RoboCupRescue Robot League

2024 Championship, Eindhoven, Netherlands

Version: 2024B

Trustees

Raymond Sheh, Australia (2021-2024)
Jackrit Suthakorn (2016-2021)
*Adam Jacoff (2009-2015)**
*Satoshi Tadokoro (2002-2008)**

Executive Committee

Stefan May, Germany
Noritaka Sato, Japan
Ann Virts, USA
Tetsuya Kimura, Japan
Sören Schwertfeger, China
Jafar Chegini, Iran
Johannes Pellenz, Germany
Raymond Sheh, Australia
Gerald Steinbauer, Austria
Ehsan Mihankhah Iran/Thailand
Andreas Birk, Germany
Claude Sammut, Australia
*Adam Jacoff, USA**
*Satoshi Tadokoro, Japan**
** Co-Founders*

Technical Committee

Martin Oehler, Germany
Archer Losely, USA
Shotaro Kojima, Japan
Emilo Platt, Mexico
Tom Haus, USA

Organizing Committee

Adam Jacoff, USA*
Johannes Pellenz, Germany
_____________ (Local Chair)

RoboCupRescue Championships

2024 Eindhoven, Netherlands
2023 Bordeaux, France
2022 Bangkok, Thailand
2021 Distributed/Remote
2020 Cancelled (Pandemic)
2019 Sydney, Australia
2018 Montreal, Canada
2017 Nagoya, Japan
2016 Leipzig, Germany
2015 Hefei, China
2014 Joao Pessoa, Brazil
2013 Eindhoven, Netherlands
2012 Mexico City, Mexico
2011 Istanbul, Turkey
2010 Singapore, Singapore
2009 Graz, Austria
2008 Suzhou, China
2007 Atlanta, USA
2006 Bremen, Germany
2005 Osaka, Japan
2004 Lisbon, Portugal
2003 Padua, Italy
2002 Fukuoka, Japan
2001 Seattle, USA
2000 AAAI Conf, Austin, TX

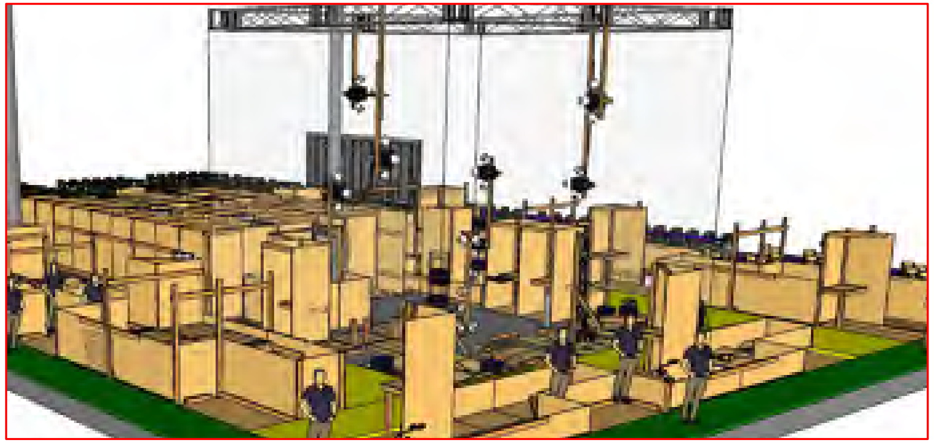
League Objectives

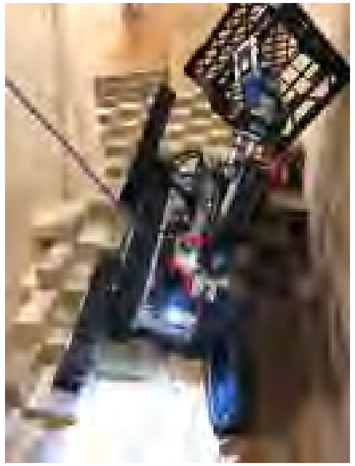
Version: 2024B

Emergency responders need robots with assistive/autonomous capabilities to perform extremely hazardous tasks in complex environments from safe standoff distances.

RoboCupRescue

provides a tangible language between emergency responders and researchers/manufacturers to refine, measure, and highlight breakthrough robotic capabilities.





League Objectives

- Established just before the World Trade Center collapse in New York City more than 20 years ago, where robots were deployed but didn't do so well (understandably). But there are partial collapses to deal with much more often.

- Gather teams of researchers capable of developing robotic systems that enable emergency responders to perform extremely hazardous tasks from safer stand-off distances.

- Demonstrate and improve upon the sate-of-the-science in robotics for unstructured environments, with an emphasis on developing autonomous and assistive capabilities that make remotely operated robots more capable and reliable.

- Develop and disseminate the standard test methods emergency responders use to
  - Objectively evaluate commercial robots
  - Train with objective measures of remote operator proficiency
  - Credential robot operators for hazardous missions

- It is a long process to harden and commercialize your robots, but this is the essential first step out of the laboratory toward making a difference for those in harm's way.

RoboCupRescue Championships

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Spectrum of Commercial Tracked/Wheeled Robots

RoboCupRescue conducts comprehensive evaluations involving essential mission tasks required by emergency responders worldwide. The arena includes a variety of reproducible terrains, obstacles, and tasks with increasing difficulty to challenge even the most capable robots. Same tests used for commercial robots.

- Ground robots range from small throwable to rather huge.
- Note the new (largest) class of firefighting robots remotely spraying water on a fire.
- All need to be evaluated similarly.


iRobot 110 FirstLook
2.4kg (5.2lbs)


Qinetiq Dragon Runner 10
4.5kg (10lbs)

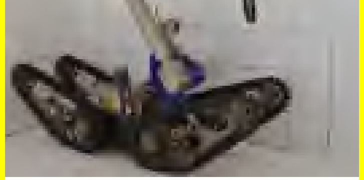

iRobot 310 SUGV
13.2kg (29lbs)


ICOR Caliber Mini
27kg (65lbs)


Remotec Titus
61kg (135lbs)


ICOR Caliber T5
64kg (140lbs)

2006 AWARD


Telerob Telemax
80kg (175lbs)


ICOR Caliber MK3
84kg (185lbs)


Remotec HD-SEL
111kg (245lb)


iRobot 710 Kobra
166.5kg (367lbs)


Remotec F6B
220kg (485lb)


WM Robotics Knight
249kg (550lbs)


Remotec Mark 5-A1
358kg (790lbs)


Remotec Wolverine
367kg (810lbs)

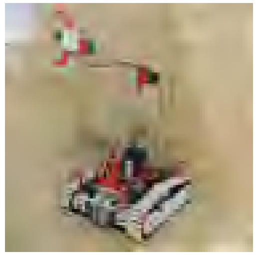

Howe & Howe Thermite RS1 & RS3
550kg (1200lbs) 1200 Gallons per Minute

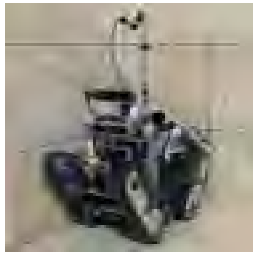
Examples of RoboCupRescue Robots

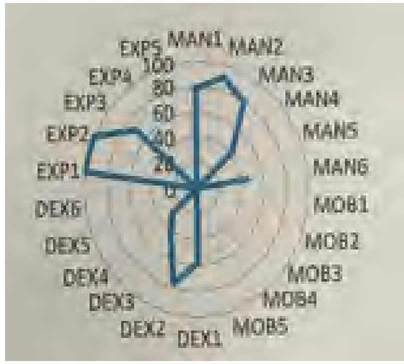
RoboCupRescue Robots can have similar designs – success is often imitated. Or they can be very different. All need to be evaluated, compared, and differentiated based on statistically significant capabilities data.

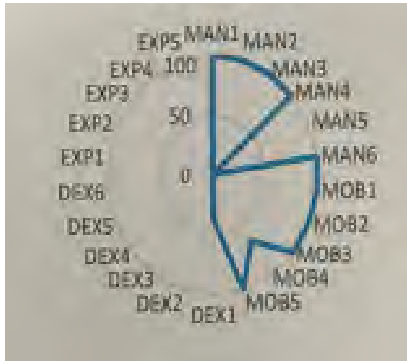


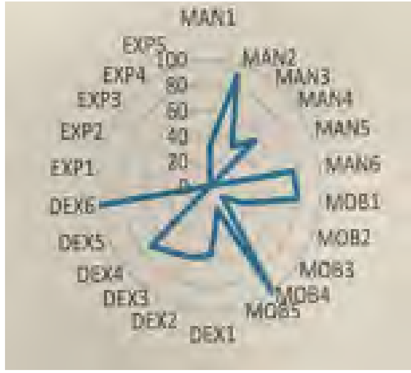




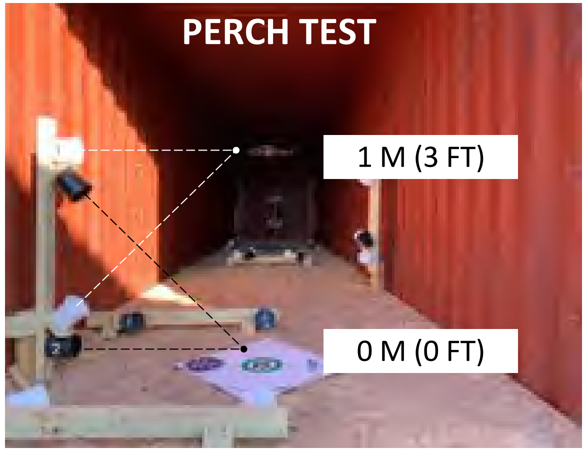


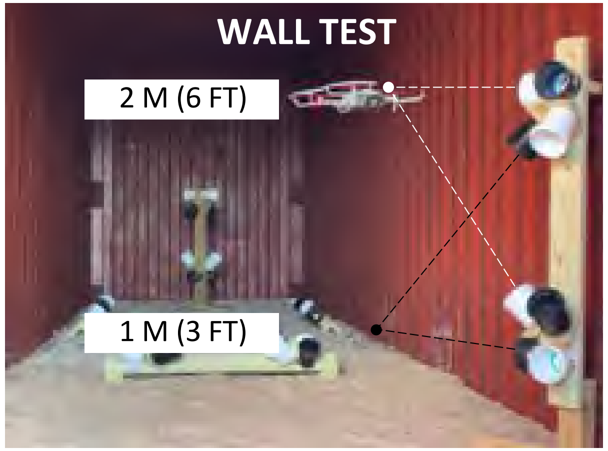




Drones for Interiors and Legged Robots are Coming

Version: 2024B





Unitree Go1
Max Height : 29 cm (12 in)
Weight: 12 kg (26 lbs)
Max Step : 10 cm (4 in)
Max Incline: ± 21 degrees

Unitree Aliengo
Max Height: 60 cm (24 in)
Weight: 21 kg (47 lbs)
Max Step : 12 cm (4.7 in)
Max Incline: ± 25 degrees

Boston Dynamics Spot
Max Height : 70 cm (28 in)
Weight : 32 kg (72 lbs)
Max Step : 30 cm (12 in)
Max Incline : ± 30 degrees

Unitree B1
Max Height : 64 cm (25 in)
Weight : 50 kg (110 lbs)
Max Step : 20 cm (8 in)
Max Incline : ± 30 degrees

Ghost Robotics Vision 60
Max Height : 76 cm (30 in)
Weight : 51 kg (112 lbs)
Max Step: __ cm (__ in)
Max Incline : ±__ degrees

Robot specifications provided by the manufacturers can be validated using standard test methods during this competition through statistically significant task repetitions.

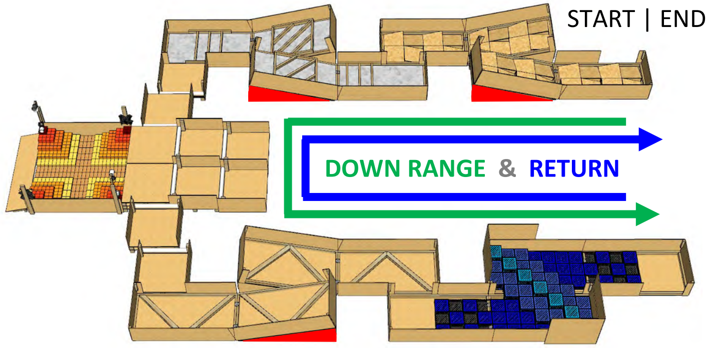
Emerging Legged Robot Capabilities

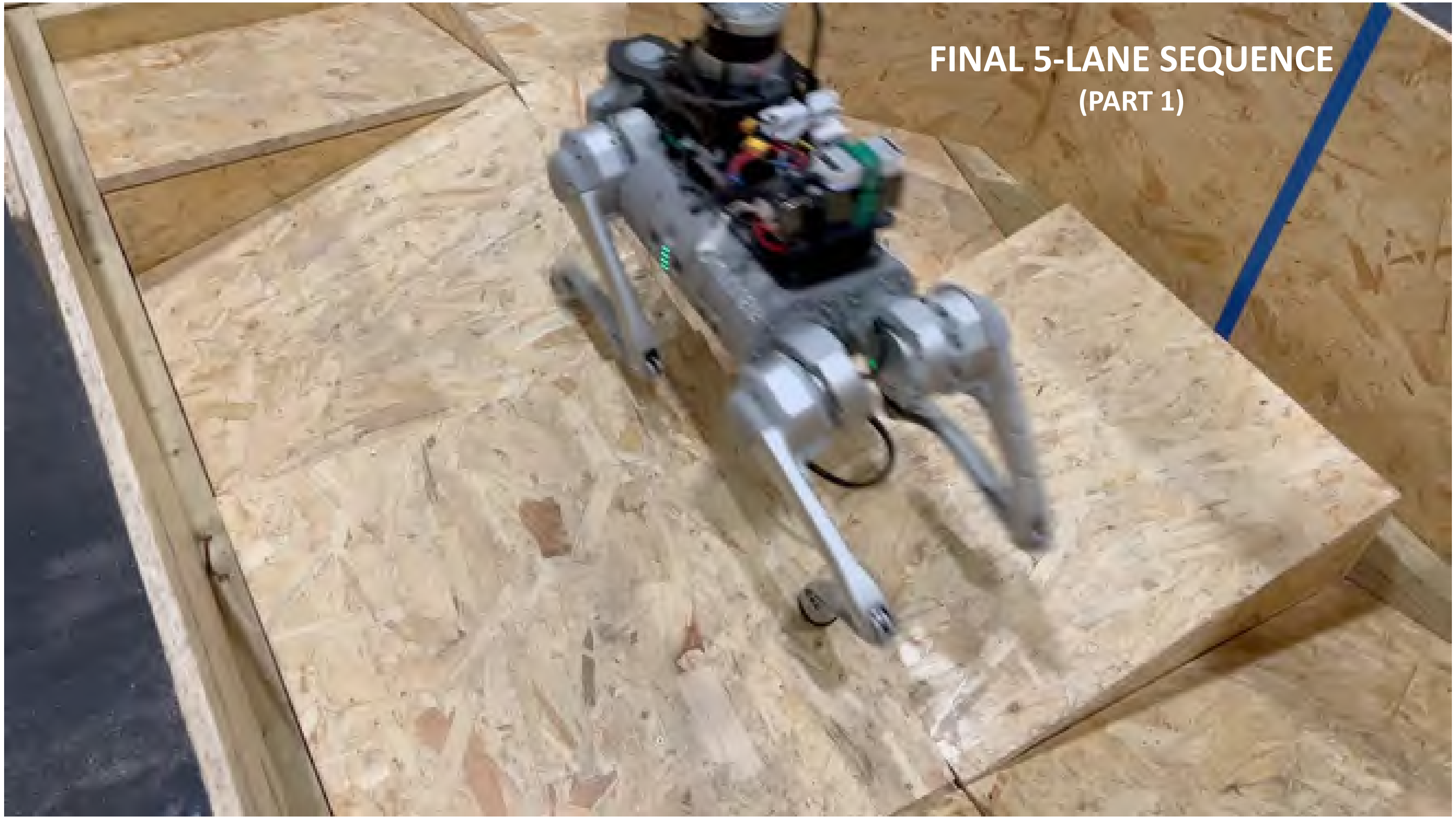
Version: 2024B

ICRA 2023 Quadruped Robot Challenge, London, England July 2023

Champion and Best-in-Class Autonomy: Team KAIST (South Korea)

FINAL 5-LANE SEQUENCE (10 MINUTE TIME LIMIT)
All 5 Lanes in Both Directions = 80 m (260 ft)





