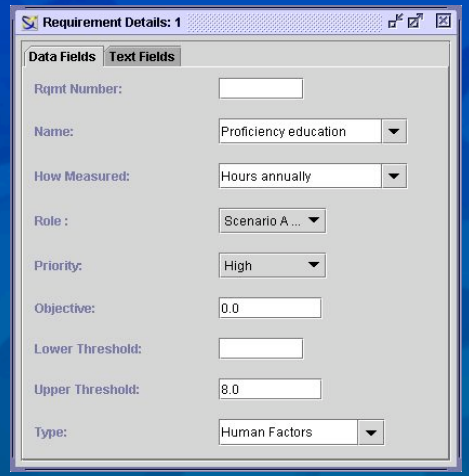
(Integrated Product and Process Development Approach)

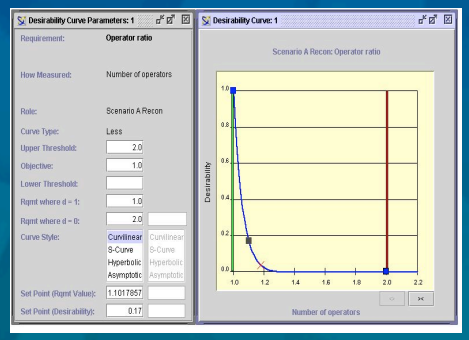
	Scenario A	Scenario B	Scenario C
Description	Upper stories of a multi-story pancake collapse	Subsurface voids	US&R Type II
Characteristics	Soft stories in the middle, undetermined stability, uneven terrain, sloped floor with holes, variable debris size, high hazmat potential, and poor visibility	Downwardly accessible void spaces, twisted/turning access (i.e., searchcam can't reach or turn necessary corners), variety of materials, complex orientations of support surfaces, sufficiently complex to cause spatial disorientation, hot, may be wet, high hazmat potential, and poor visibility	Rapid extraction of many non-ambulatory live victims from a contaminated (WMD / CBRNE) environment in a large urban area. This assumes that explosions or collapses have not compromised structures. Sample areas include malls, stadiums, several city blocks, etc. Teams may be pre-deployed.
Representative Image			

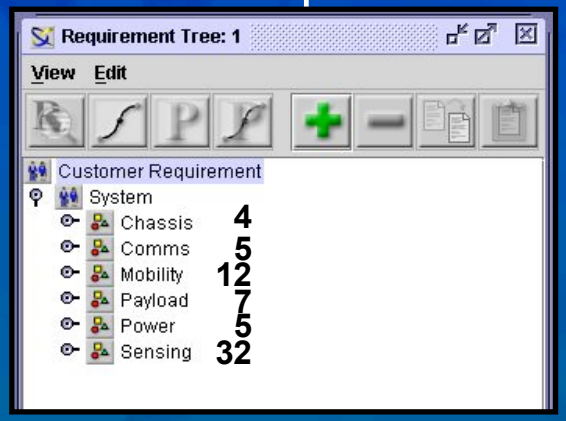
Robot Requirements Hierarchy (103 total)









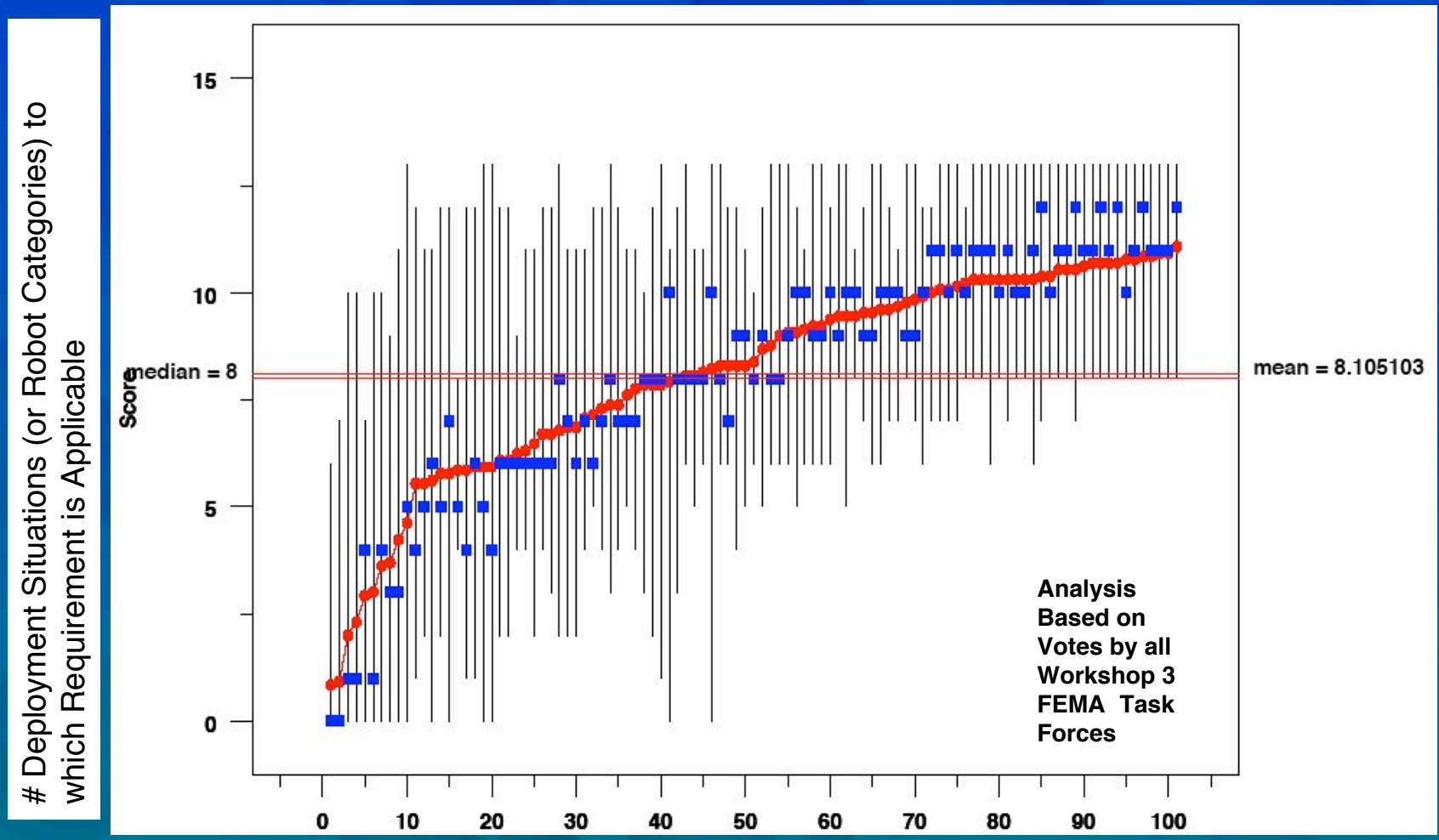


Robot Categories and Deployment Methods (13 total)

Robot Category	Ground: Peek Robots	Ground: Collapsed Structure--Stair/Floor climbing, map, spray, breach bots	Ground: Non-collapsed Structure--Wide area survey Bot	Ground: Wall Climbing Deliver Bots	Ground: Confined Space, Temporary Shore Bots	Ground: Confined Space Shape Shifters	Ground: Confined Space Retrieval Bots	Aerial:High Altitude Loiter Bots	Aerial: Rooftop Payload Drop Bots	Aerial: Ledge Access Bot	Aquatic: Variable Depth Sub Bots	Aquatic: Bottom Crawler Bot	Aquatic: Swift Water Surface Swimmer
Employment Role(s)	Provide rapid audio visual situational awareness; provide rapid HAZMAT detection; data logging for subsequent team work	Stairway & upper floor situational awareness; mitigation activities; stay behind monitoring	human access stairway & upper floor situational awareness; contaminated area survey; site assessment; victim identification; mitigation activities; stay behind monitoring	Deliver Payloads to upper floors; provide expanded situational awareness when aerial platforms are unavailable or untenable	Adaptive, temporary shoring; provide stay behind monitoring; victim triage & support	Search; provide stay behind monitoring	Retrieve objects from confined spaces; provide stay behind monitoring	Provide overhead perspective & sit. awareness; provide HAZMAT plume detection; provide comm repeater coverage	Payload delivery to rooftops; provide overhead perspective; provide comm repeater coverage	Object retrieval from upper floors; crowd control with a loudspeaker object attached, provide situational awareness	Structural inpsection; leak localization/mitigation; object (body) recovery	Water traverse; rapid current station keeping; object recovery	Upstream access and station keeping; payload delivery; object recovery
Deployment Method(s)	Tossed; chucked, thrown pneumatically, w/surgical tubing; marsupially deployed	Backpacked; self driven; marsupially deployed	Backpacked; self driven; marsupially deployed	Placed; thrown pneumatically, w/surgical tubing; marsupially deployed	Placed: lowered	Placed; lowered	Placed; lowered via tether	Released: baloon or F/W; tethered LTAF (kite)	Launched F/W; tethered LTAF (kite)	Launched VTOL; VTOL	Dropped into water; lowered via tether	Driven across w	Dropped into water; marsupially deployed
Tradeoffs	Trade mobility, duration, sensing for increased expendability	form factor for increased mobility, sensing, manipulation; mapping variant; spraying variant; breaching variant	form factor for increased mobility, sensing, manipulation; mapping variant; spraying variant; breaching variant	trade payload capacity for vertical mobility and stable perching	trade mobility and payload capacity for shoring capacity	trade payload capacity for confined space access	trade sensing capacity for manipulators, confined space access	trade penetration capacity for vertical perspective	trade penetration capacity & loiter time for vertical drop	trade simplicity, penetration capacity, loiter time for precise vertical drop	trade ground mobility for sub surface access & free swim capacity	pursue amphibious mobility at cost of other performance	pursue swift water capacity at cost of other performance

Composite Statistics

(Integrated Product and Process Development)



Cache Packaging, Weight, and Volume

ASTM International Standard Test Method

ASTM E2592-07

Apparatus: Qualified packing containers, scale, timer
Method: Weigh and count qualified shipping containers, time setup, note tools
Measure: Shipping and down-range weight, time to setup

Visual Acuity, Field of View, Variable Illumination

Example Requirements

Number:	**99 ***
Type:	**SENSING**
Sub-Type:	**REAL-TIME COLOR VIDEO**
Requirement:	**SYSTEM ACUITY - FAR**
Metric:	**METERS**
Description:	This requirement captures the responders' ex such as maneuvering (hence the real-time emphasis), object identificati path planning (hence the emphasis on long-range system acuity). The r consider the entire system, including possible communications signal d when testing this capability. They also noted that the limiting case for l assessment of structural integrity of buildings. This requires identifying inspecting the tops/bottoms of load bearing columns, and generally asse ceilings, and floors. The responders made no distinction regarding tethe address this requirement.
Test Method:	**SEE REAL-TIME VISION SYSTEM AC**

Number:	**96**
Type:	**SENSING**
Sub-Type:	**REAL-TIME COLOR VIDEO**
Requirement:	**SYSTEM ACUITY - NEAR**
Metric:	**MILLIMETERS**
Description:	This requirement captures the responders' expectation to use video for key tasks such as maneuvering (hence the real-time emphasis), object identification (hence the color emphasis), and detailed inspection (hence the emphasis on short-range system acuity). The responders noted the need to consider the entire system, including possible communications signal degradation and display quality, when testing this capability. They also noted that this requirement is closely tied to the need for adjustable illumination to avoid washing out the image of close objects. The responders made no distinction regarding tethered or wireless implementations to address this requirement.
Test Method:	**SEE REAL-TIME VISION SYSTEM ACUITY TEST**

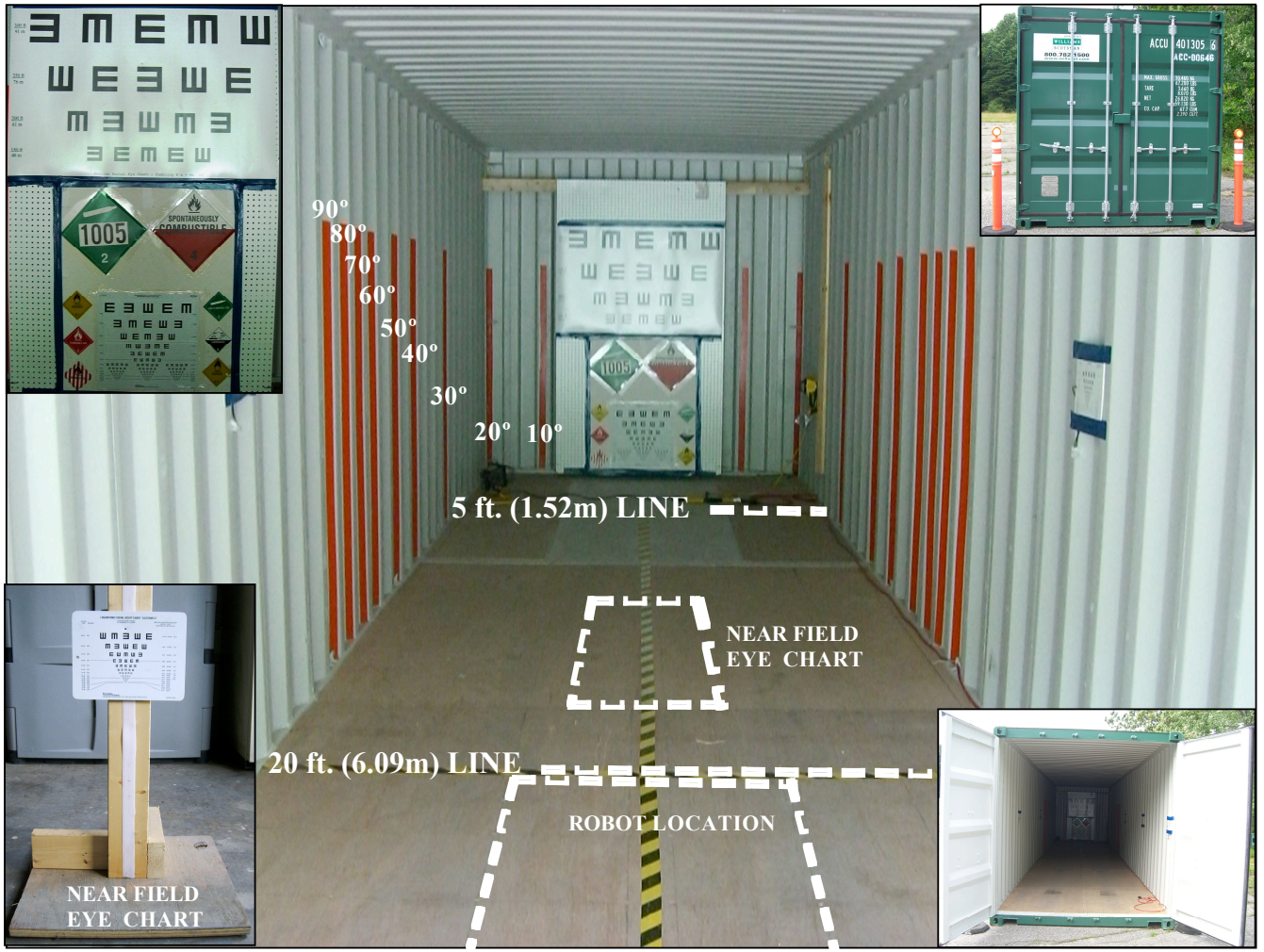
Number:	**101**
Type:	**SENSING**
Sub-Type:	**REAL-TIME COLOR VIDEO**
Requirement:	**FIELD OF VIEW**
Metric:	**DEGREES**
Description:	This requirement captures the responders' expectation to use real-time video for a variety of tasks. The responders noted that this requirement is closely tied to requirements addressing independent pan/tilt capabilities.
Test Method:	**SEE REAL-TIME VISION SYSTEM AC**

Number:	**03**
Type:	**CHASSIS**
Sub-Type:	**ILLUMINATION**
Requirement:	**ADJUSTABLE**
Metric:	**YES/NO**
Description:	This requirement captures the responders' expectation to use video in confined spaces and for short-range object identification, which can wash out from excessive illumination of the scene.
Test Method:	**SEE REAL-TIME VISION SYSTEM ACUITY TEST**

Visual Acuity and Field of View

ASTM International Standard Test Method

ASTM E2566-08



Apparatus: Snellen "tumbling E" charts (near field and far field) and field of view lines

Method: From 6m (20 ft) read smallest line in ambient (>1000 lux) and dark (< 1 lux)

Measure: Smallest line read (correlated to hazmat labels and placards)

Mobility/Endurance

Example of an Abstract Test Method




Apparatus: Random stepfield pallets (flat, hill, diagonal hill) or pitch/roll ramps in figure-8
Method: Negotiate a continuous path for one battery cycle
Measure: Number of laps, time (and if failures, note maintenance time and tools)

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Developing

Standard Test Methods For Response Robots

Version: 2007.4

MOBILITY/ENDURANCE

ROBOT: _____ ☐TETHER ☐RADIO

OPERATOR: _____ ORG: _____

TRAINING TIME: ☐ 0-24 HRS ☐ 24-100 HRS ☐ > 100 HRS

INSTRUCTIONS: TRAVERSE THE FIGURE-8 WITHOUT BUMPING THE WALLS FOR ONE COMPLETE BATTERY CYCLE. REPAIRS ARE ALLOWED BUT MUST BE DONE IN PLACE TO CONTINUE TEST.

ADMINISTRATOR: 1) COUNT THE NUMBER OF LAPS (16 PALLETS PER LAP). 2) NOTE THE ELAPSED TIME. THE CLOCK SHOULD STOP FOR SWITCHING OF OPERATORS AND REPAIRS. 3) NOTE THE NUMBER OF REPAIRS, TYPE OF REPAIRS, AND TOOLS USED.