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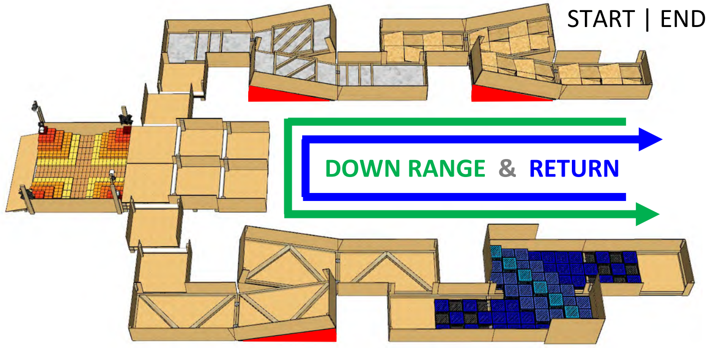

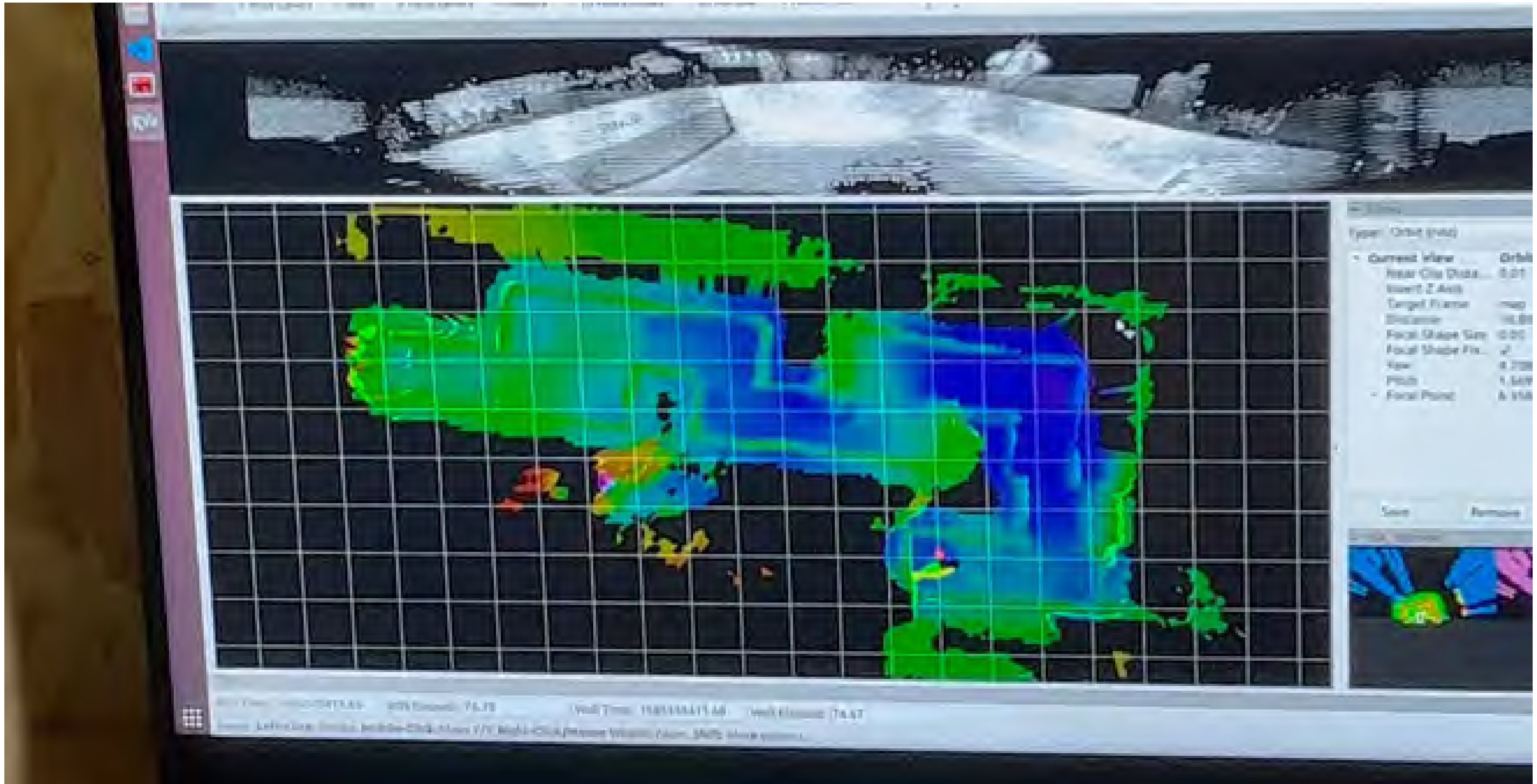

EXAMPLE OF THEIR PATH PLANNING THROUGH A SEQUENCE OF ZIG-ZAG LANES

Emerging Legged Robot Capabilities

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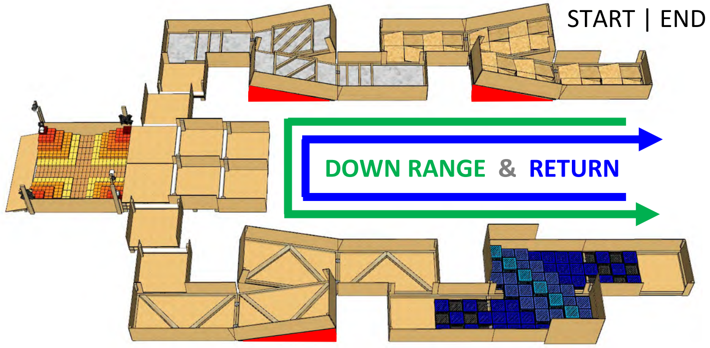


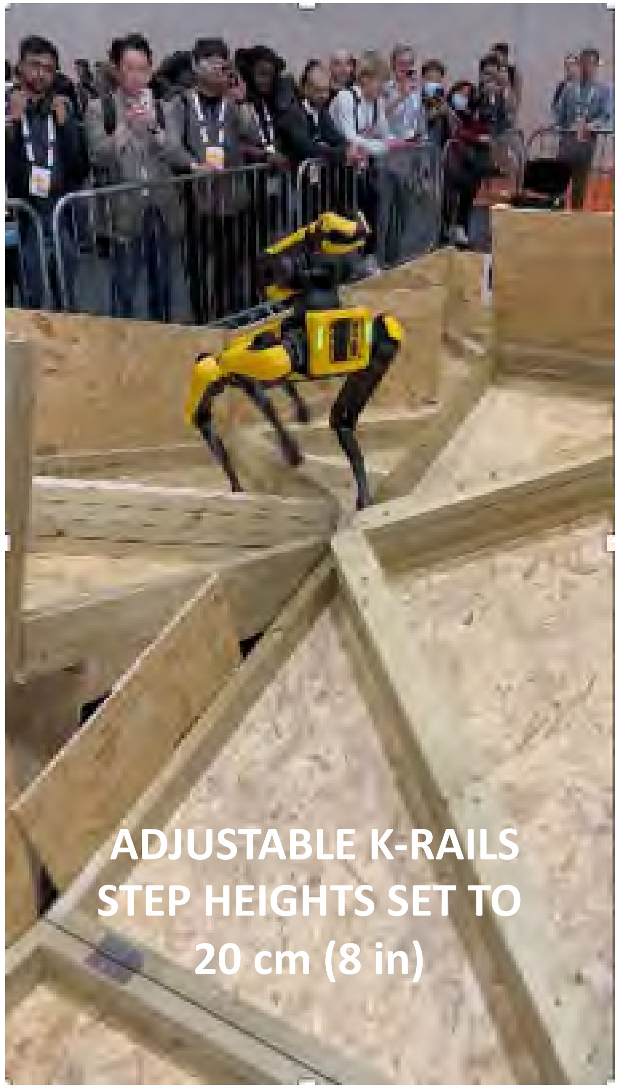
Emerging Legged Robot Capabilities

ICRA 2023 Quadruped Robot Challenge, London, England July 2023

Version: 2024B

These standard test lanes apply to a range of robot sizes with variable levels of difficulty in each.

Remote teleoperative demonstrations were conducted between test trials using a ***Boston Dynamics Spot*** to help refine and validate settings for larger robots.



Emerging Legged Robot Capabilities

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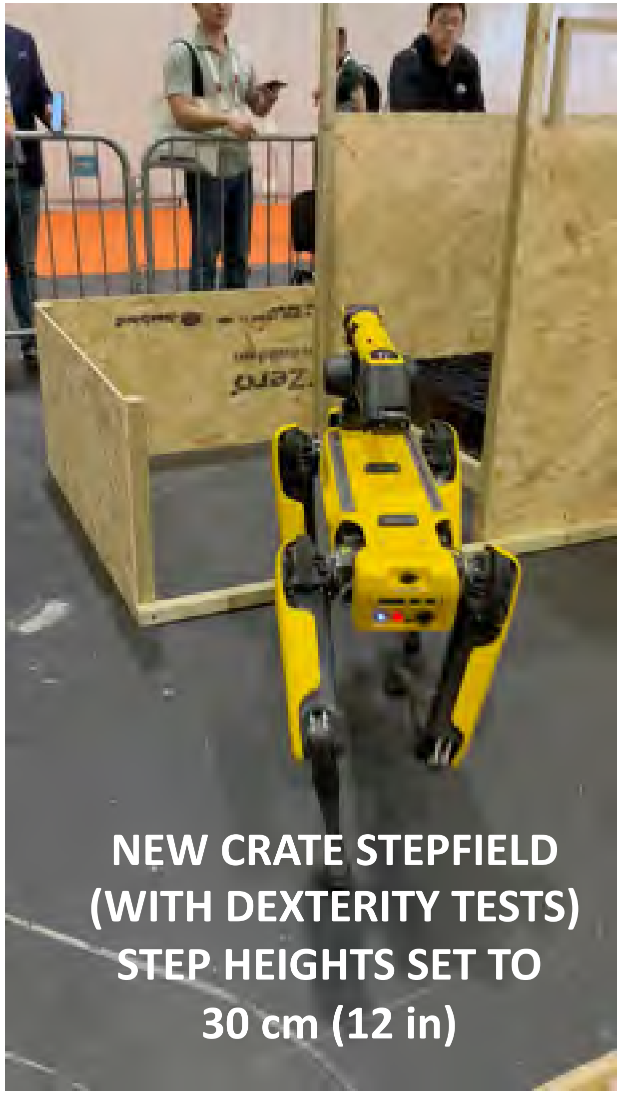


Three Scales of Tests

Choose the Scale that Matches the Intended Environment

60 cm (24 in) lateral clearance guaranteed.

Environments like dwellings, trains, busses, planes, or between parked cars, etc.

Three Scales of Tests

Choose the Scale that Matches the Intended Environment

30 cm (12 in) lateral clearance guaranteed.

Small throwable robots, potentially disposable, are deployed through access holes into large scale tests.

Emphasis on 3D printed robots with effective designs that can be readily disseminated or improved.

League Emphasis

League Emphasis

Version: 2024B

Maneuvering (MAN) refers to terrains that can typically be driven FORWARD and REVERSE to demonstrate bi-directional situational awareness, fine motor control, precise steering, etc.

Mobility (MOB) refers to terrains and obstacles that are typically too difficult to mandate a particular driving direction. These are reproducible tests abstracted from real-world situations that robots need to perform in emergency response operations.

Dexterity (DEX) refers to manipulator tasks embedded within the various terrains and obstacles. They include some standard tests that are easy for everyone to replicate and compare performance along with other tasks that are more operationally relevant and variable. They are on linear rails to evaluate manipulator reach and omni directional objects to evaluate orientational dexterity.

Exploration (EXP) refers to autonomous maneuvering tasks within complex terrains to generate 2D and 3D maps of the environment while identifying objects of interest. The resulting maps are scored for accuracy and quality as if they were about to be handed to an emergency responder for immediate use.

League Approach (1 of 5)

Evaluate and Compare

- The main objective for teams is to challenge and learn about their robotic system capabilities while refining their approaches.
- Teams learn what it will take for their robots to succeed.
- The best scoring teams can win awards to recognize their accomplishments.

Resilience to Failure

- Robot resets are allowed during trials to ensure some level of measurable success.
- The operator or team member with the best view should declare a reset.
- A 2-minute penalty allows the robot to be safely reset at the start of the terrain or obstacle in which it failed. The trial continues after the penalty time has elapsed.

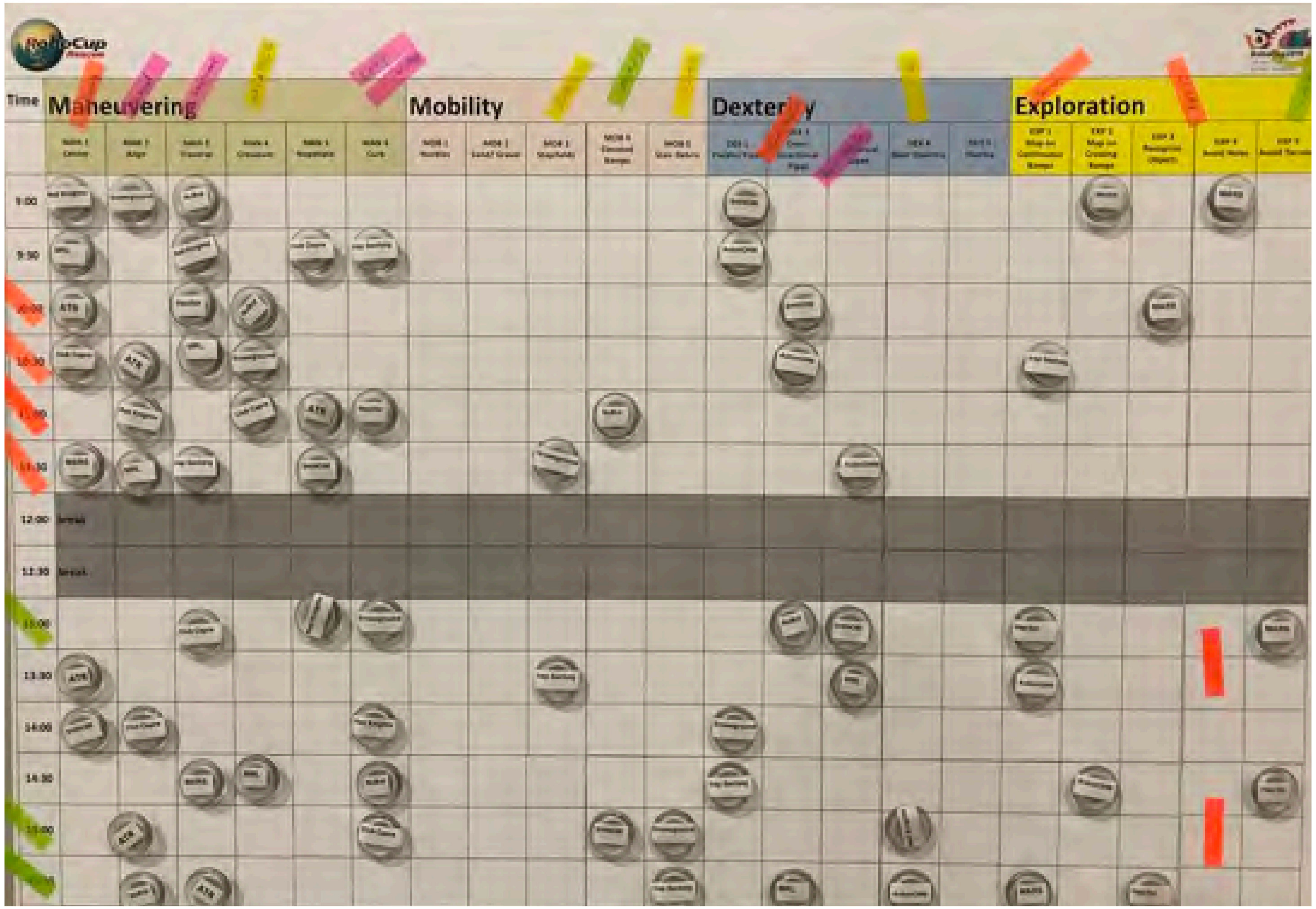
Inclusiveness

- Teams get as many trials as possible within the time available, so they can rigorously evaluate their robots in support of their research objectives.
- Teams schedule their own test plan each day to manage their own risks.

League Approach (2 of 5)

Hundreds of Test Trials to Conduct

- RoboCupRescue hosts astonishingly productive public evaluations with massively concurrent Preliminary trials across 10 individual test lanes.
- Teams proctor and score other team trails to practice conducting tests for their own team at home.
- Teams choose which tests they focus on to support their research goals.
- Teams participate during most days until the best teams conduct more difficult combined sequences of tests.