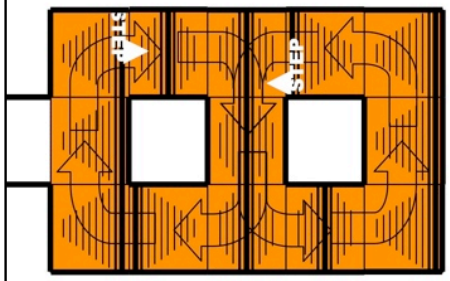
PITCH/ROLL RAMPS

START TIME: _____

END TIME: _____

ELAPSED TIME: _____ m:s

TOTAL PALLETS: _____



REPAIRS

TYPE	TIME		TOOLS		
_____	_____	m:s	☐ NONE	☐TYPICAL	☐ SPECIAL
_____	_____	m:s	☐ NONE	☐TYPICAL	☐ SPECIAL
_____	_____	m:s	☐ NONE	☐TYPICAL	☐ SPECIAL
_____	_____	m:s	☐ NONE	☐TYPICAL	☐ SPECIAL
_____	_____	m:s	☐ NONE	☐TYPICAL	☐ SPECIAL

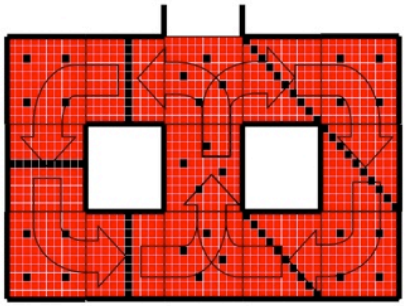
FULL CUBIC (RED) STEPFIELDS

START TIME: _____

END TIME: _____

ELAPSED TIME: _____ m:s

TOTAL PALLETS: _____



REPAIRS

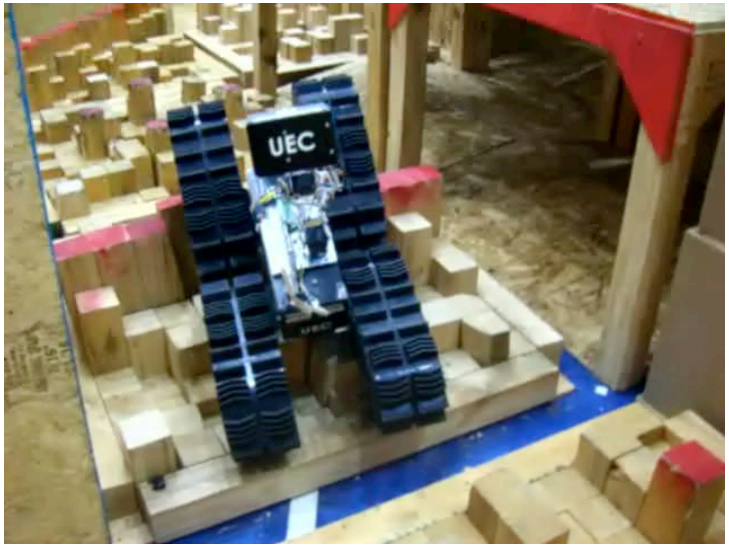
TYPE	TIME		TOOLS		
_____	_____	m:s	☐ NONE	☐TYPICAL	☐ SPECIAL
_____	_____	m:s	☐ NONE	☐TYPICAL	☐ SPECIAL
_____	_____	m:s	☐ NONE	☐TYPICAL	☐ SPECIAL
_____	_____	m:s	☐ NONE	☐TYPICAL	☐ SPECIAL
_____	_____	m:s	☐ NONE	☐TYPICAL	☐ SPECIAL

TEST LEADER DATE NOTES

Mobility/Endurance

Example of an Abstract Test Method



Apparatus: Random stepfield pallets (flat, hill, diagonal hill) or pitch/roll ramps in figure-8
Method: Negotiate a continuous path for one battery cycle
Measure: Number of laps, time (and if failures, note maintenance time and tools)

Mobility/Endurance

Example of an Abstract Test Method

Apparatus: Random stepfield pallets (flat, hill, diagonal hill) or pitch/roll ramps in figure-8
Method: Negotiate a continuous path for one battery cycle
Measure: Number of laps, time (and if failures, note maintenance time and tools)

Mobility/Endurance

Example of an Abstract Test Method

Mobility/Endurance

Example of an Abstract Test Method

Mobile Manipulation: Directed Perception

Example of an Abstract Test Method

Apparatus: Shelves with face/top holes (up to 4 levels) and terrains: flat, roll, stepfields
Method: Identify targets inside holes (visual, CBRNE) with three constraints: open, over, under
Measure: Number targets identified at each level with each constraint, time

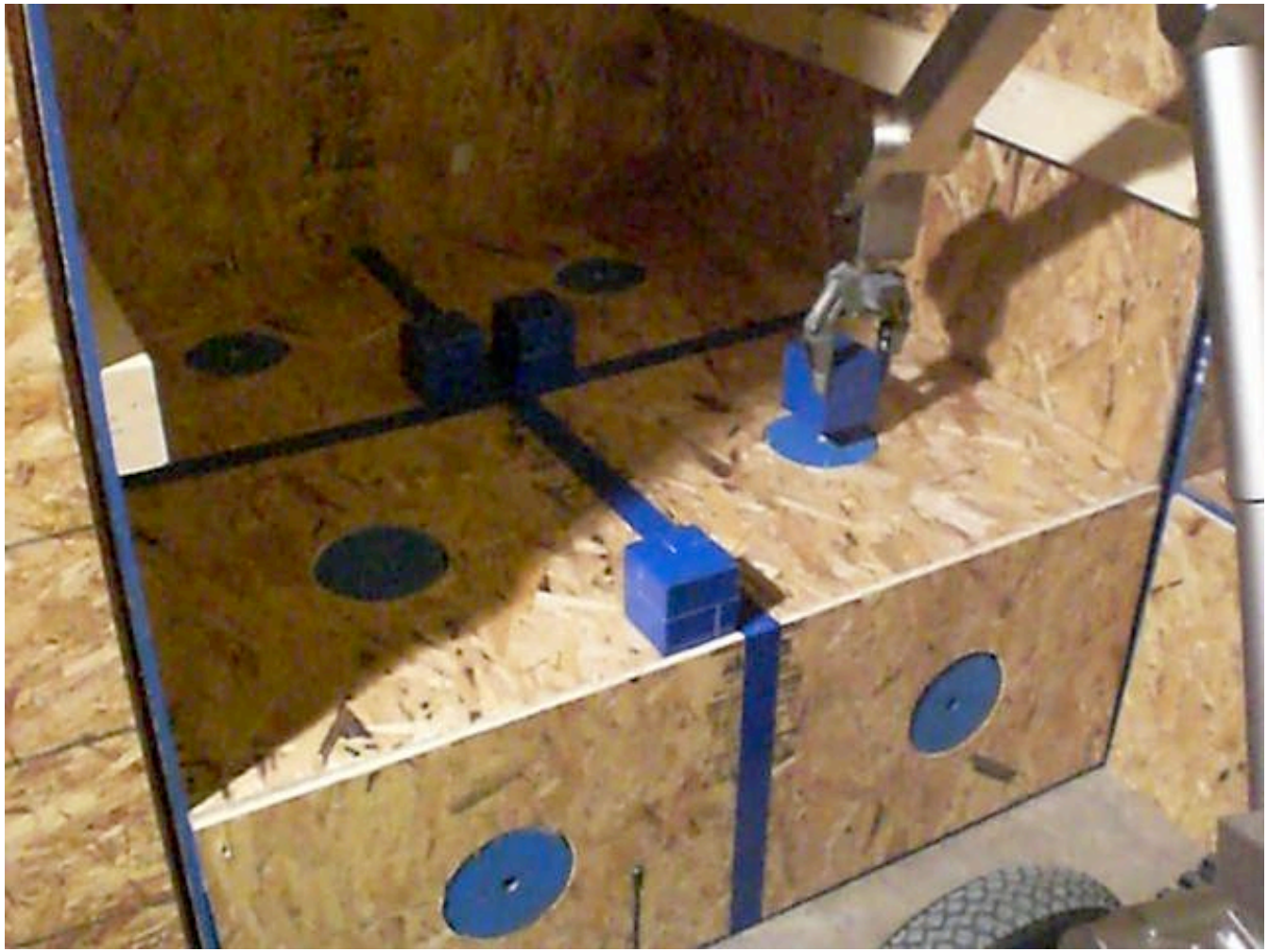
Mobile Manipulation: Directed Perception

Example of an Abstract Test Method

Apparatus: Shelves with face/top holes (up to 4 levels) and terrains: flat, roll, stepfields
Method: Identify targets inside holes (visual, CBRNE) with three constraints: open, over, under
Measure: Number targets identified at each level with each constraint, time

Mobile Manipulation: Grasping Dexterity

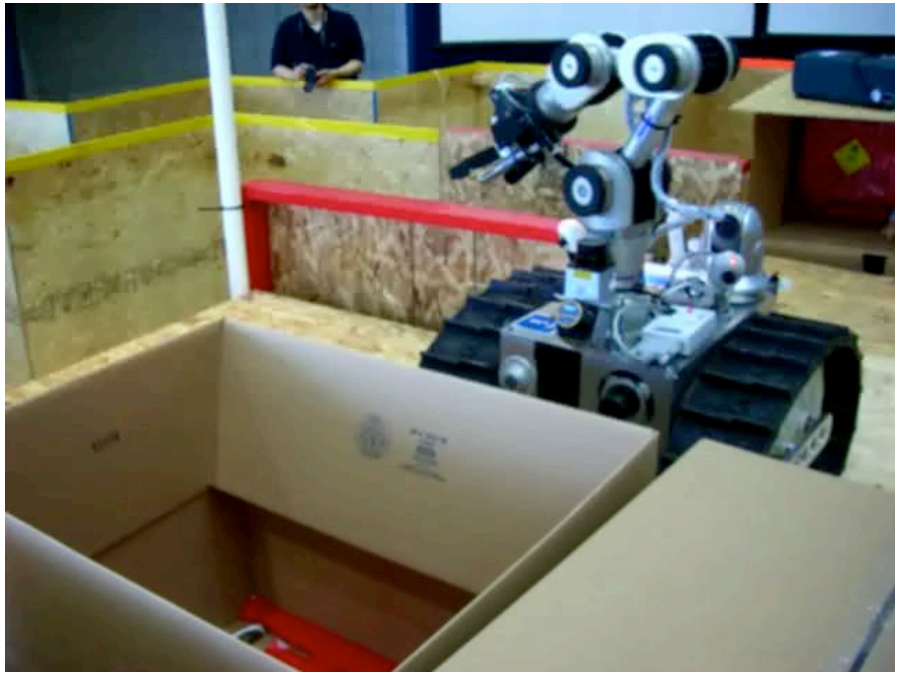
Example of an Abstract Test Method

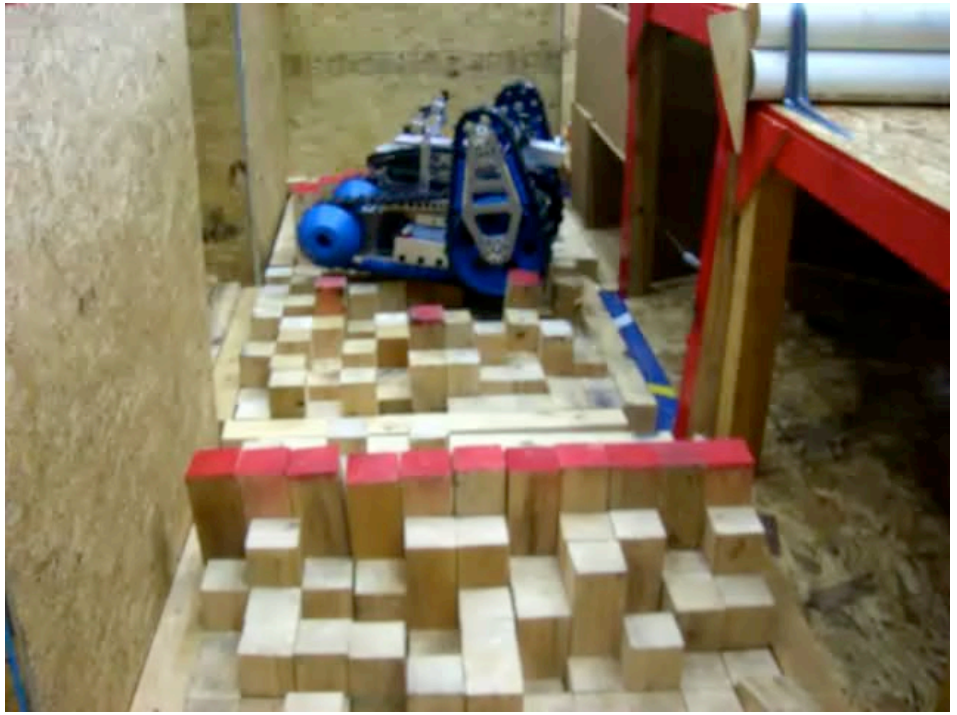


Apparatus: Shelves with top holes (up to 4 levels) and terrains: flat, roll, stepfields
Method: Place blocks into holes with three constraints: open, over, under
Measure: Number of blocks placed at each level with each constraint, time