League Approach (3 of 5)

Lane Difficulty Settings

- Enable incremental challenges for robots with various capabilities.
- League organizers can set the level of difficulty to provide challenges just beyond the participating robot capabilities to measure the resulting behaviors and reliability.
- When the apparatus difficulty setting is the same for all teams, and the time limit is the same, the trial results are comparable.

Trial Time Limits

- Not intended to make it a race.
- There is enough time for a capable robot to demonstrate a statistically significant number of task repetitions.
- This provides a measure of reliability that the task can be performed.
- Trials begin every 30 minutes (at 00 and 30 past the hour):
  - 5 minutes to set up
  - **20 minutes of operation**
  - 5 minutes to exit

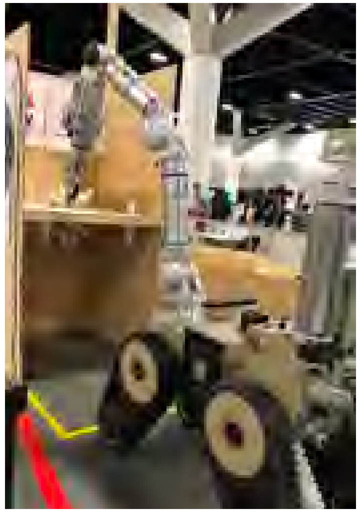
League Approach (4 of 5)

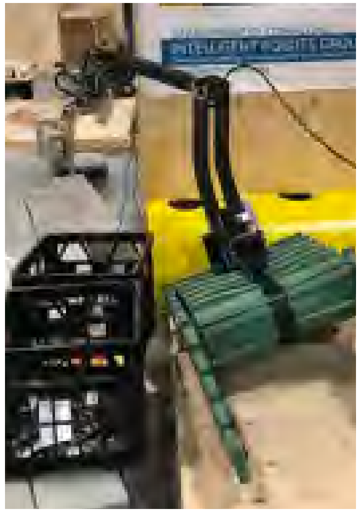
Remote Control

- Operators remotely control their robots while out of sight of the lane.
- All situational awareness must come through the operator interface.
- No talking to the operator is allowed during the trial except to reset a robot or for any other safety issue.

Autonomy

- Autonomous behaviors are encouraged because real-world communications between the robot and the remote operator is often unreliable or intermittent with radio drop-out zones.
- Successful autonomous traverses require NO INTERACTION WITH THE OPERATOR INTERFACE between end zones within each lane. The operator may only set a end GOAL POINT at the far end zone, no waypoints.
- Autonomous lane traverses score a 4x multiplier because autonomy is often slower than teleoperation.
- The operator may take over teleoperative control in the lane end zones to set the next waypoint downrange or at any time during the traverse to finish the lane for a teleop score.

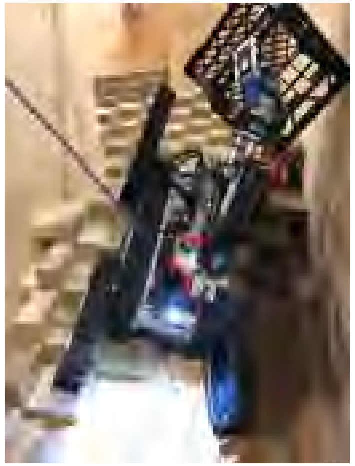




League Approach (5 of 5)

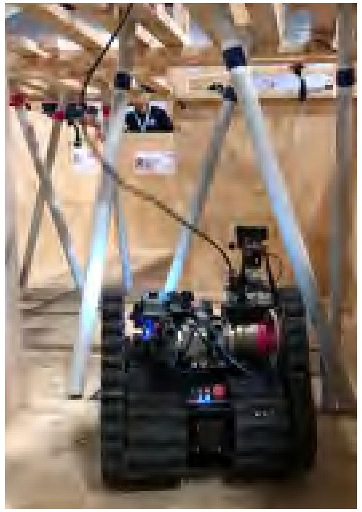
Radio Comms Degradation

- Happens inside intact and partially collapsed structures.
- Assistive and autonomous behaviors are needed to improve the effectiveness and reliability of robots being operated from safe locations outside the structure.
- NEW: We provide scoring incentives (2x multiplier) to encourage teleoperated robots to work with intermittent and unpredictable communications.

Tethers

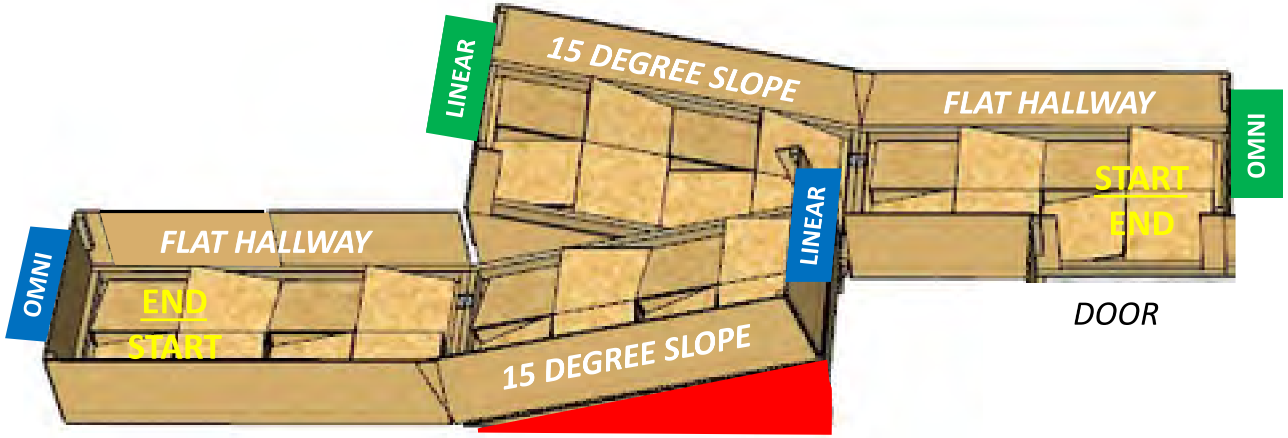
- Are always allowed because they can provide secure communications and ongoing power to drive the robot or recharge batteries over time.
- They must be managed from the lane door by a helper, not guided over the walls.
- Tethers can glow in the dark with arrows identifying the route the robot took. Tethers should be spooled on the robot and act as a winch when necessary to help descend stairs then climb back up if necessary.

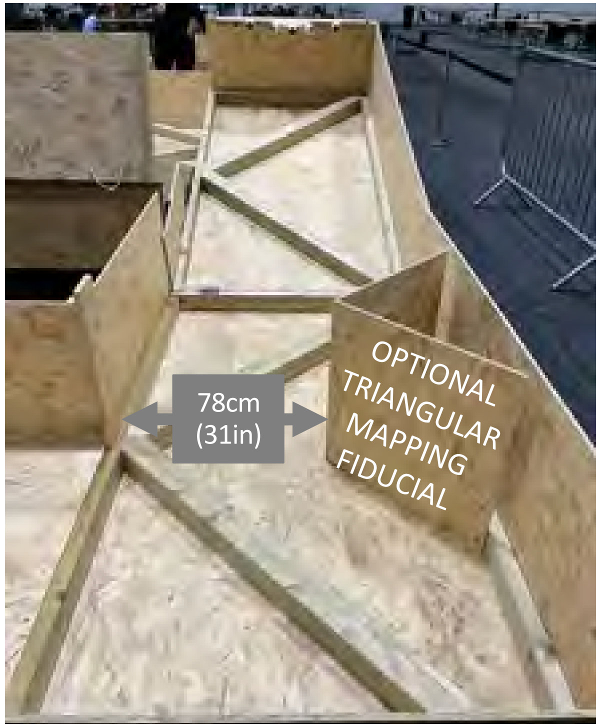


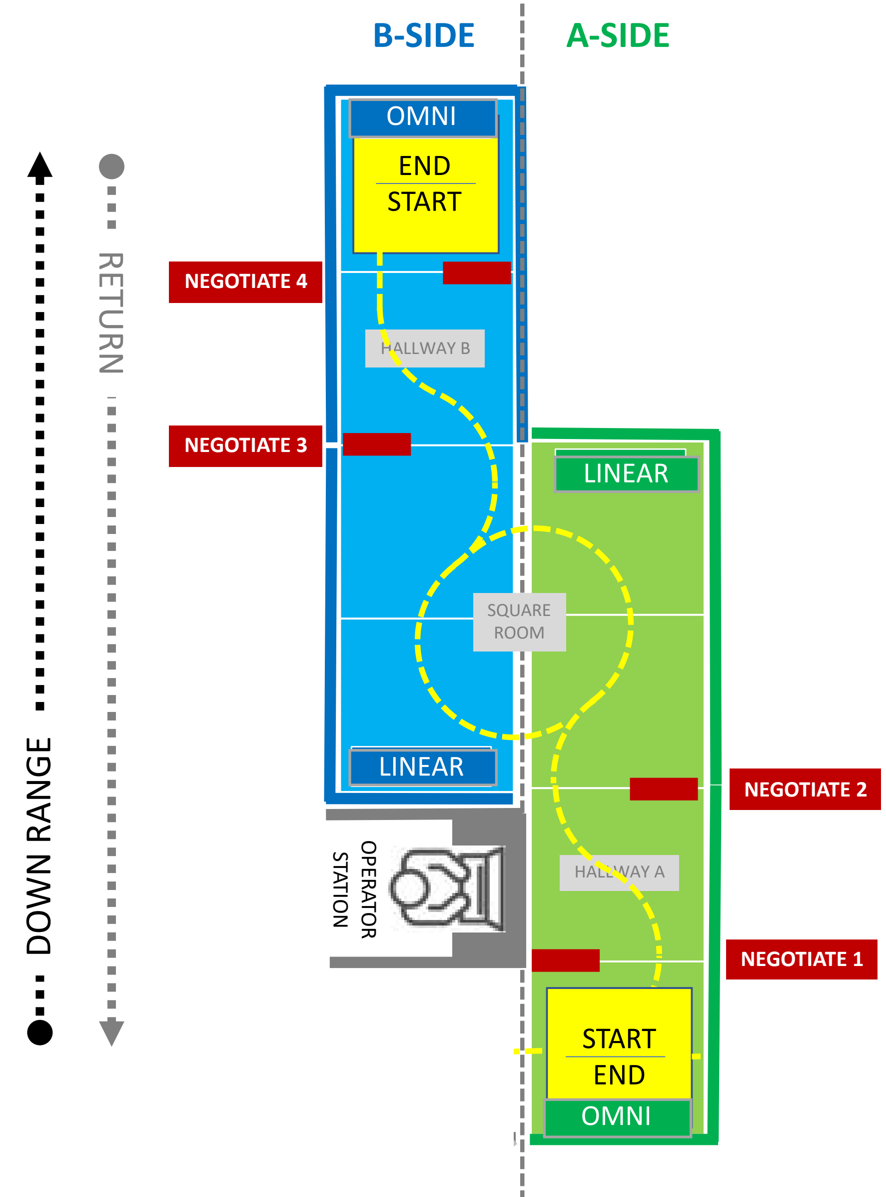

Zig-Zag Lanes

Version: 2024B

Linear Dexterity Tasks on Slopes, Omni Dexterity Tasks in Flat End Zones





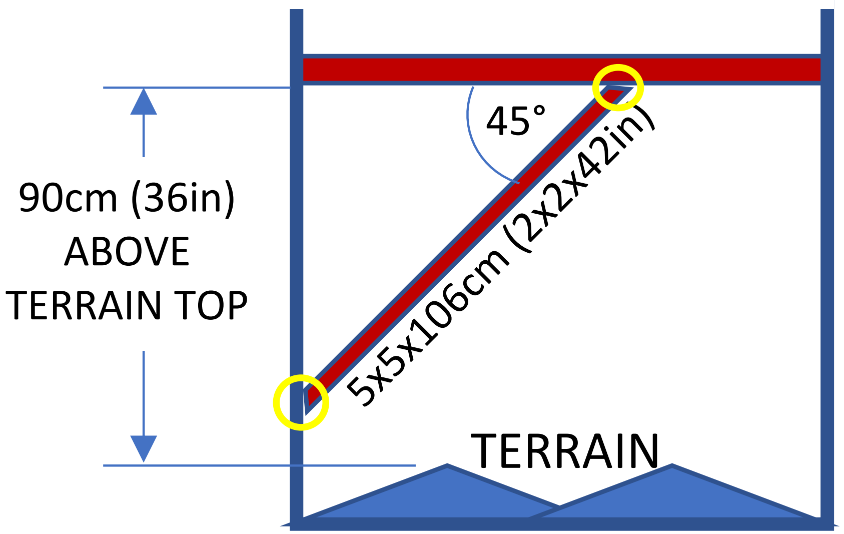


NEW CHALLENGE: Embedded Negotiate Tasks

Could be in any Terrain Lane

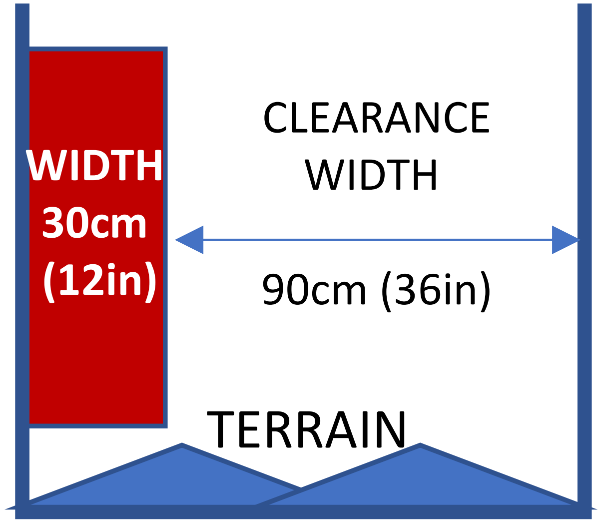
Version: 2024B

ANGLED/MAGNETIZED



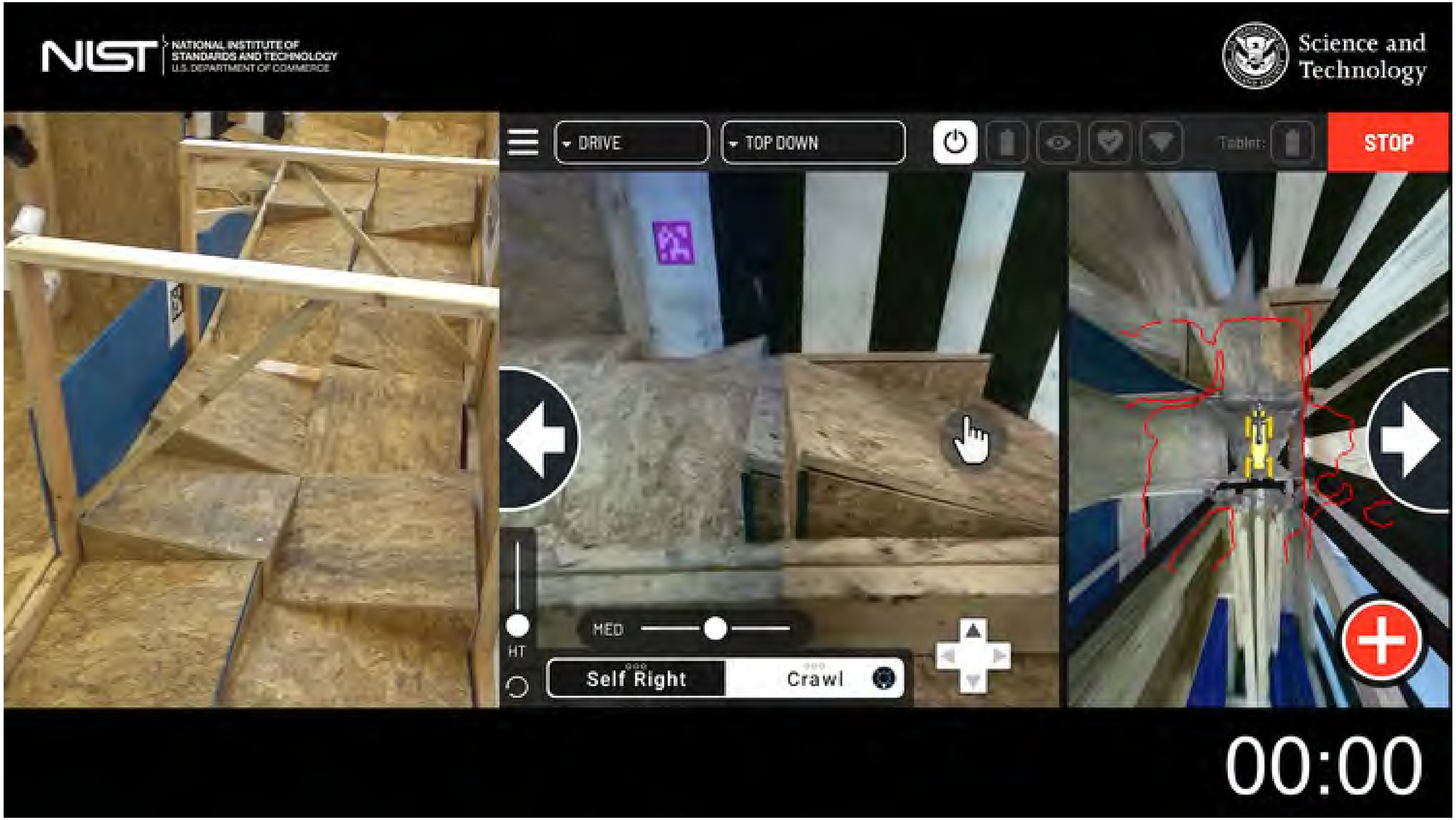
ANGLED BEAM HANGS FROM THE CROSSBAR AND IS AFFIXED TO THE SIDE WALL WITH A MAGNET AND WASHER SO IT CAN RELEASE IF BUMPED.