Mobile Manipulation: Directed Perception

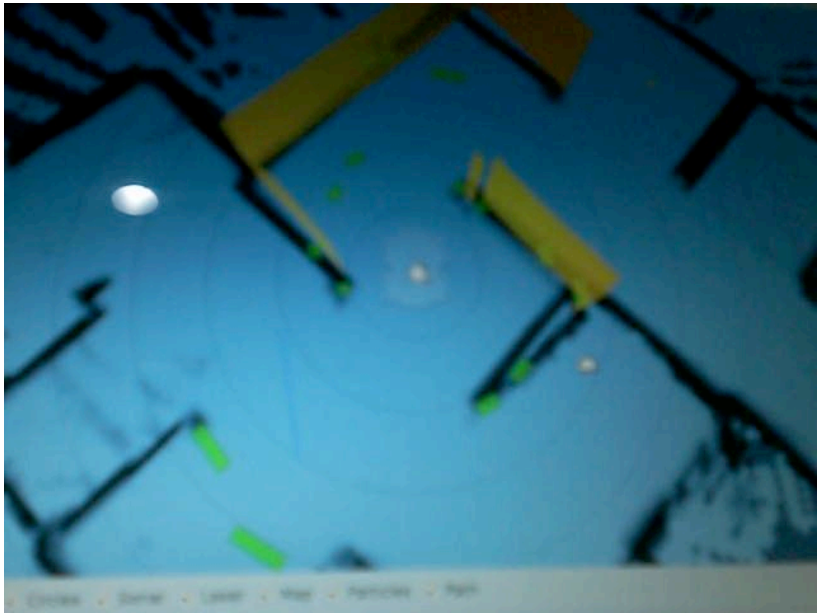
Example of an Abstract Test Method

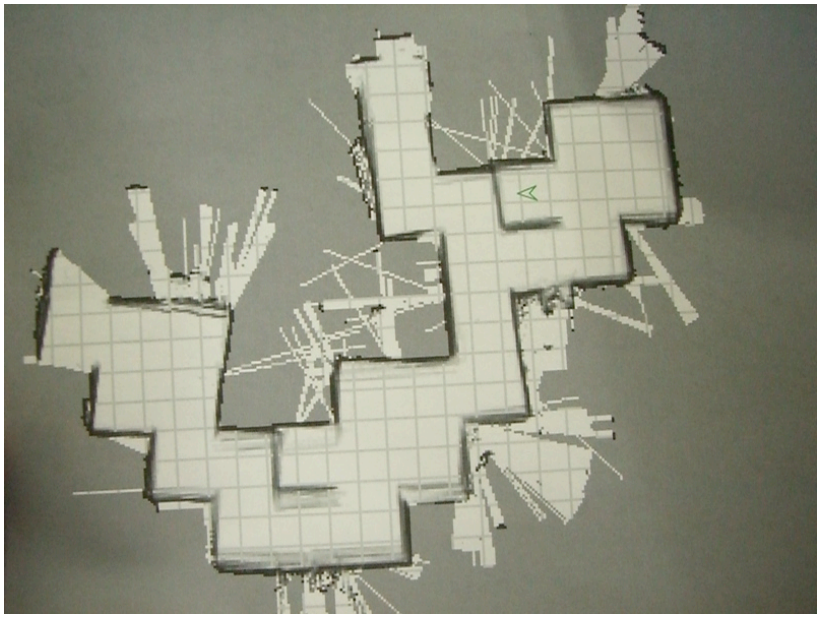




Remote Situational Awareness: Random Mazes

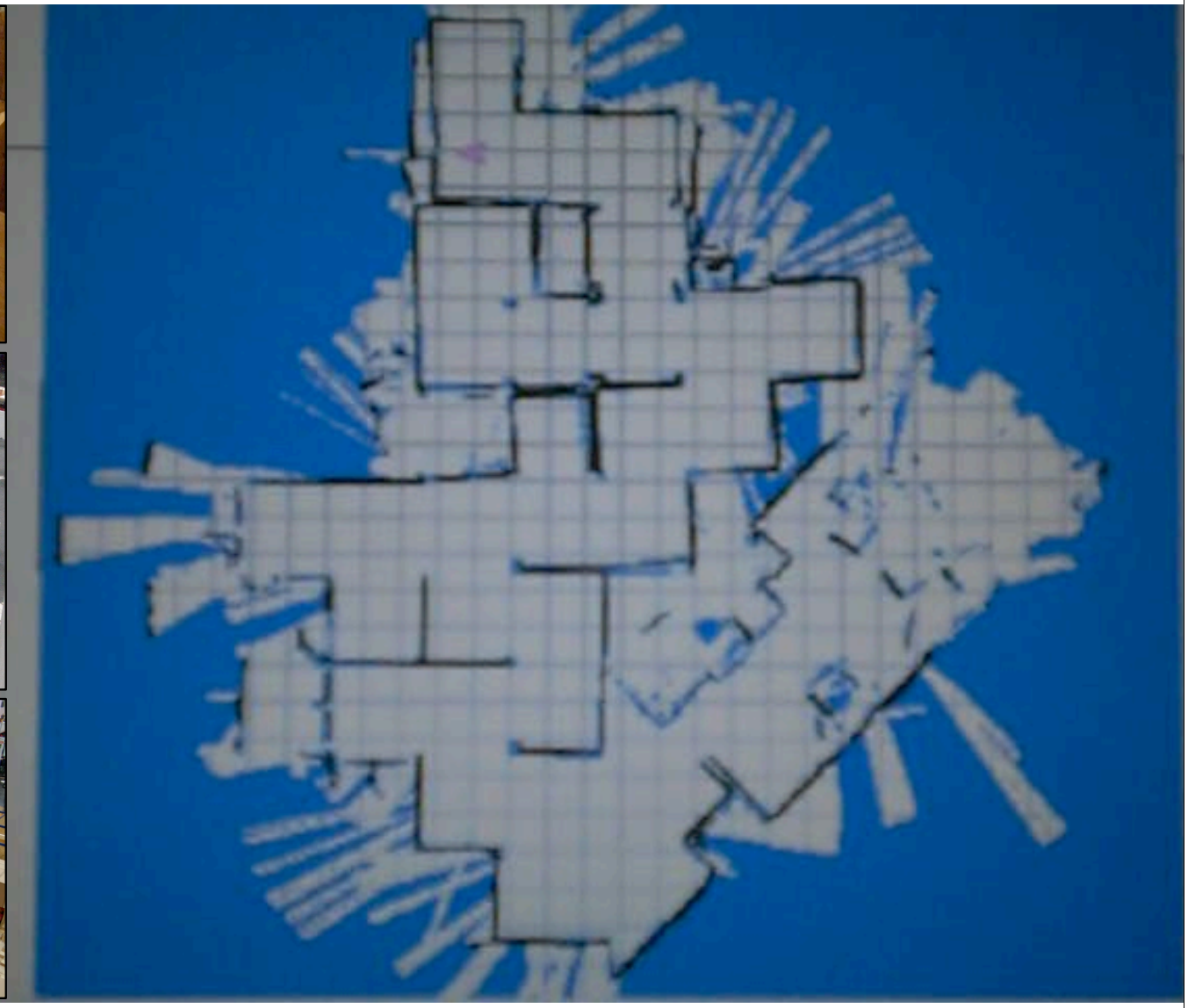
Example of an Abstract Test Method





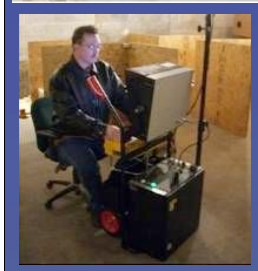
Remote Situational Awareness: Random Mazes

Example of an Abstract Test Method




Cache Packaging


Confined Space




Human Factors

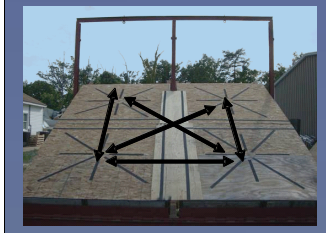
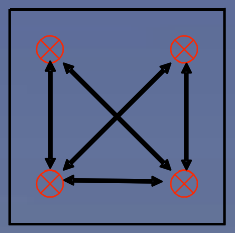

Stairs


Visual Acuity


Mobility/Endurance


Radio Comms


Random Mazes

Inclined Plane


Directed Perception


Random Stepfields

Grasping Dexterity

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CACHE PACKAGING

ROBOT: _____ ☐TET

OPERATOR: _____ ORG: ___

TRAINING TIME: ☐ 0-24 HRS ☐ 24-100 HRS

ADMINISTRATOR: 1) NOTE THE NUMBER OF EACH TYPE CONTAINER NECESSARY FOR THE ROBOT TO DEPLOY F WITHOUT RE-SUPPLY FOR THE FIRST 72 HOURS. 2) TIME PROCESS UNTIL READY TO GO DOWN RANGE. 3) NOTE NEEDED TO PERFORM SETUP AND REPAIR AND TAKE A F THE TOOL SET. 4) WEIGH THE ROBOT AND OPERATOR IN

PLANNING FOR A 10 DAY DEPLOYMENT, WITHOUT RE-SUPPLY FOR THE FIRST 72 HOURS

NUMBER OF PACKAGES: ____ PELICANS: _____ lbs

____ HARDIGGS: _____ lbs

____ ROPACKS : _____ lbs

____ PALLETS : _____ lbs

TOTAL WEIGHT: _____ lbs

SETUP TIME: START TIME: _____

END TIME: _____

ELAPSED: _____ s

FOR SETUP AND REPAIRS PERFORMED AT THE BASE OF OPERATIONS

TOOLS NEEDED: ☐ NONE:

☐ TYPICAL TOOLBOX

☐ ANY SPECIALIZED TOOLS: DESCRIBE: _____

DESCRIBE: _____

DESCRIBE: _____

DOWN-RANGE WEIGHT: ROBOT: _____ lbs OPERATOR INTERFACE: ___

TEST LEADER DATE

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Standard Test Methods For Response Robots

Version: 2007.4

VISUAL ACUITY and FIELD OF VIEW

ROBOT: _____ ☐TETHER ☐RADIO

OPERATOR: _____ ORG: _____

TRAINING TIME: ☐ 0-24 HRS ☐ 24-100 HRS ☐ > 100 HRS

ADMINISTRATOR: 1) NOTE THE CAMERA LOCATION AND ASSOCIATED FEATURES. 2) PLACE THE SNELLEN CHARTS AT THE PROPER DISTANCES: *FAR FIELD* = 6 M AND *NEAR FIELD* = 40 CM. 3) NOTE THE LUX LEVEL OF LIGHTED AND DARK CHARTS. 4) CIRCLE THE DECIMAL EQUIVALENT FOR THE SMALLEST CORRECT LINE READ NORMALLY AND WITH ZOOM LENS IN AMBIENT LIGHT. 6) REPEAT WITH LIGHTS OUT (ILLUMINATION <1 LUX).

CAMERA: _____ FOV:____° PAN:____° TILT:____° ZOOM:____x LIGHT: Y | N VARIABLE: Y | N

FAR FIELD TEST (DISTANCE = 6.0 METERS)

TEST DISTANCE 6 M	(20 FT)	LIGHTED CHART (_____ LUX) NORMAL	ZOOM	DARK CHART (_____ LUX) NORMAL	ZOOM
AERIAL CHART		NONE	NONE	NONE	NONE
6/90	(20/300)	0.07	0.07	0.07	0.07
6/75	(20/250)	0.08	0.08	0.08	0.08
6/60	(20/200)	0.10	0.10	0.10	0.10
6/45	(20/150)	0.13	0.13	0.13	0.13
FAR FIELD CHART (5M)					
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	(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	(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)	1.7	1.7	1.7	1.7
6/3.0	(20/10)	2.0	2,0	2.0	2.0
6/2.4	(20/8)	2.5	2.5	2.5	2.5
6/1.7	(20/6)	3.3	3.3	3.3	3.3
6/1.5	(20/5)	4.0	4.0	4.0	4.0
NEAR FIELD CHART (BOTTOM NINE LINES ADJUSTED TO 6M)					
6/1.25	(20/4)	5.0	5.0	5.0	5.0
6/1.00	(20/3.3)	6.0	6.0	6.0	6.0
6/0.8	(20/2.7)	7.5	7.5	7.5	7.5
6/0.6	(20/2.0)	10	10	10	10
6/0.5	(20/1.7)	12	12	12	12
6/0.40	(20/1.3)	15	15	15	15
6/0.3	(20/1.1)	20	20	20	20
6/0.25	(20/.08)	24	24	24	24
6/0.20	(20/.07)	30	30	30	30

VISUAL ACUITY RATIOS NOTED MEAN:

READABLE AT ACTUAL TEST DISTANCE

READABLE DISTANCE WITH STANDARD VISION

CIRCLE DECIMAL EQUIVALENT IN EACH COLUMN

NEAR FIELD TEST (DISTANCE = 0.40 METER)

EQUIVALENT DISTANCE 6 M	(20 FT)	LIGHTED CHART (_____ LUX) NORMAL	ZOOM	DARK CHART (_____ LUX) NORMAL	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