MAPPING FIDUCIALS



NEW CHALLENGE: Embedded Negotiate Tasks

Could be in any terrain lane



Arena Layout

Arena Overview

10 Test Lanes

Version: 2024B

TERRAINS (TER) Either "FLAT" or "SLOPED" 15degrees

Continuous Ramps (FLAT)

Crossing "Pinwheel" Ramps (15deg slopes)

K-Rails (15deg slopes)

Sand & Gravel (15deg slopes)

OBSTACLES (OBS) All have adjustable features to increase difficulty

Incline & Center (15deg plane, variable door widths top/bottom)

Pallet/Pipe Hurdles (10/20/30cm elevations with pipes)

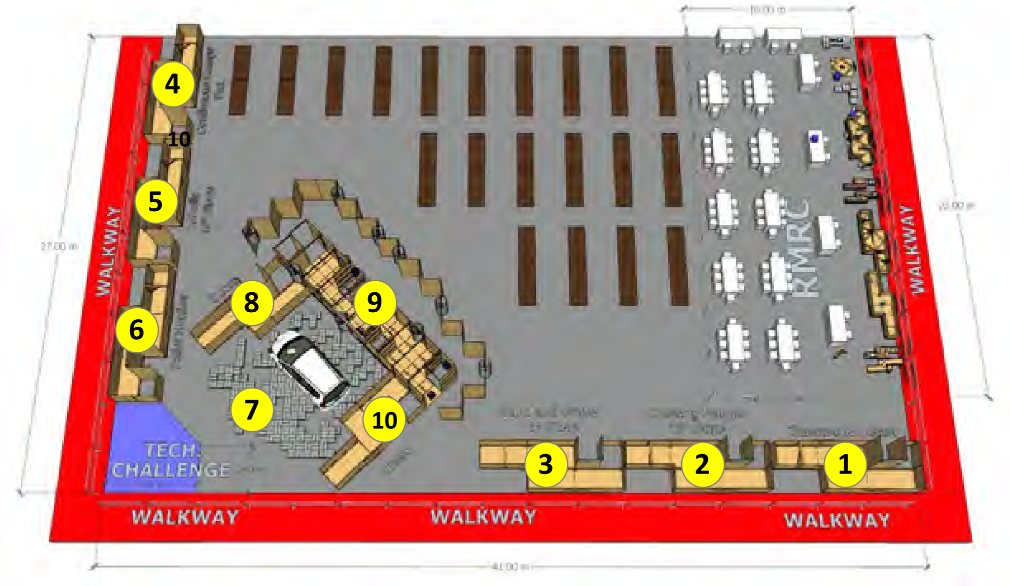
Stairs (35/40/45deg, 20cm Risers, 2/4 debris)

Doors (Push/Pull, 240cm "room" or 120cm "hallway" access)

EXPORATION (EXP) All emphasize autonomy and mapping

Avoid Holes (elevated paths, objects to identify)

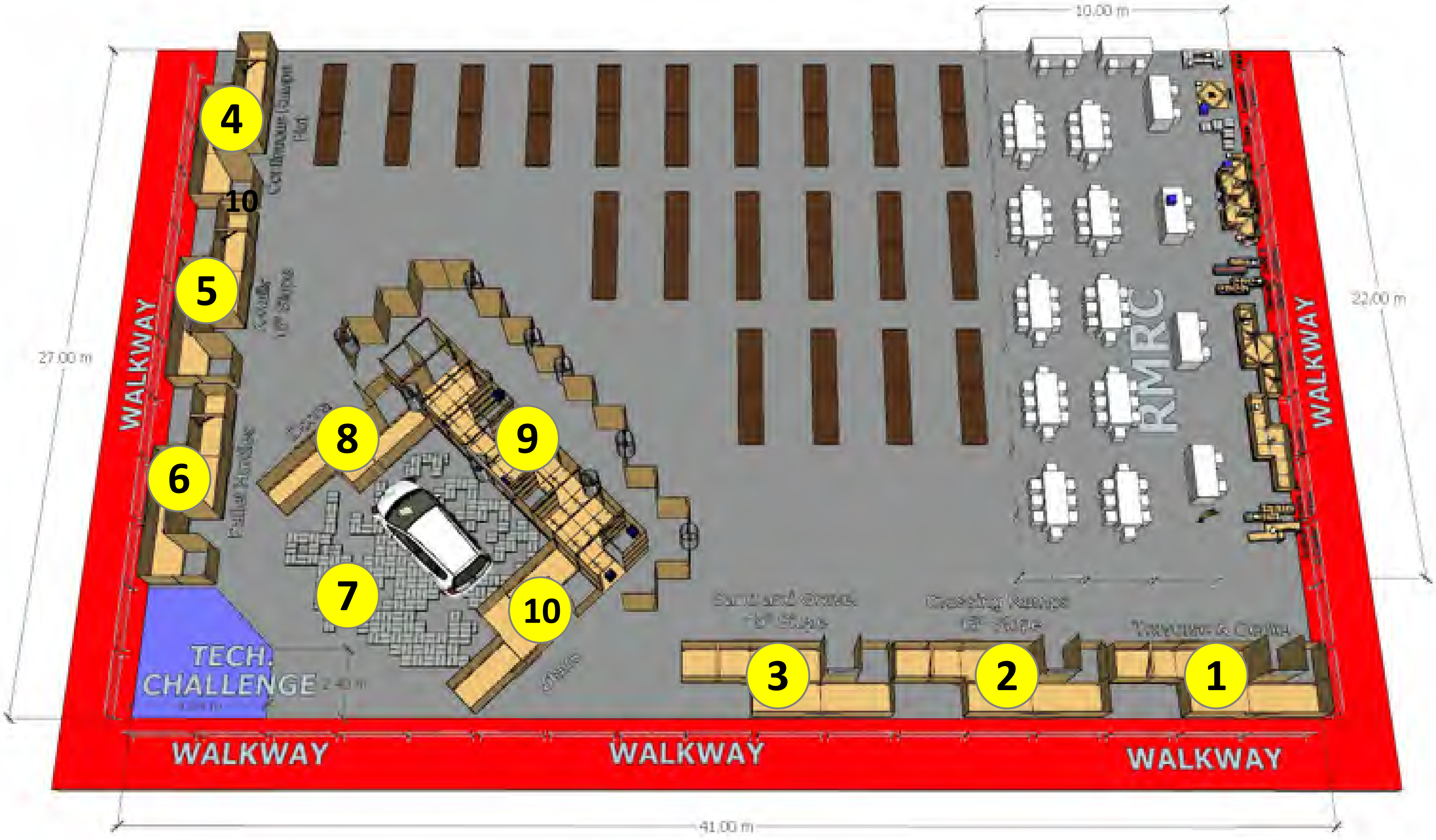
Labyrinth (various terrains, mapping fiducials, objects to identify)



Arena Overview

Version: 2024B

Prelims: 10 Concurrent Lanes (Enter and Exit Through the Same Doors)

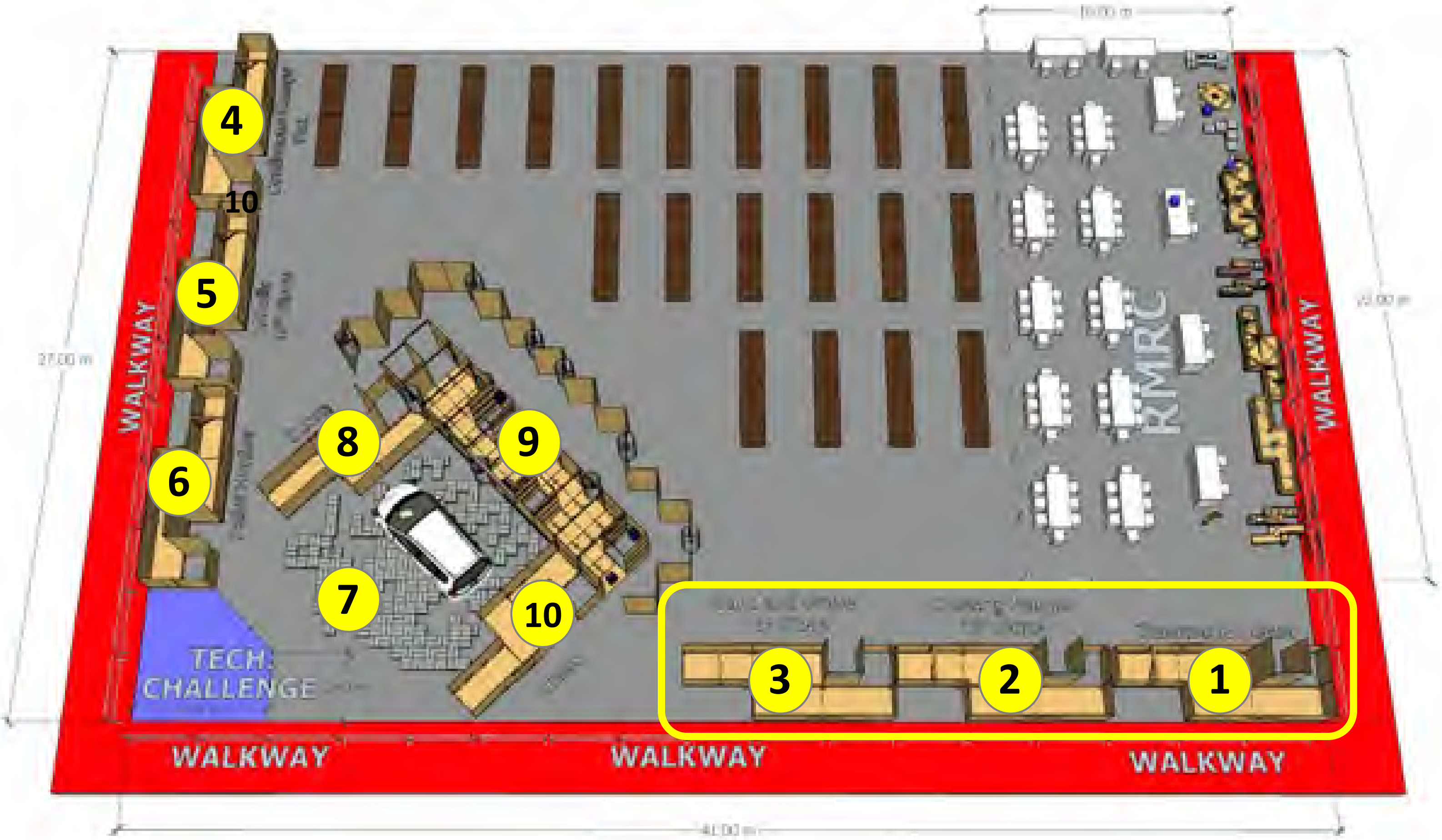


Semis: 3 Concurrent Sequences (Enter and Exit Through the Same Doors)

Approach an Urban Dwelling

Sequence Lanes 1-2-3 (in any order):

- Obstacles: Traverse and Center
- Terrain: Crossing Ramps
- Terrain: Sand & Gravel



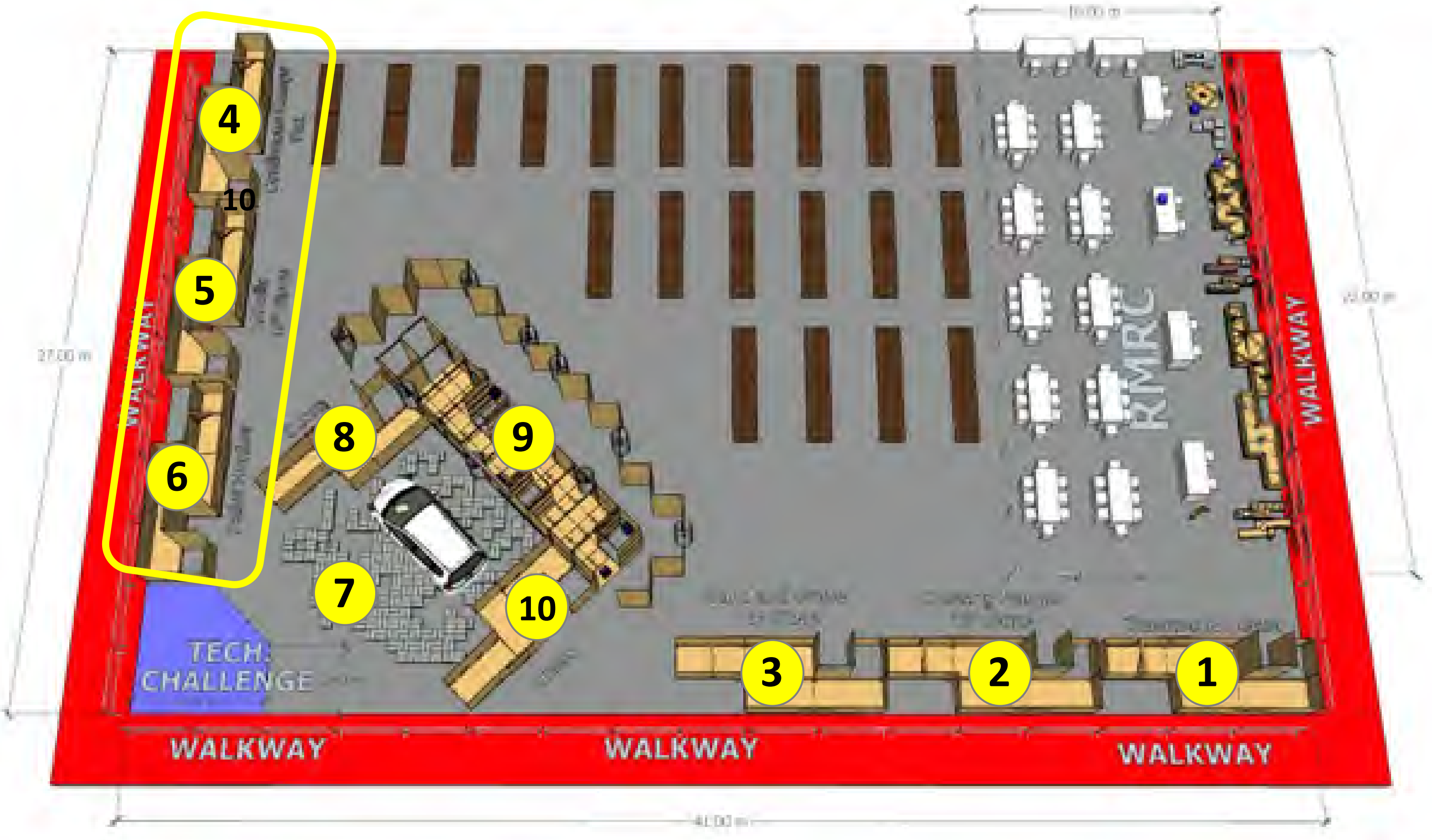
Semis: 3 Concurrent Sequences (Enter and Exit Through the Same Doors)

Version: 2024B

Approach a Country Dwelling

Sequence Lanes 4-5-6 (in any order):

- Terrain: Continuous Ramps
- Terrain: K-Rails
- Obstacles: Pallets with Pipes



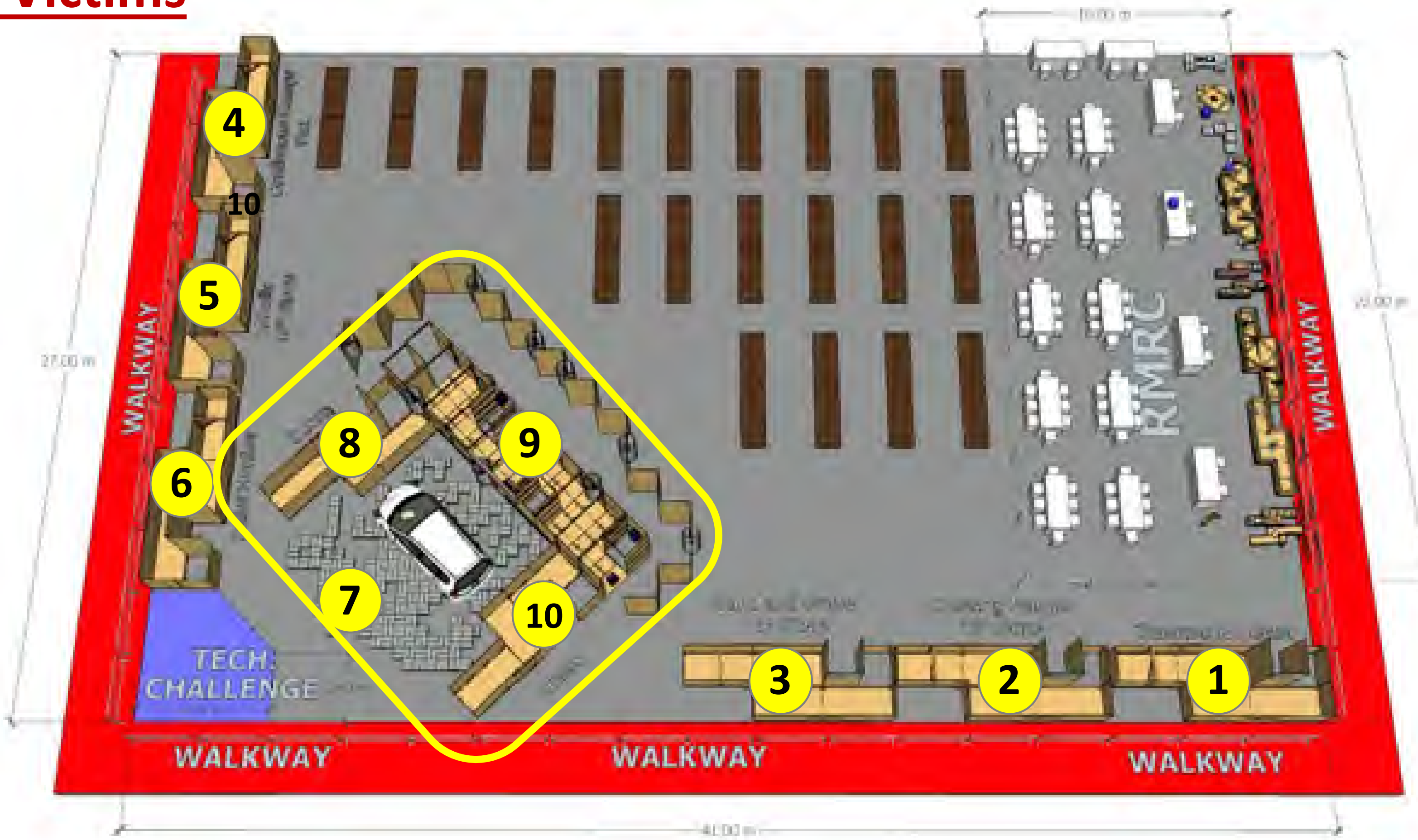
Arena Overview

Semis: 3 Concurrent Sequences (Enter and Exit Through the Same Doors)

Search a Dwelling and Vehicle for Victims

Sequence Lanes 7-8-9-10 (in any order):

- Exploration: Avoid Holes
- Obstacles: Doors
- Exploration: Labyrinth
- Obstacles: Stairs

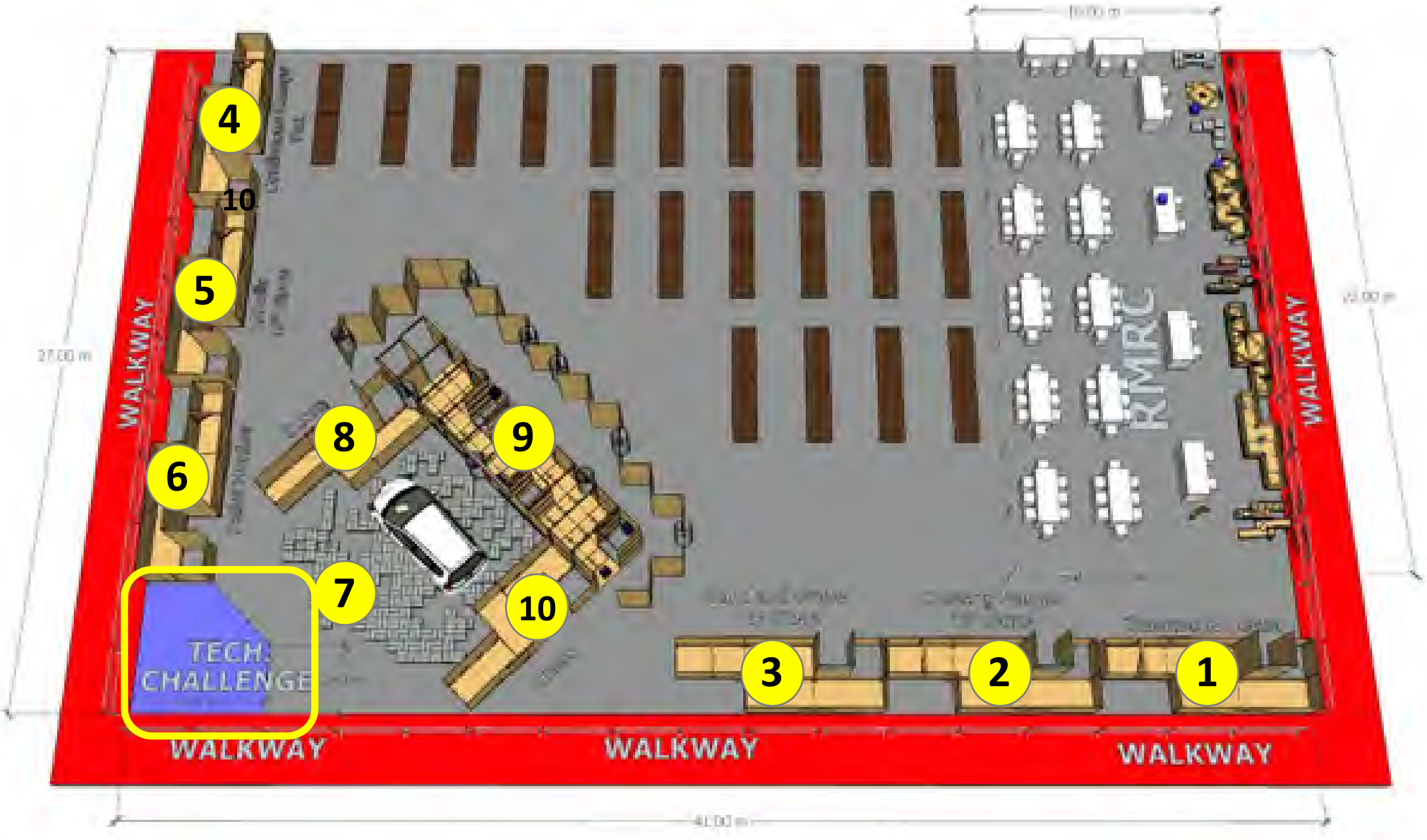


Arena Overview

Version: 2024B

Semis: 3 Concurrent Sequences (Enter and Exit Through the Same Doors)

Tech Challenge Area (Optional)



10 Test Lanes

Version: 2024B

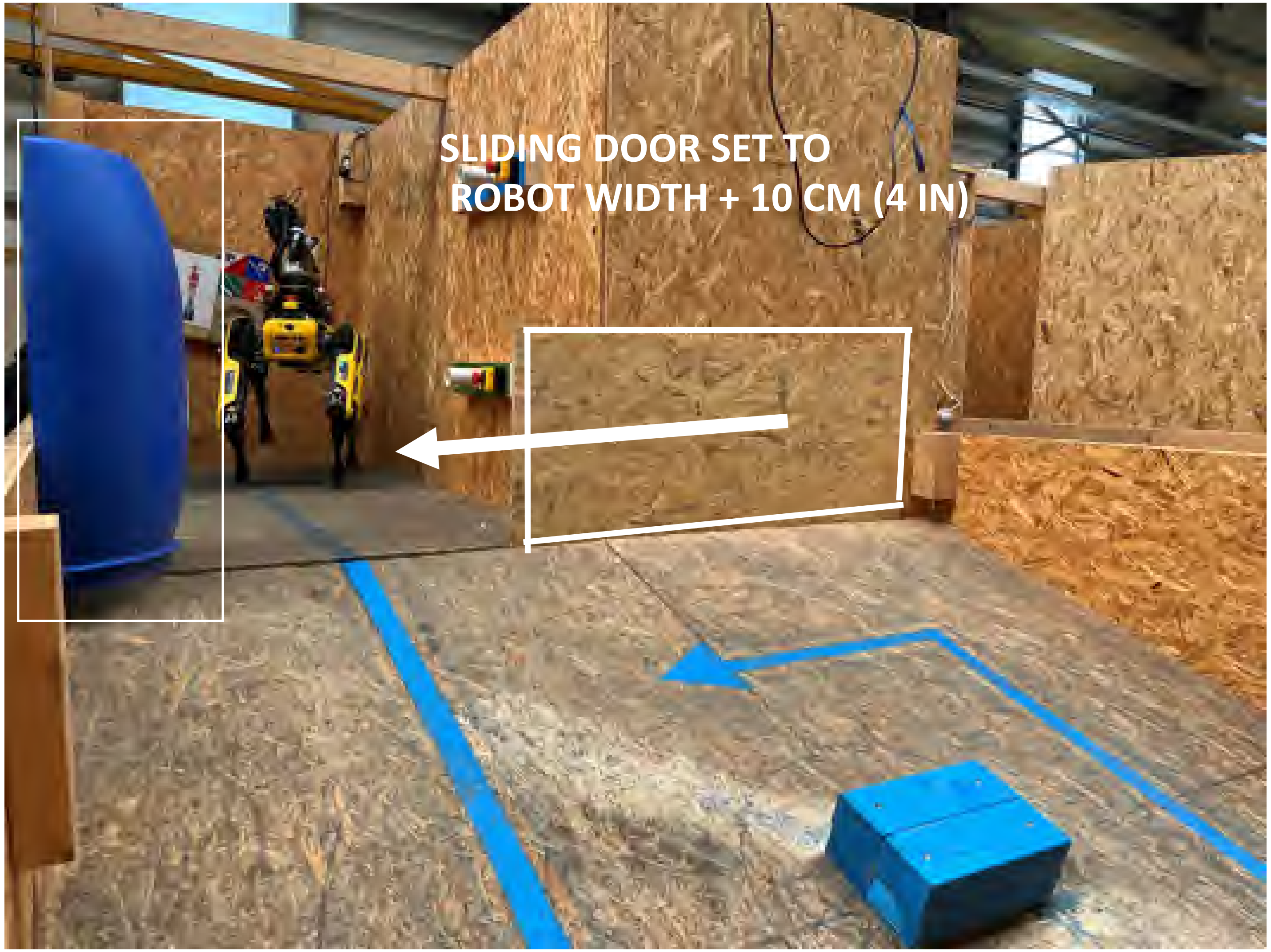
Obstacle: Traverse & Center

- Doorways at top and bottom of 15 degree slope set to

  ROBOT WIDTH + 10cm (4in)

- Mapping fiducial or post prevents riding the wall.

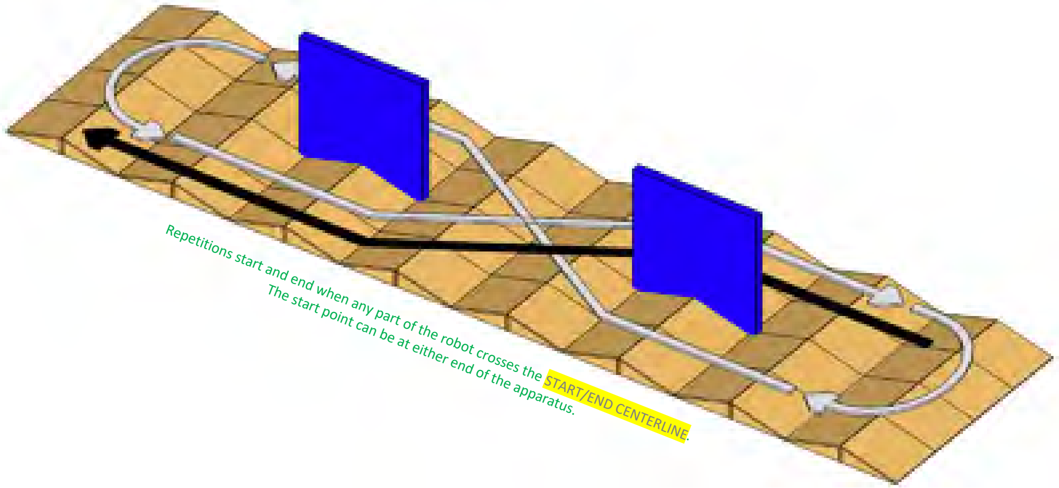
- Optional center task is to be avoided, could be dexterity location.



Test Lanes

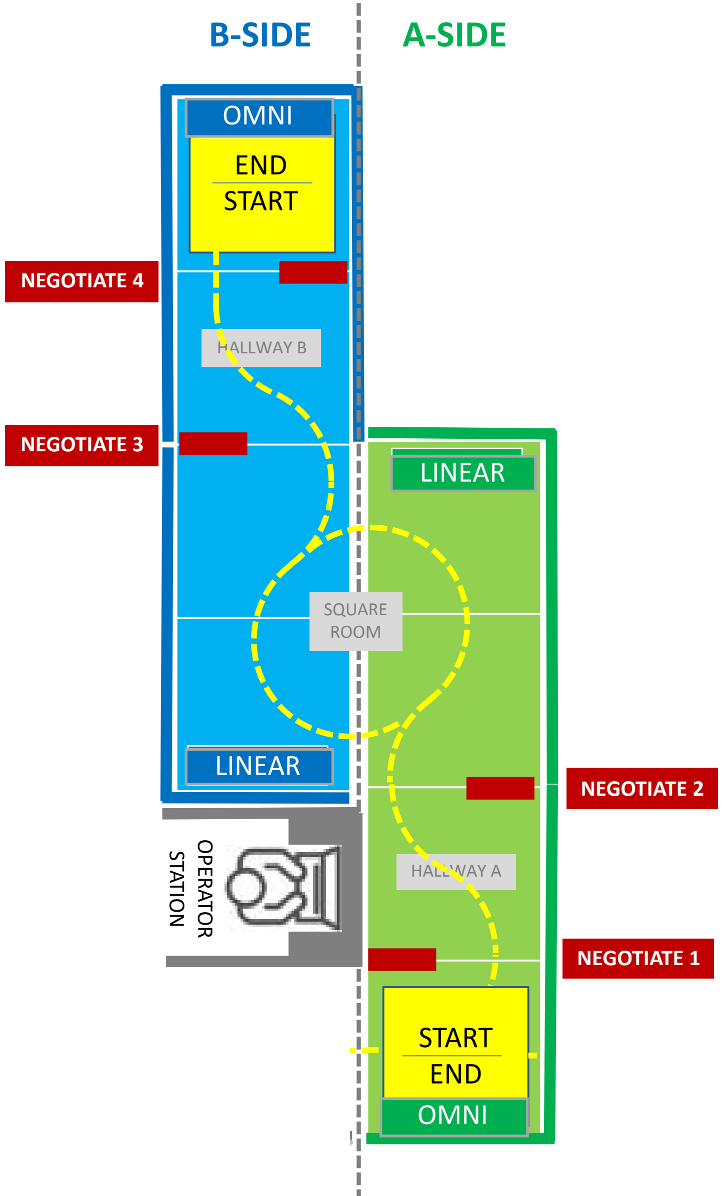
Terrain: Continuous Ramps

15 DEGREE CONTINUOUS RAMPS
IN FLAT CONFIGURAITON



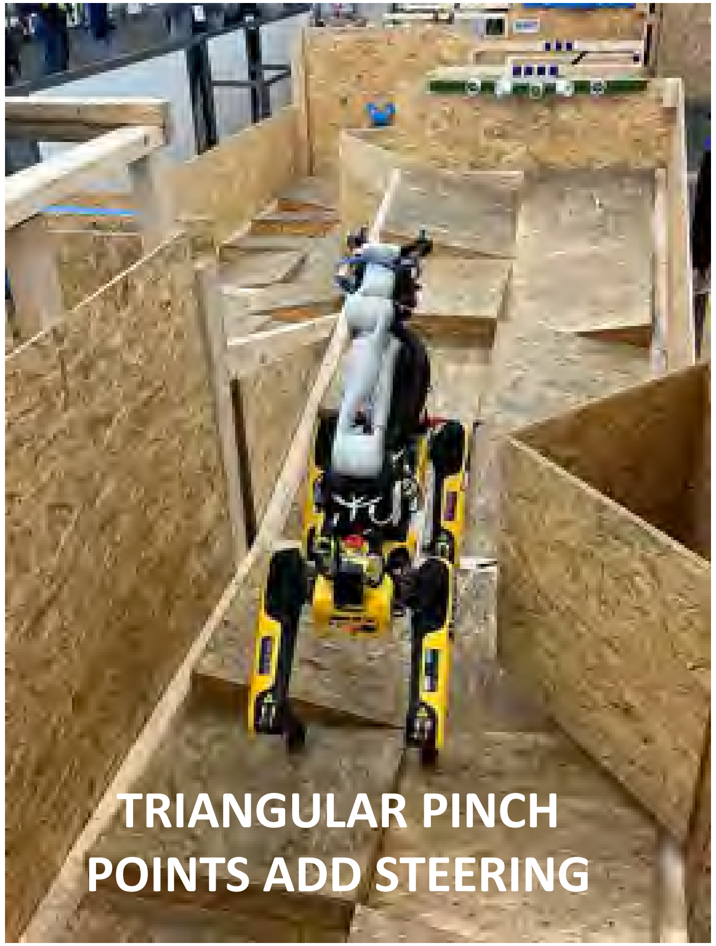
OPTION:
15 DEGREE CONTINUOUS RAMPS
ON 15 DEGREE SLOPES

(SO 30 DEGREES IN PLACES)