TEST LEADER DATE NOTES ☐

NIST
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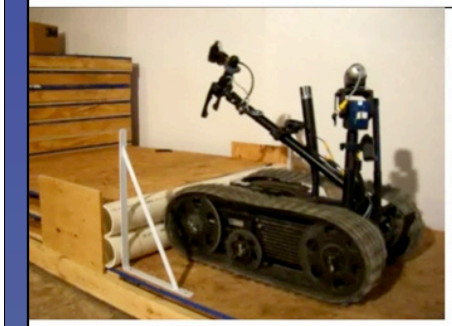
Technology Administration, U.S. Department of Commerce

Developing
Standard Test Methods For Response Robot



STEP/GAP

ROBOT: _____ ☐TET

OPERATOR: _____ ORG: ___

TRAINING TIME: ☐ 0-24 HRS ☐ 24-100 HRS

INSTRUCTIONS: TRAVERSE THE OBSTACLE AND RETUR
POINT (ONE REPETITION). REPEAT FIVE TIMES CONTINU

ADMINISTRATOR: 1) FOR EACH OBSTACLE, INCREASE O
UNSUCCESSFUL IN ONE OF FIVE REPETITIONS. CIRCLE
OBSTACLE DIMENSION WITH FIVE CONTINUOUS REPETI
THE ELAPSED TIME FOR FIVE CONTINUOUS TRAVERSES

STEP WITH EDGE

HEIGHT	1	2	3	4	5	ELAPSED TIME
☐ 100 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 90 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 80 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 70 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 60 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 50 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 40 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 30 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 20 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 10 cm	☐	☐	☐	☐	☐	_____ m:s

GAP WITH NO STEP

HEIGHT	1	2	3	4	5	E
☐ 100 cm	☐	☐	☐	☐	☐	
☐ 90 cm	☐	☐	☐	☐	☐	
☐ 80 cm	☐	☐	☐	☐	☐	
☐ 70 cm	☐	☐	☐	☐	☐	
☐ 60 cm	☐	☐	☐	☐	☐	
☐ 50 cm	☐	☐	☐	☐	☐	
☐ 40 cm	☐	☐	☐	☐	☐	
☐ 30 cm	☐	☐	☐	☐	☐	
☐ 20 cm	☐	☐	☐	☐	☐	
☐ 10 cm	☐	☐	☐	☐	☐	

STEP WITH PIPE

HEIGHT	1	2	3	4	5	ELAPSED TIME
☐ 100 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 90 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 80 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 70 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 60 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 50 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 40 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 30 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 20 cm	☐	☐	☐	☐	☐	_____ m:s
☐ 10 cm	☐	☐	☐	☐	☐	_____ m:s

GAP WITH 20CM STE

HEIGHT	1	2	3	4	5	E
☐ 100 cm	☐	☐	☐	☐	☐	
☐ 90 cm	☐	☐	☐	☐	☐	
☐ 80 cm	☐	☐	☐	☐	☐	
☐ 70 cm	☐	☐	☐	☐	☐	
☐ 60 cm	☐	☐	☐	☐	☐	
☐ 50 cm	☐	☐	☐	☐	☐	
☐ 40 cm	☐	☐	☐	☐	☐	
☐ 30 cm	☐	☐	☐	☐	☐	
☐ 20 cm	☐	☐	☐	☐	☐	
☐ 10 cm	☐	☐	☐	☐	☐	

TEST LEADER DATE

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Technology Administration, U.S. Department of Commerce

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Standard Test Methods For Response Robots

Version: 2007.4

STAIRS

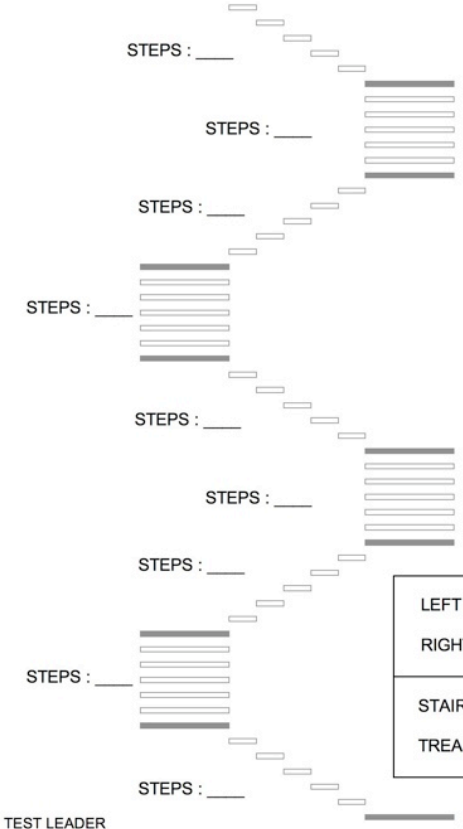
ROBOT: _____ ☐TETHER ☐RADIO

OPERATOR: _____ ORG: _____

TRAINING TIME: ☐ 0-24 HRS ☐ 24-100 HRS ☐ > 100 HRS

INSTRUCTIONS: ASCEND THE STAIRS TO THE TOP, TURN AND DESCEND BACK TO THE START POINT.

ADMINISTRATOR: 1) NOTE THE AVERAGE STEP RISER AND TREAD DIMENSIONS. 2) NOTE THE WALL CONDITIONS AS SOLID OR OPEN. 3)NOTE THE NUMBER OF STAIRS AND LANDINGS (SHOWN IN GREY). 4)TIME THE SEQUENCE.



	ASCENDING	DESCENDING
START TIME:	_____	_____
END TIME:	_____	_____
ELAPSED TIME:	_____ s	_____ s
TOTAL STEPS: (COUNT LANDINGS AS A STAIR)	_____	_____
AVG RATE: (COUNT LANDINGS AS A STAIR)	_____	_____

LEFT WALL (ASCENDING): ☐ SOLID ☐ EMPTY W/ RAILING

RIGHT WALL (ASCENDING): ☐ SOLID ☐ EMPTY W/ RAILING

STAIR HEIGHT: _____ cm ☐ SOLID RISER

TREAD DEPTH: _____ cm ☐ EMPTY RISER

TEST LEADER DATE NOTES

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Standard Test Methods For Response Robot

INCLINED PLANE

ROBOT: _____ ☐TETH

OPERATOR: _____ ORG: _____

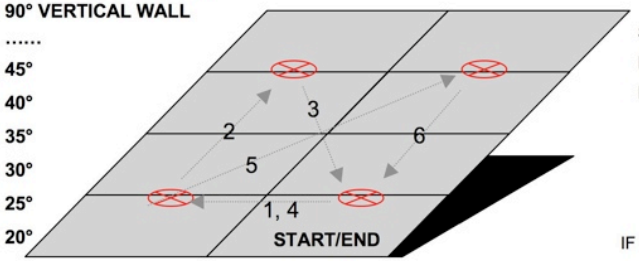
TRAINING TIME: ☐ 0-24 HRS ☐ 24-100 HRS

INSTRUCTIONS: TRAVERSE THE TWO PATTERNS SHOWN OF GRAVITY OF THE ROBOT ROUGHLY PASSING OVER EA

ADMINISTRATOR: 1) FOR EACH ANGLE, CHECK IF COMPL NUMBER OF SEGMENTS COMPLETED IN ORDER. TARGET OF ORDER IS INCOMPLETE. 2) TIME THE SEQUENCE. 4) I ANGLE UNTIL INCOMPLETES REPEAT. THE PREVIOUS CO WILL BE CONSIDERED AS THE MAXIMUM.

INCLINE (CHECK ONE):

- ☐ 90° VERTICAL WALL
- .....
- ☐ 45°
- ☐ 40°
- ☐ 35°
- ☐ 30°
- ☐ 25°
- ☐ 20°



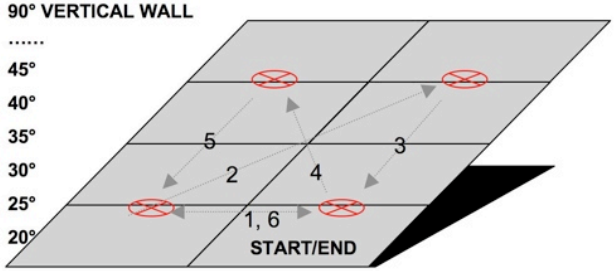
SURFACE TYPE:
☐ OSB PANEL
☐ OTHER: ___
START TIME:
END TIME:
ELAPSED

☐ COMPLETE
(YES = √ , N

IF NO, SEGMENTS C
_____ OF 6 (DRA

INCLINE (CHECK ONE):