Test Lanes

Terrain: Crossing Ramps (15Deg Slopes)



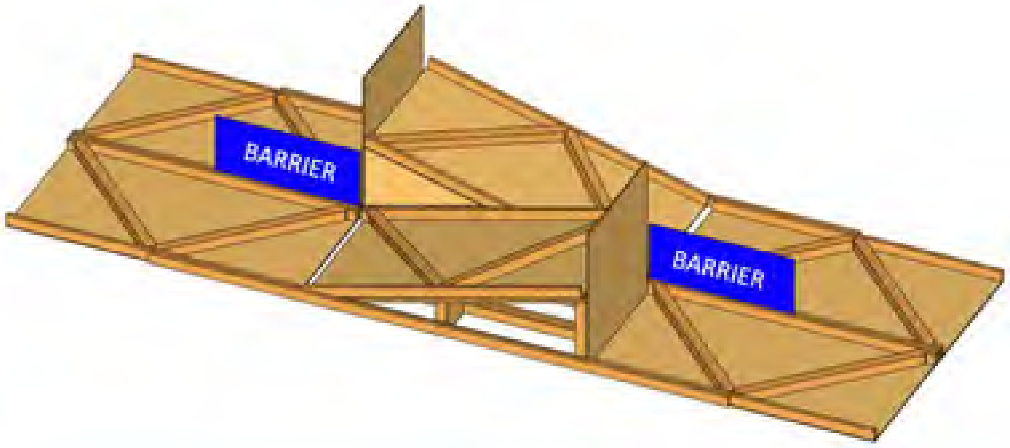
Test Lanes

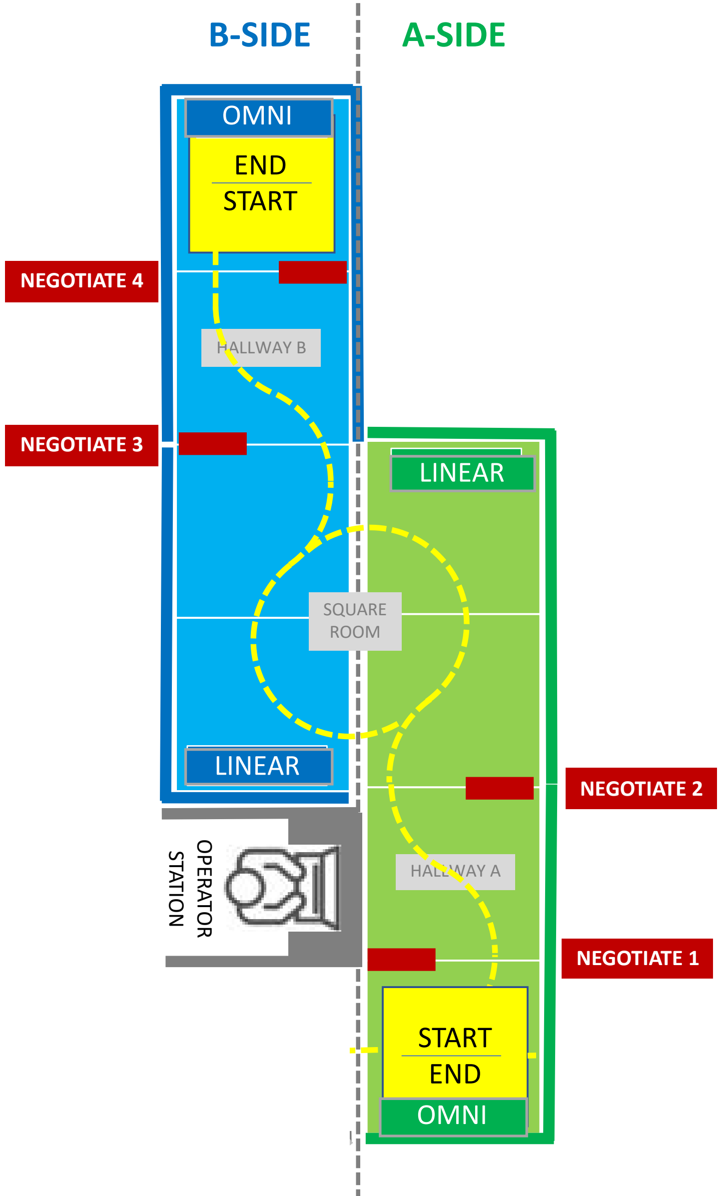
Terrain: Sand and Gravel




Test Lanes

Terrain: K-Rails



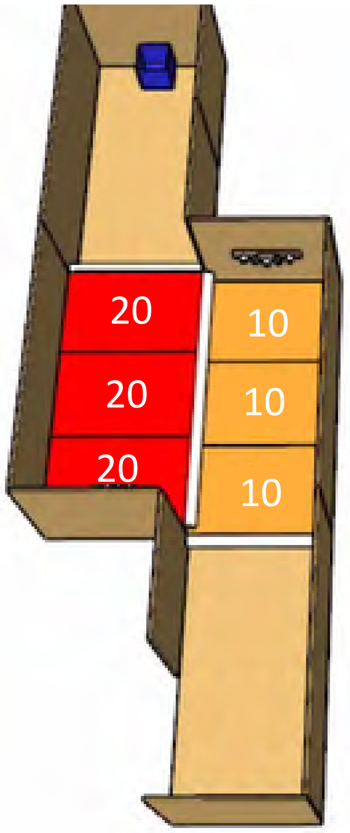


Version: 2024B

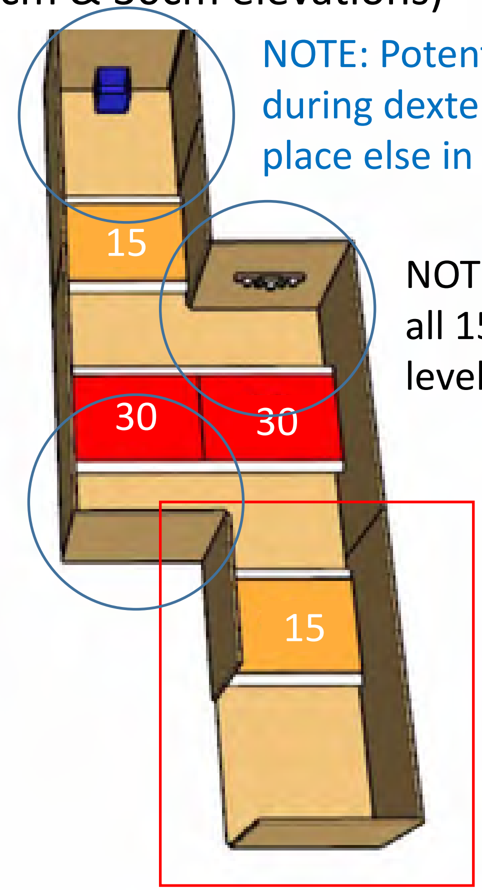
Obstacle: Pallet Hurdles with Pipes

European pallets appear extra thick (14.4cm) so maybe it is time for hurdles to increase their difficulty from 10cm and 20cm steps.

2022 Lane Design
(10cm & 20cm elevations)



2023-24 Lane Design
(15cm & 30cm elevations)

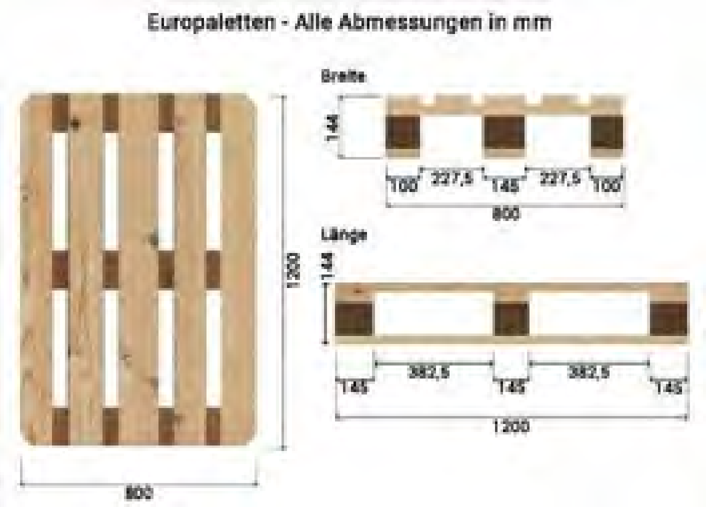


NOTE: Potential "Down Dog" positions during dexterity tasks, which happens no place else in RoboCupRescue

NOTE: We can start PRELIMS with all 15cm elevations. Then add a level for SEMIS.

NOTE: Front hallway basically conforms to the standard test method. Easy for everybody to fabricate and practice coordinated flipper control as an elemental test at incremental elevations.

TYPICAL PALLETS IN EUROPE 120M X 80CM



PIPES CAN SIT ON TOP OF HORIZONTAL POSTS SHIMMED WITH OSB LAYERS TO GET BE COINCIDENT WITH TOP ELEVATIONS.

Test Lanes

Version: 2024B

Obstacle: Stairs (35/40/45 Deg, 2/4 Debris)

- Upper landing is now CONFINED at 1.2m x 2.4m (4ft x 8ft)
- Starts with no DEBRIS in Preliminaries and adds more difficulty in Semis and Finals
- Needs a belay over the top for robot safety on more difficult settings

SLIDING STAIR TREADS SPACED VERTICALLY 20CM (8IN)

UPPER LANDING IS A "HALLWAY" 1.2 x 2.4 M (4 x 8 FT)

TEAM CHOOSES 1, 2, or 3 ANGLED OBSTACLES FOR EXTRA NEGOTIATE POINTS

Test Lanes

Obstacle: Doors (Push/Pull)

- BOTH sides any door can be contained with ”L walls” to adjust the approach paths
  - “ROOM” is 2.4m (8ft) square, which is easier in the Prelims
  - “HALLWAY” is 1.2m (4ft) x 2.4m (8ft), which is harder in the Semis and Finals
- Reverse the direction for PUSH vs PULL tasks

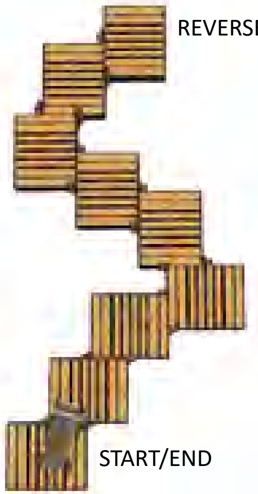
SQUARE ”ROOM” (EASIER)

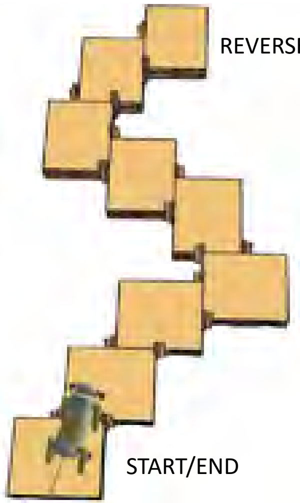
RECTANGULAR ”HALLWAY” HARDER)

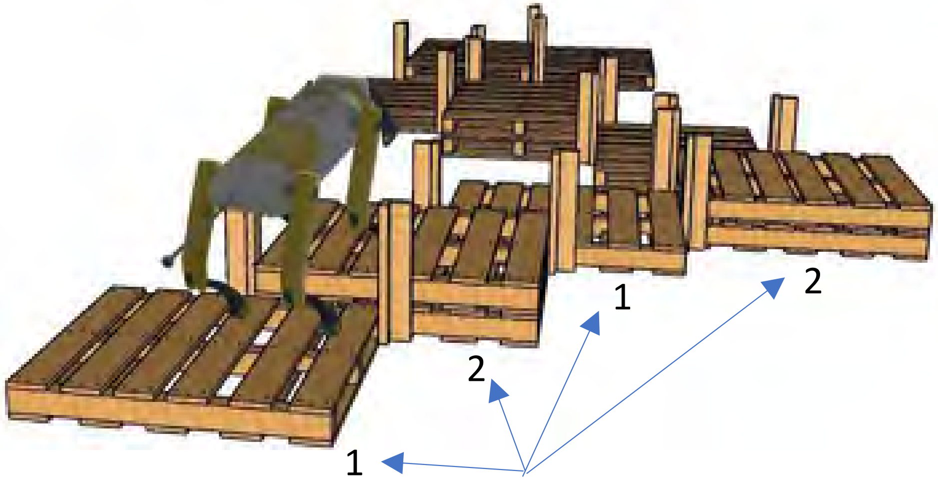
Test Lanes

Exploration: Avoid Holes

- Autonomous and teleop robots must avoid negative/positive obstacles while exploring and mapping the exterior of the Labyrinth and surrounding scene. <u>**Falling off the driving surface is a reset (2 min. penalty).**</u>
- Autonomous robot operators may give a rough estimate of the end goal location relative to the start. Successful autonomous traverses get the 4x multiplier on the Mapping score.
- Mapping score from 0-10 minutes (traverse – score – clear the map – repeat). Dexterity tasks are available to score from 10-20 minutes.
- Self standing fiducials and shared fiducials with the interior of the Labyrinth (different test), can facilitate map merging.







Pallet stacks can also vary in height.

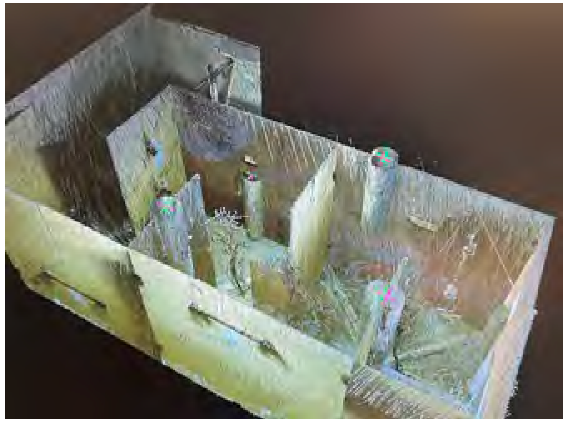
Blocks make amorphous surface areas

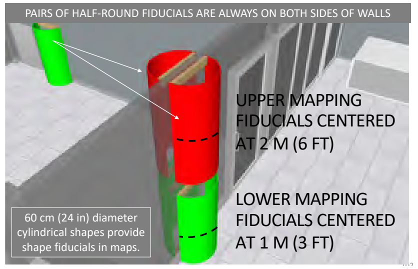
Test Lanes

Exploration: Labyrinth/Maze

Version: 2024B

- Autonomous and teleoperative robots must explore and map the interior of the Labyrinth like a dwelling (can merge with Avoid Holes map).
- Autonomous robot operators may give a rough estimate of the end goal location relative to the start. Successful autonomous traverses get the 4x multiplier on the Mapping score.
- Mapping score from 0-10 minutes (traverse – score – clear the map – repeat).
- Dexterity tasks are available to score from 10-20 minutes.
- Lighting will be dim for object recognition and dexterity – bring remotely adjustable lighting.



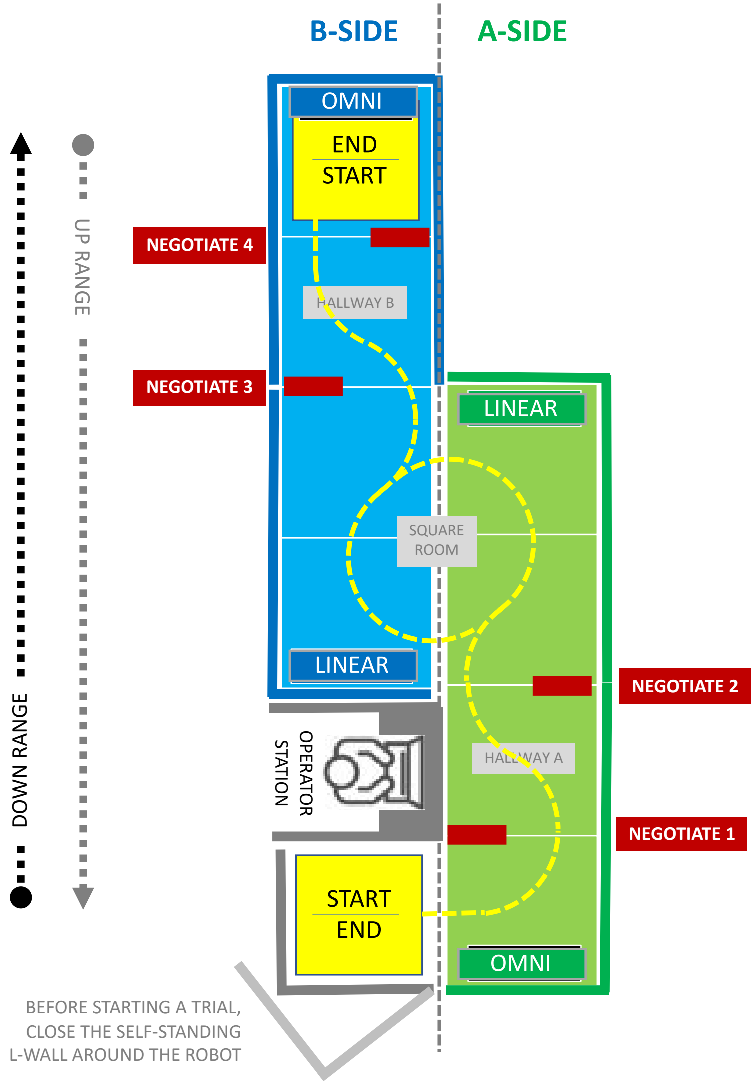


Scoring Mobility
(During 0-10 Minutes of Trial)

Scoring Mobility (During 0-10 Minutes)

Version: 2024B

- Mobility scoring is based on driving continuous **end-to-end traverses** in the lane. The robot must **start** and **end** completely within the squares.
- Driving teleoperatively **scores 1 point** for completion in each direction.
- Driving autonomously (hands off the interface) **scores 4 points** for successful completion in each direction. The remote operator may take over control at any time to finish a traverse teleoperatively for 1 point and try again autonomously on the next repetition. Teleoperation is allowed in both end zones to set waypoints, evaluate maps, etc.
- *Single Lane Missions* perform up to **10 end-to-end traverses** in the first 10 minutes of the trial. If finished early, use the elapsed time as a measure of efficiency. Wait for the Dexterity time to start.
- *Multiple Lane Missions* perform a **sequence of end-to-end traverses** in each lane by entering and exiting from the same doorway. Teams may choose the order of lanes based on risk, but may need to drive further to complete all. No repeated lanes are allowed until all lanes are completed.



Scoring Mobility (During 0-10 Minutes)

Proctors Circle the Scored Points as They Happen

Version: 2024B

MOBILITY: Drive TELEOPERATIVELY or AUTONOMOUSLY (no hands on interface) end-to-end in the lane.

CIRCLE A SINGLE LANE IN THE LIST ABOVE OR WRITE SEQUENCE OF LANES IN ORDER		TELEOP	COMMS x2	AUTO x4	NEGOTIATE 1	2	3	4
1		1	2	4	N	N	N	N
2	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
3		1	2	4	N	N	N	N
4	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
5		1	2	4	N	N	N	N
6	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
7		1	2	4	N	N	N	N
8	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
9		1	2	4	N	N	N	N
10	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N

ELAPSED TIME

MM : SS

TELEOP

POINTS

AUTO

POINTS

Scoring Mobility (During 0-10 Minutes)

Proctors Circle the Scored Points as They Happen

Version: 2024B

Example: Teleoperative Robot in Single Lane Mission

MOBILITY: Drive TELEOPERATIVELY or AUTONOMOUSLY (no hands on interface) end-to-end in the lane.

	CIRCLE A SINGLE LANE IN THE LIST ABOVE OR WRITE SEQUENCE OF LANES IN ORDER	TELEOP	COMMS x2	AUTO x4	NEGOTIATE 1	2	3	4
1	Continuous Ramps	1	2	4	N	N	N	N
2	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
3	Continuous Ramps	1	2	4	N	N	N	N
4	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
5	Continuous Ramps	1	2	4	N	N	N	N
6	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
7	Continuous Ramps	1	2	4	N	N	N	N
8	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
9	Continuous Ramps	1	2	4	N	N	N	N
10	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N

ELAPSED TIME

9:35

MM : SS

TELEOP

23

POINTS

AUTO

POINTS

Scoring Mobility (During 0-10 Minutes)

Proctors Circle the Scored Points as They Happen

Version: 2024B

Example: Autonomous Robot in Single Lane Mission

MOBILITY: Drive TELEOPERATIVELY or AUTONOMOUSLY (no hands on interface) end-to-end in the lane.

	CIRCLE A SINGLE LANE IN THE LIST ABOVE OR WRITE SEQUENCE OF LANES IN ORDER	TELEOP	COMMS x2	AUTO x4	NEGOTIATE 1	2	3	4
1	Continuous Ramps	1	2	4	N	N	N	N
2	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
3	Continuous Ramps	1	2	4	N	N	N	N
4	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
5	Continuous Ramps	1	2	4	N	N	N	N
6	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
7	Continuous Ramps	1	2	4	N	N	N	N
8	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
9	Continuous Ramps	1	2	4	N	N	N	N
10	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N

ELAPSED TIME

9:35

MM : SS

TELEOP

4

POINTS

AUTO

32

POINTS

Scoring Mobility (During 0-10 Minutes)

Proctors Circle the Scored Points as They Happen

Version: 2024B

Example: Autonomous Robot in Multiple Lane Mission

MOBILITY: Drive TELEOPERATIVELY or AUTONOMOUSLY (no hands on interface) end-to-end in the lane.

	CIRCLE A SINGLE LANE IN THE LIST ABOVE OR WRITE SEQUENCE OF LANES IN ORDER	TELEOP	COMMS x2	AUTO x4	NEGOTIATE 1	2	3	4
1	Continuous Ramps	1	2	4	N	N	N	N
2	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
3	K-Rails	1	2	4	N	N	N	N
4	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
5	Pallets and Pipes	1	2	4	N	N	N	N
6	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
7	Pallets and Pipes	1	2	4	N	N	N	N
8	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
9	Continuous Ramps	1	2	4	N	N	N	N
10	RETURN UP RANGE TO START POINT	~~1~~	~~2~~	~~4~~	~~N~~	~~N~~	~~N~~	~~N~~

ELAPSED TIME
10:00
MM : SS

TELEOP
10
POINTS

AUTO
12
POINTS

SKIPPED K-RAILS TO FINISH 5 LANES.
DROVE PAST IT TO GET TO CONTINUOUS RAMPS.

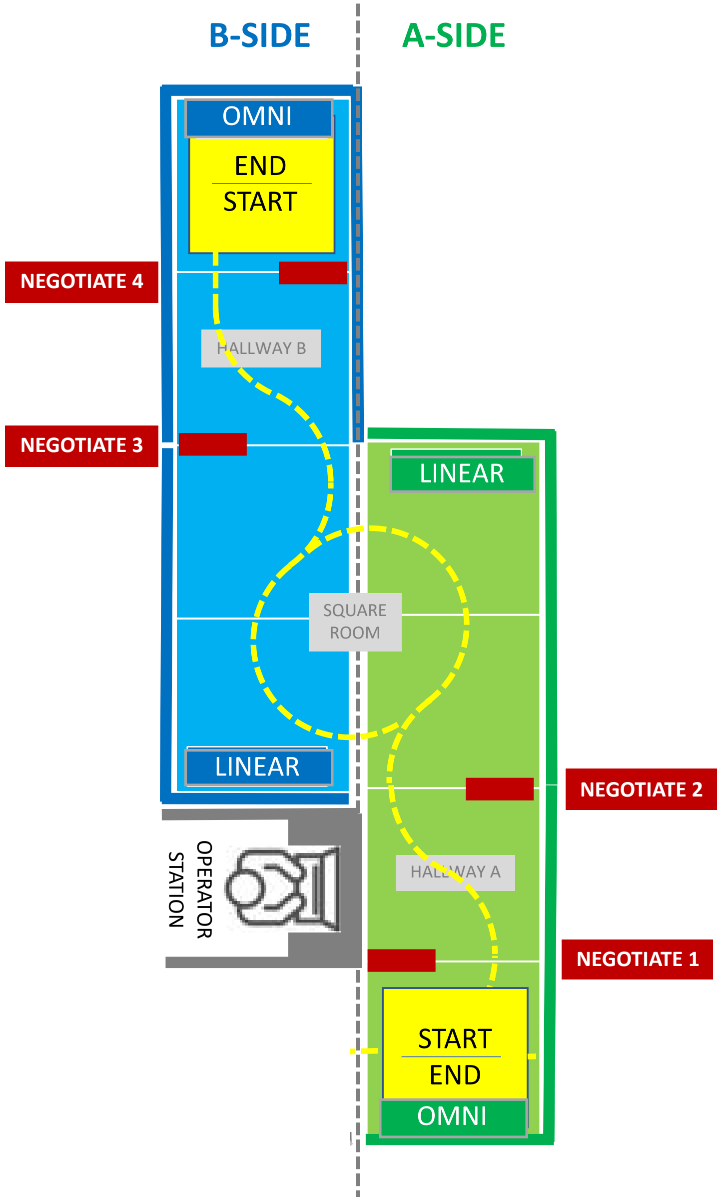
TIME ELAPSED - DID NOT FINISH
STRIKE THROUGH LINE

Embedded Dexterity Tests
(During 10-20 Minutes of Trial)

Embedded Dexterity Tasks

Version: 2024B

- The dexterity tasks inside each zig-zag lane are intended to encourage multi-joint manipulators with coordinated control to compensate for unknown chassis orientations and difficulties of repositioning on difficult terrains.
- After completing the designated Mobility repetitions or when Mobility time expires, perform the Dexterity tasks starting anywhere and in any order. No repeated tasks are allowed.
- Linear tasks encourage straight line gripper/tool paths and reach.
- Omni tasks encourage dexterous gripper/tool orientations. OMNI tasks are harder so score double compared to similar LINEAR tasks.
- No additional multiplier for autonomous driving because it is interrupted by the dexterity tasks.
- Operational tasks are all OMNIS and involve friction, force, or more precision so score even more, but are not available until the Finals.



Embedded Dexterity Tasks

Version: 2024B

Sensor Crate (White) Prelims/Semis/Finals

- Visual, Proximity, Hazmat, Motion, Thermal

Inspect Tasks (Green) Prelims/Semis/Finals

- Linear – 1 point each
- Omni – 2 point each

Touch Tasks (Blue) – Prelims Only (easier, use your own tool)

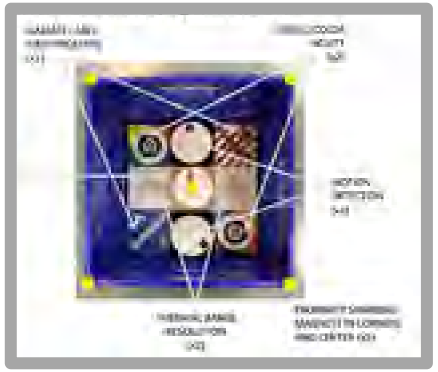
- Linear – 2 point each
- Omni – 4 point each

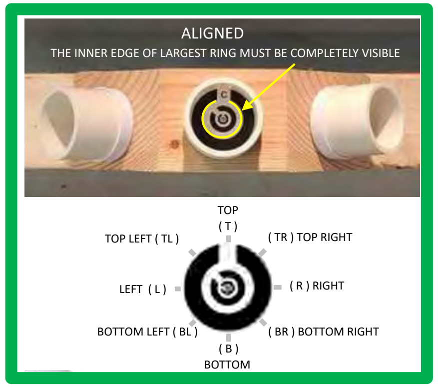
Insert Tasks (Blue) - Semis (add the grasp shaft tool in center)

- Linear – 3 point each
- Omni – 6 point each

Operational Tasks (Black) – Finals only due to force & friction

- **Omni – 10 point each**





Embedded Dexterity Tasks

Version: 2024B

VICTIM CRATE PLACED FLAT ON GROUND WITH OPEN TOP

THERMAL IMAGE ACUITY
Hand warmer with 3D printed Concentric Cs

AUDIO ACUITY
MP3 Player with alpha-numeric sequence to identify (2-way)

MOTION DETECTION
Rotating jewelry display with Concentric Cs (AUTO ONLY)

PARTIAL IMAGE RECOGNITION
Random hazmat labels from a known set. (AUTO ONLY)

PROXIMITY SAMPLING
Magnet to detect with magnetometer on tool tip

VISUAL/COLOR ACUITY
Stationary Concentric Cs or QR Code (AUTO ONLY)

Embedded Dexterity Tasks

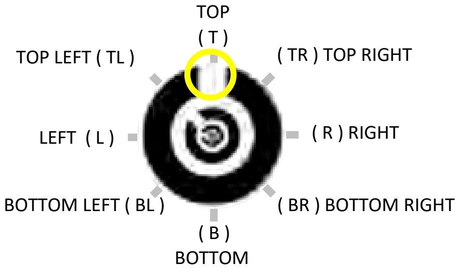
Version: 2024B

CLASSIFICATION TASKS – INSPECT OBJECTS (Green)

Available in All Rounds

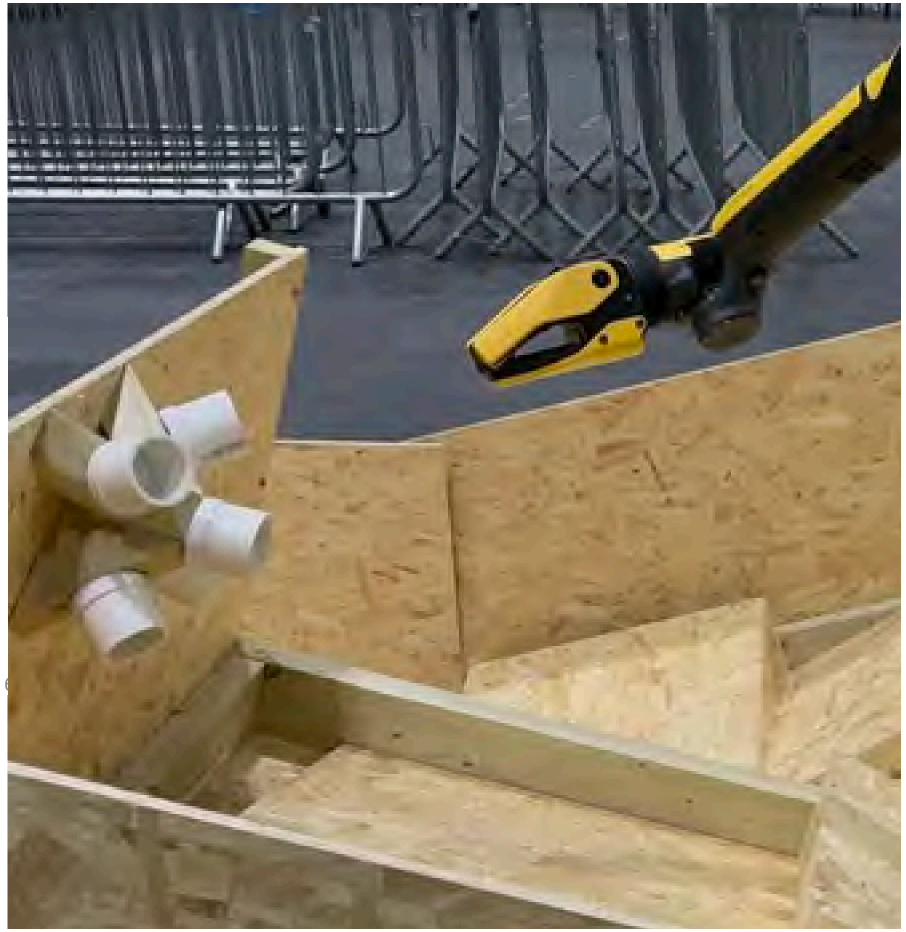
LINEAR – 1 point for each alignment

ONCE ALIGNED
MUST IDENTIFY
ORIENTATION OF GAPS IN
CONCENTRIC Cs
TO SCORE POINTS



50 mm (2 in) inside diameter PVC Pipe
https://www.amazon.com/PVC-Pipe-Sch-Inch-White/dp/B072Q9M54Z/