- ☐ 90° VERTICAL WALL
- .....
- ☐ 45°
- ☐ 40°
- ☐ 35°
- ☐ 30°
- ☐ 25°
- ☐ 20°



SURFACE TYPE:
☐ OSB PANEL
☐ OTHER: ___
START TIME:
END TIME:
ELAPSED

☐ COMPLETE
(YES = √ , I

IF NO, SEGMENTS C
_____ OF 6 (DRA

TEST LEADER DATE

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ZIG-ZAG DASHES

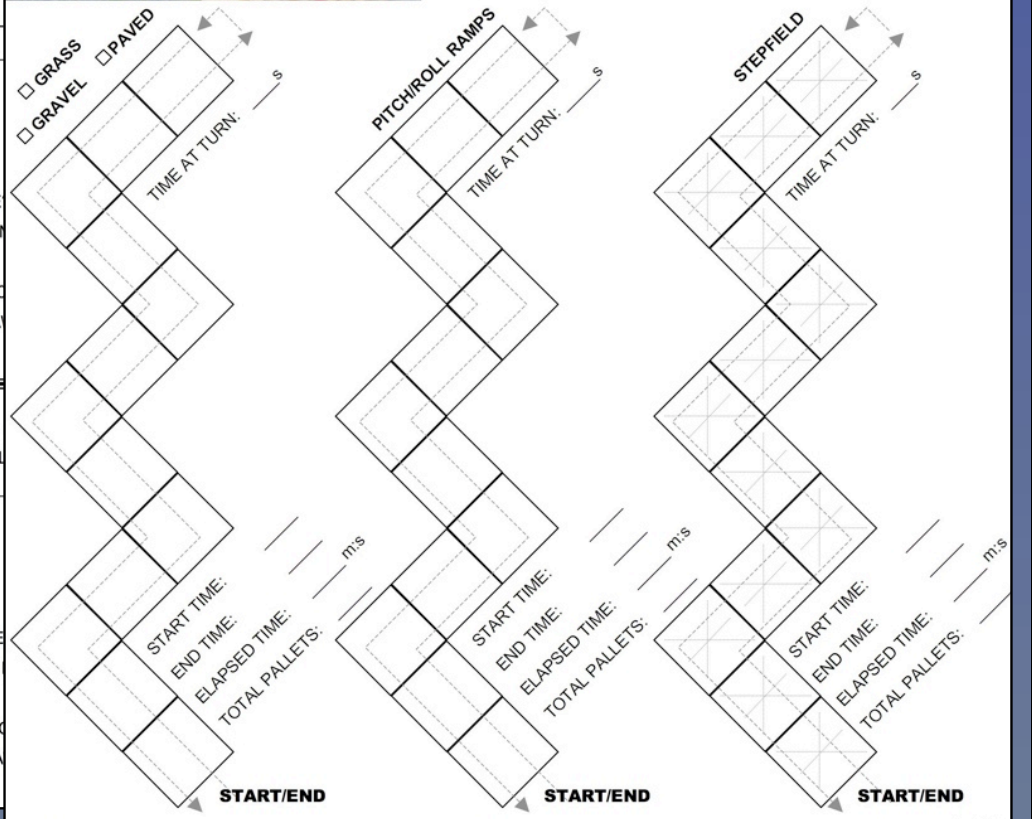
ROBOT: _____ ☐TETHER ☐RADIO

OPERATOR: _____ ORG: _____

TRAINING TIME: ☐ 0-24 HRS ☐ 24-100 HRS ☐ > 100 HRS

INSTRUCTIONS: TRAVERSE THE ZIG-ZAG TO FAR END AND BACK WITHOUT BUMPING THE WALLS. TURNING IN PLACE AT FAR END IS OPTIONAL.

ADMINISTRATOR:1) TRACE THE ELEVATIONS (IF ANY) FOR THE GIVEN TERRAIN. 2) NOTE THE LOCATIONS OF WALL BUMPS WITH AN "X" ON THE GRAPHIC. 3) NOTE THE NUMBER OF PALLETS IF INCOMPLETE. 4) NOTE THE ELAPSED TIME.



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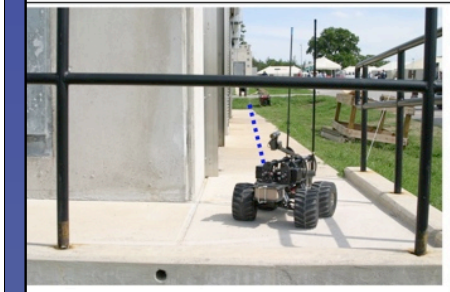


RADIO COMMS (LINE-OF-SIGH

ROBOT: _____ ☐TET

OPERATOR: _____ ORG: _

TRAINING TIME: ☐ 0-24 HRS ☐ 24-100 HRS

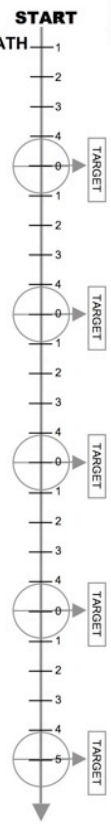
INSTRUCTIONS: WHILE TRAVERSING THE PATH SHOWN, THE SMALLEST COMPLETE LINE ON THE VISUAL ACUITY PERFORMANCE DEGRADES TO UNUSABLE. THEN RETUR SAME TARGETS IN REVERSE ORDER. ANTENNA HEIGHT

ADMINISTRATOR: 1) NOTE ALL RADIO INFORMATION. 2) N DISTANCES FROM THE START POINT TO EACH EQUALLY 3) NOTE THE TIME ON TARGET TO POINT TO AND READ T CORRECT LINE. 4) CIRCLE LAST LINE MARKER IF FARTH BETWEEN TARGETS.

START TIME: _____

START

LINE OF SIGHT PATH



RADIO COMMUNICATIONS
(COMMANDS, DATA, VIDEO, AUDIO, SENSORS, OTHER)

OCU TRANSMITTERS:
Content: _____
_____ MHz _____ W
_____ cm antenna height

Content: _____
_____ MHz _____ W
_____ cm antenna height

ROBOT TRANSMITTERS:
Content: _____
_____ MHz _____ W
_____ cm antenna height

Content: _____
_____ MHz _____ W
_____ cm antenna height

	OUTBOUND	INBO
1ST TARGET:	_____ meters	
ARRIVAL TIME:	_____	
TIME ON TARGET:	_____	
SMALLEST ACUITY:	_____	
2ND TARGET:	_____ meters	
ARRIVAL TIME:	_____	
TIME ON TARGET:	_____	
SMALLEST ACUITY:	_____	
3RD TARGET:	_____ meters	
ARRIVAL TIME:	_____	
TIME ON TARGET:	_____	
SMALLEST ACUITY:	_____	
4TH TARGET:	_____ meters	
ARRIVAL TIME:	_____	
TIME ON TARGET:	_____	
SMALLEST ACUITY:	_____	
5TH TARGET:	_____ meters	
ARRIVAL TIME:	_____	
TIME ON TARGET:	_____	
SMALLEST ACUITY:	_____	

TEST LEADER DATE

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Standard Test Methods For Response Robots

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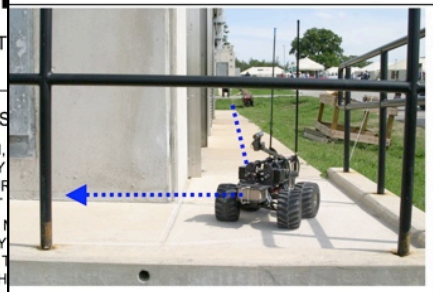


RADIO COMMS (NON-LINE-OF-SIGHT)

ROBOT: _____ ☐TETHER ☐RADIO

OPERATOR: _____ ORG: _____

TRAINING TIME: ☐ 0-24 HRS ☐ 24-100 HRS ☐ > 100 HRS

INSTRUCTIONS: WHILE TRAVERSING THE PATH SHOWN, STOP AND READ THE SMALLEST COMPLETE LINE ON THE VISUAL ACUITY TARGETS UNTIL PERFORMANCE DEGRADES TO UNUSABLE. THEN RETURN READING ALL THE SAME TARGETS IN REVERSE ORDER. ANTENNA HEIGHT < 2 METERS.

ADMINISTRATOR: 1) NOTE ALL RADIO INFORMATION. 2) NOTE THE DISTANCES FROM THE START POINT TO EACH EQUALLY SPACED TARGET. 3) NOTE THE TIME ON TARGET TO POINT TO AND READ THE SMALLEST CORRECT LINE. 4) CIRCLE LAST LINE MARKER IF FARTHEST RANGE IS BETWEEN TARGETS.

START TIME: _____

START (STANDOFF = _____ meters)

BUILDING OR OTHER LARGE OBSTACLE

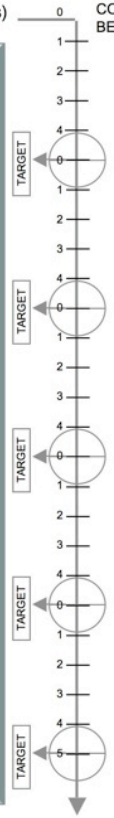
RADIO COMMUNICATIONS
(COMMANDS, DATA, VIDEO, AUDIO, SENSORS, OTHER)

OCU TRANSMITTERS:
Content: _____
_____ MHz _____ W
_____ cm antenna height

Content: _____
_____ MHz _____ W
_____ cm antenna height

ROBOT TRANSMITTERS:
Content: _____
_____ MHz _____ W
_____ cm antenna height

Content: _____
_____ MHz _____ W
_____ cm antenna height



	OUTBOUND	INBOUND
1ST TARGET:	_____ meters	
ARRIVAL TIME:	_____	_____ m:s
TIME ON TARGET:	_____	_____ m:s
SMALLEST ACUITY:	_____	_____ (decimal)
2ND TARGET:	_____ meters	
ARRIVAL TIME:	_____	_____ m:s
TIME ON TARGET:	_____	_____ m:s
SMALLEST ACUITY:	_____	_____ (decimal)
3RD TARGET:	_____ meters	
ARRIVAL TIME:	_____	_____ m:s
TIME ON TARGET:	_____	_____ m:s
SMALLEST ACUITY:	_____	_____ (decimal)
4TH TARGET:	_____ meters	
ARRIVAL TIME:	_____	_____ m:s
TIME ON TARGET:	_____	_____ m:s
SMALLEST ACUITY:	_____	_____ (decimal)
5TH TARGET:	_____ meters	
ARRIVAL TIME:	_____	_____ m:s
TIME ON TARGET:	_____	_____ m:s
SMALLEST ACUITY:	_____	_____ (decimal)

TEST LEADER DATE NOTES

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Standard Test Methods For Response Robot

GRASPING DEXTERITY

ROBOT: _____ ☐TET

OPERATOR: _____ ORG: ___

TRAINING TIME: ☐ 0-24 HRS ☐ 24-100 HRS

INSTRUCTIONS: 1) TRACE GROUND TERRAIN AND STACK
SEQUENCE TO REMOVE AS MANY BLOCKS FROM EACH
POSSIBLE (DROPPING BLOCKS ONTO FLOOR IS OKAY).
ANGLED BLOCKS ("B") AND CENTERED OBJECTS ("O") AR
NOTE ELAPSED TIME.

START TIME: _____

END TIME: _____

ELAPSED: _____ s

BLOCKS REMOVED
BY LEVEL (CENTER)

#:___

BLOCKS REMOVED
BY LEVEL (LEFT)

#:___

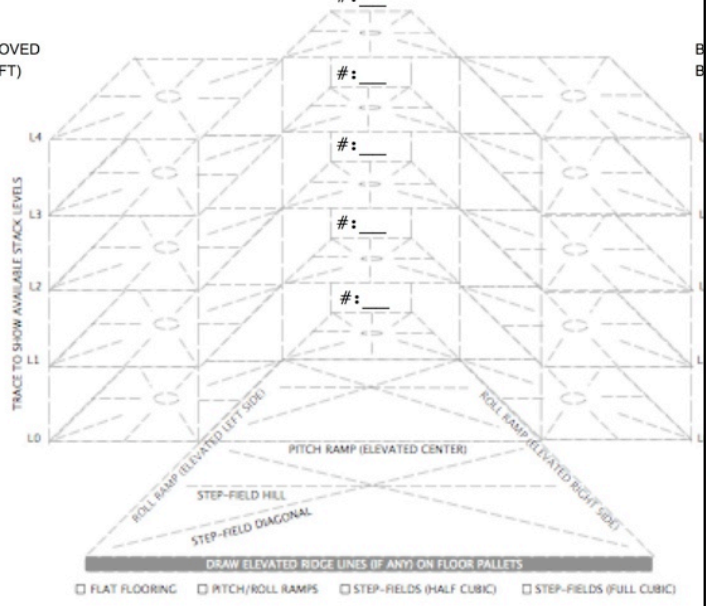
#:___

#:___

#:___

#:___

#:___



☐ FLAT FLOORING ☐ PITCH/ROLL RAMPS ☐ STEP-FIELDS (HALF CUBIC) ☐ STEP-FIELDS (FULL CUBIC)

TEST LEADER DATE

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Technology Administration, U.S. Department of Commerce

Developing
Standard Test Methods For Response Robots

Version: 2007.4

DIRECTED PERCEPTION

ROBOT: _____ ☐TETHER ☐RADIO

OPERATOR: _____ ORG: _____

TRAINING TIME: ☐ 0-24 HRS ☐ 24-100 HRS ☐ > 100 HRS

INSTRUCTIONS: FOR EACH LEVEL (UP TO FOUR LEVELS) , IDENTIFY RANDOMIZED TARGETS IN HOLES WITHOUT BUMPING ANY BOXES.

ADMINISTRATOR: 1) CHECK TERRAIN TYPE AND TRACE ELEVATIONS (IF ANY). 2) CIRCLE TARGETS IDENTIFIED WITH TWO OF FOUR FEATURES (COLOR/ICON/WORD/NUMBER). 3) COUNT BUMPS AND ELAPSED TIME. 4)FOR CHEMICAL/EXPLOSIVE/RADIATION SOURCES, CHECK DISTANCE AT FIRST DETECTION AND USE SQUARES TO IDENTIFY CO-LOCATED TARGETS.

LEVEL 4 START TIME: _____

LEVEL 4 END TIME: _____

LEVEL 4 ELAPSED: _____ m:s

BUMPS: ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

LEVEL 3 START TIME: _____

LEVEL 3 END TIME: _____

LEVEL 3 ELAPSED: _____ m:s

BUMPS: ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

LEVEL 2 START TIME: _____

LEVEL 2 END TIME: _____

LEVEL 2 ELAPSED: _____ m:s

BUMPS: ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

LEVEL 1 START TIME: _____

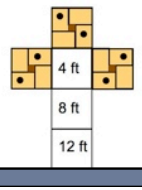
LEVEL 1 END TIME: _____

LEVEL 1 ELAPSED: _____ m:s

BUMPS: ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

FIRST DETECTION:
☐ CHEMICAL
☐ EXPLOSIVE
☐ RADIATION

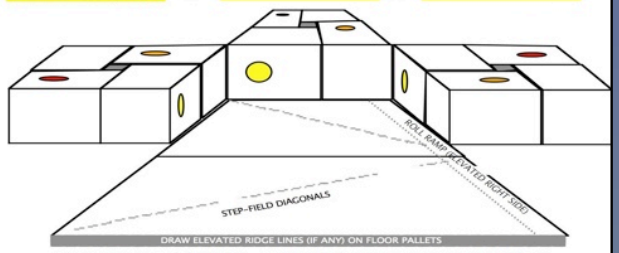
CIRCLE DISTANCE:



TEST LEADER

TOP FAR
TOP NEAR
FACE HOLES
TOP FRONT

L4 L3 L2 L1



☐ FLAT FLOORING ☐ ROLL RAMPS ☐ STEP-FIELDS (HALF CUBIC) ☐ STEP-FIELDS (FULL CUBIC)

DATE NOTES

Response Robot Evaluation Exercises

FEMA US&R Task Force Representatives and NIST Personnel


Robot Developers


Test Methods

Operational Scenarios

Response Robot Evaluation Exercises

Homeland Security NIST

Response Robot Evaluation Exercise

FEMA US&R Task Force Training Facility (TX-TF1)
Disaster City, College Station, TX
November 17-21, 2008
(including an ASTM E54.08.01 standards committee meeting Friday morning)

Sponsor: Bert Coursey, Science &Technology Directorate, DHS www.isd.mel.nist.gov/us&r_robot_standards
Test Director: Adam Jacoff, Intelligent Systems Division, NIST usar.robots@nist.gov

TEXAS A&M SYSTEM TEEX

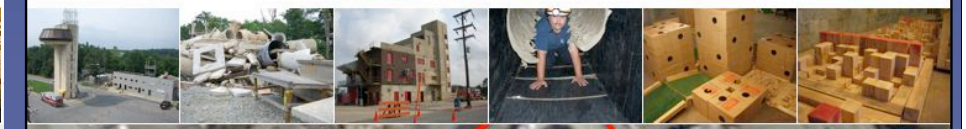
Homeland Security NIST

Response Robot Evaluation Exercise

MD-TF1 Training Academy
Rockville, MD
August 19-21, 2006
(with a standards meeting August 21, 2006)

www.isd.mel.nist.gov/us&r_robot_standards usar.robots@nist.gov

Maryland



Emerging Standard Test Methods for Response Robots

Logistics: Cache Packaging, Setup, Tools
Sensors: Video: Acuity
Sensors: Video: Field of View
Sensors: Video: Spatial Awareness
Sensors: Audio: Two Way Comms
Sensors: Sonar: Resolution
Radio Comms: Line of Sight
Radio Comms: Non Line of Sight
Radio Comms: Structure Penetration
Human Factors: Check List Items
Human Factors: Random Maze Search
Energy: Endurance
Mobility: Inclined Plane
Mobility: Pipe Step
Mobility: Gap Crossing
Mobility: Stairs
Mobility: Stepfield Terrain
Mobility: Confined Space
Mobility: Towing
Manipulation: Directed Perception
Manipulation: Grasping Dexterity
Aquatic: Station Keeping in Current
Aerial (<2kg): Airworthiness
Aerial (<2kg): Fixed Wing Orbits
Aerial (<2kg): VTOL Station Keeping

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