OMNI – 2 points for each alignment



Version: 2024B

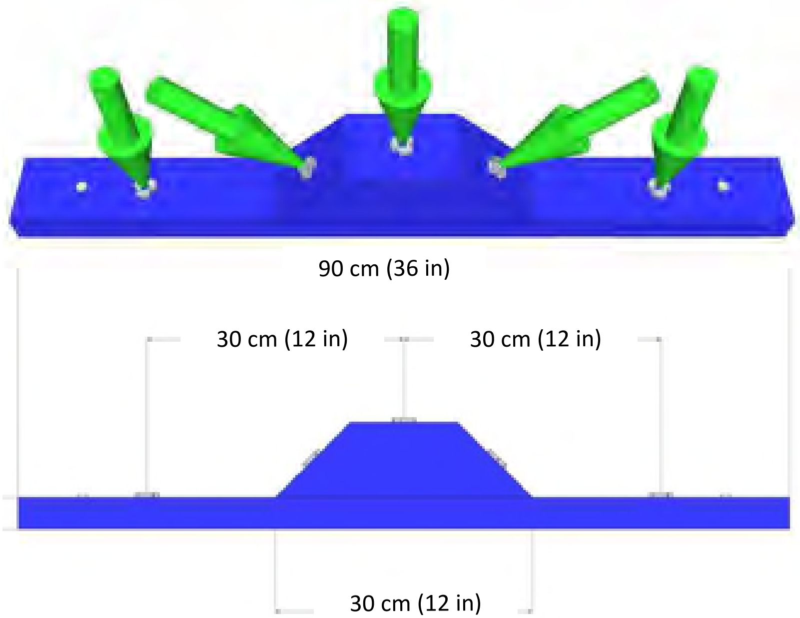
CLASSIFICATION TASK – TOUCH or INSERT TOOLS (Blue)

TOUCH = Sustained contact of shaft tip to hole interior in any orientation Easier – Only in Preliminaries

INSERT = Perpendicular penetration of shaft into hole at least 25mm (1in) Harder – In Semis and Finals

LINEAR

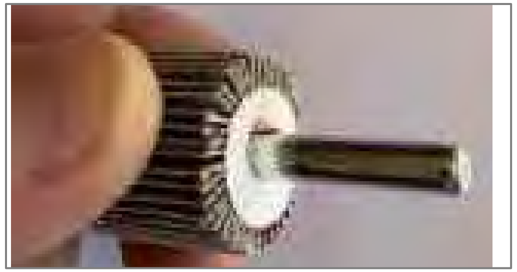
TOUCH = 2 points each
INSERT = 3 points each



CAN BE MADE WITH 5x5cm (2x2in) WOOD

Threaded Inserts:
8 mm (5/16in) diameter hole

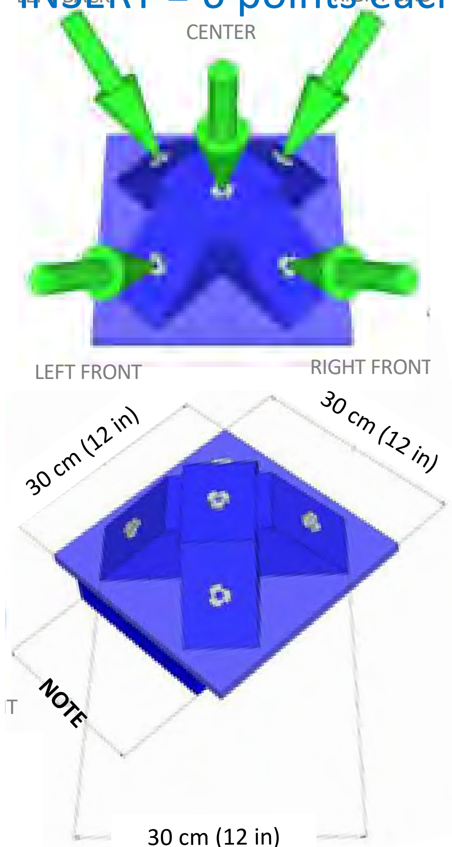
Steel Shaft with Handle:
6 mm (1/4 in) diameter shaft
at least 25 mm (1 in) long



Small Round Abrasive Flap Wheel Sanders
Grasp Object: 25 mm (1 in) diam high friction cylinder
Shaft: 6 mm (¼ in) diameter, at least 25 mm (1 in) long
https://www.amazon.com/dp/B07ZRQ9YL3/

OMNI

TOUCH = 4 points each
INSERT = 6 points each



Embedded Dexterity Tasks

Version: 2024B

CLASSIFICATION TASK – TOUCH or INSERT TOOLS (Blue)

TOUCH = Sustained contact of shaft tip to hole interior in any orientation Easier – Only in Preliminaries

INSERT = Perpendicular penetration of shaft into hole at least 25mm (1in) Harder – In Semis and Finals

One of the standard dexterity tests is "Touch" tools which is conducted in every terrain. See the blue apparatuses shown in both Linear (easier) and Omnidirectional (harder) configurations.

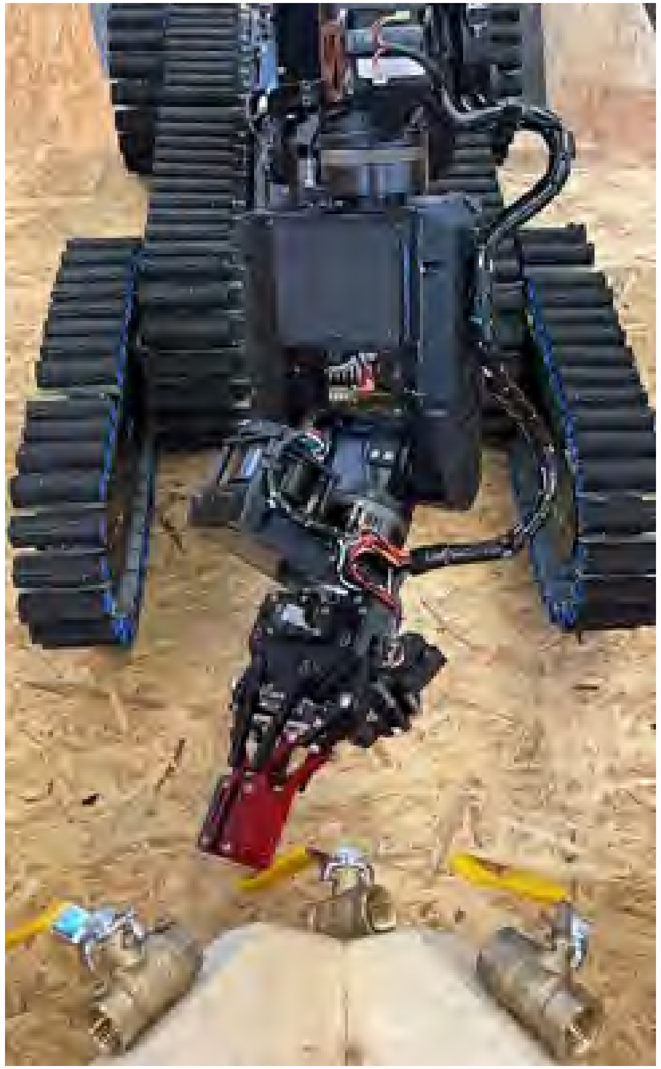
OPERATIONAL TASK – PRESS BUTTONS (Black)

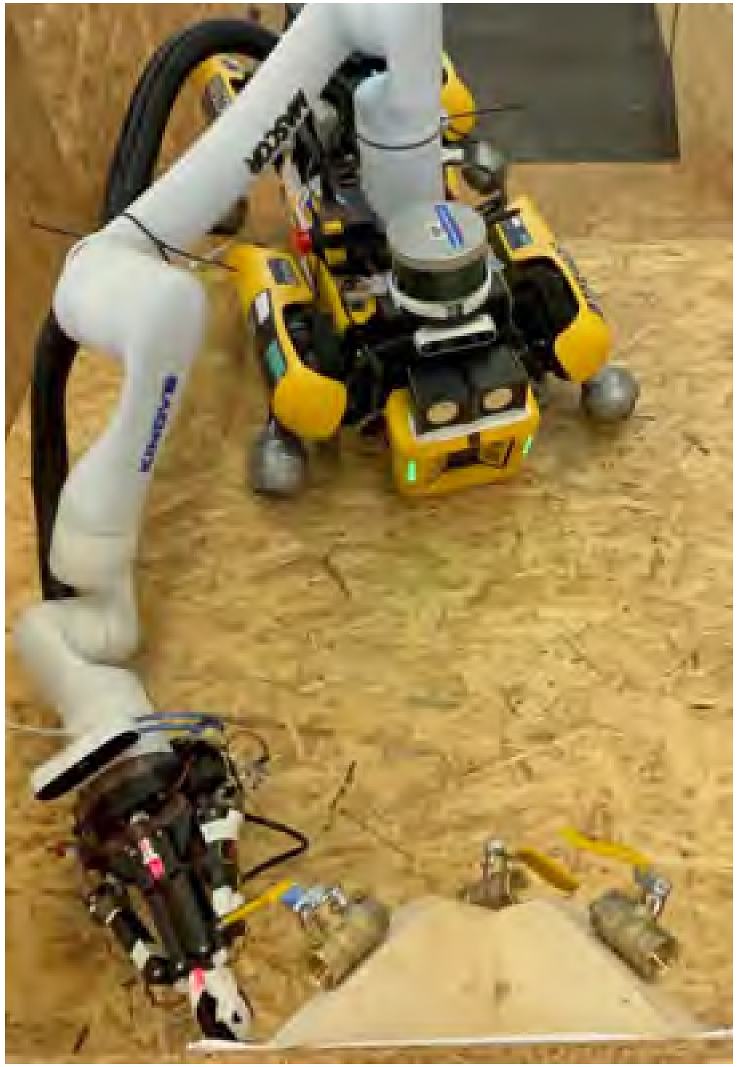
Harder due to force, friction, or precision. Omni configuration only. 10 points per task.

Version: 2024B

OPERATIONAL TASK – TURN VALVES (Black)

Harder due to force, friction, or precisions. Omni configuration only. 10 points per task.





Scoring Dexterity (During 10-20 Minutes)

Proctors Circle the Scored Points as They Happen

Version: 2024B

DEXTERITY: Perform the available SETS OF TASKS starting anywhere and in any order. No repeated tasks.

SENSOR TASKS	VISUAL	PROXIMITY	MOTION	HAZMAT	THERMAL
VICTIM CRATE (ALWAYS)	1	2	3	4	5

LINEAR TASKS	L 90°	L 45°	CENTER	R 45°	R 90°
INSPECT (ALWAYS)	1	1	1	1	1
TOUCH (PRELIMS)	2	2	2	2	2
INSERT (SEMIS, FINALS)	3	3	3	3	3

OMNI TASKS	L BOT	L TOP	CENTER	R TOP	R BOT
INSPECT (ALWAYS)	2	2	2	2	2
TOUCH (PRELIMS)	4	4	4	4	4
INSERT (SEMIS, FINALS)	6	6	6	6	6
PUSH E-STOPS (FINALS)	10	10	10	10	10
CLOSE VALVES (FINALS)	10	10	10	10	10
INSERT KEYS (FINALS)	10	10	10	10	10

DEXTERITY

TOTAL POINTS

ELAPSED TIME

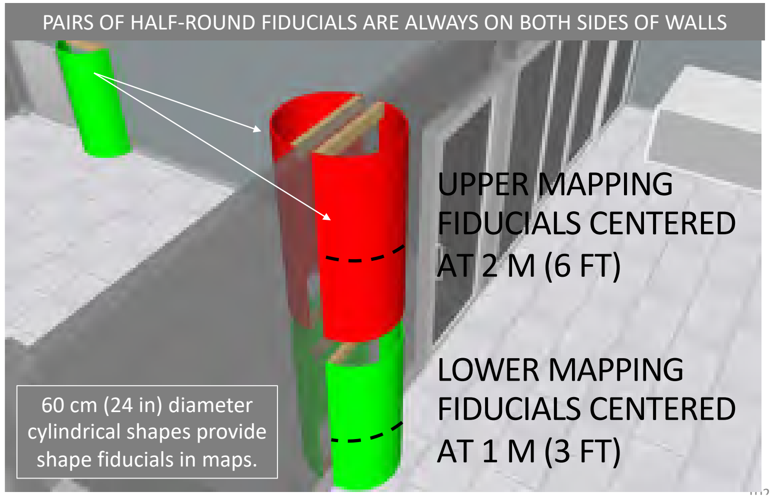
MM : SS

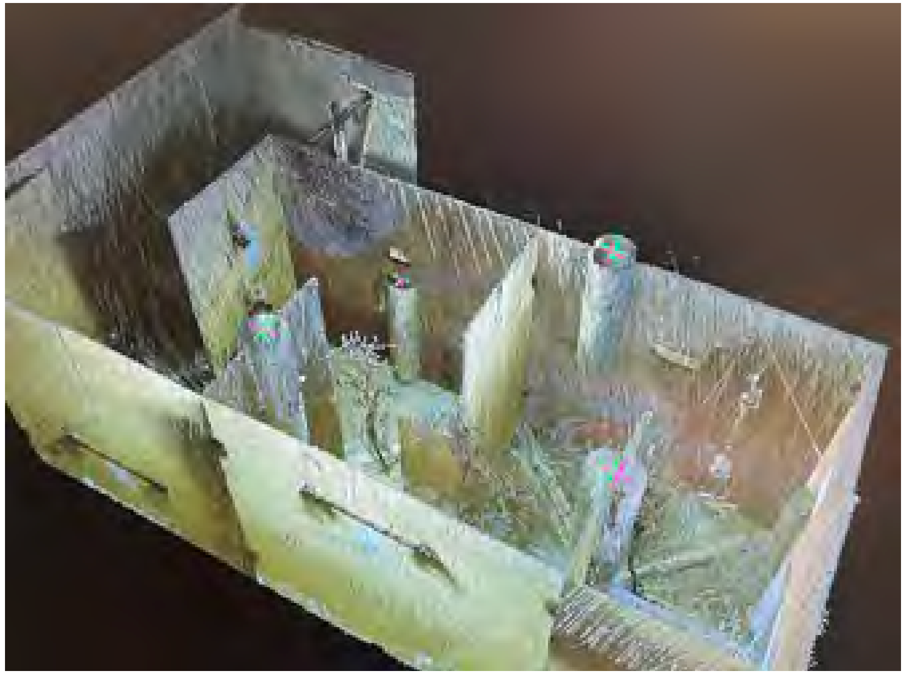
Mapping Tests

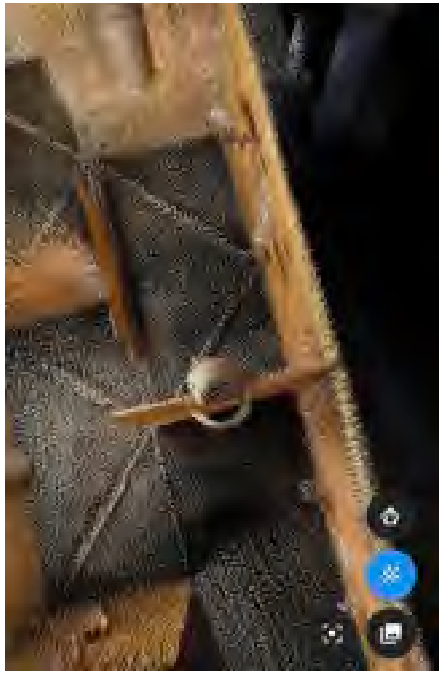
Embedded Mapping Tasks

Version: 2024B

Labyrinth and Maze





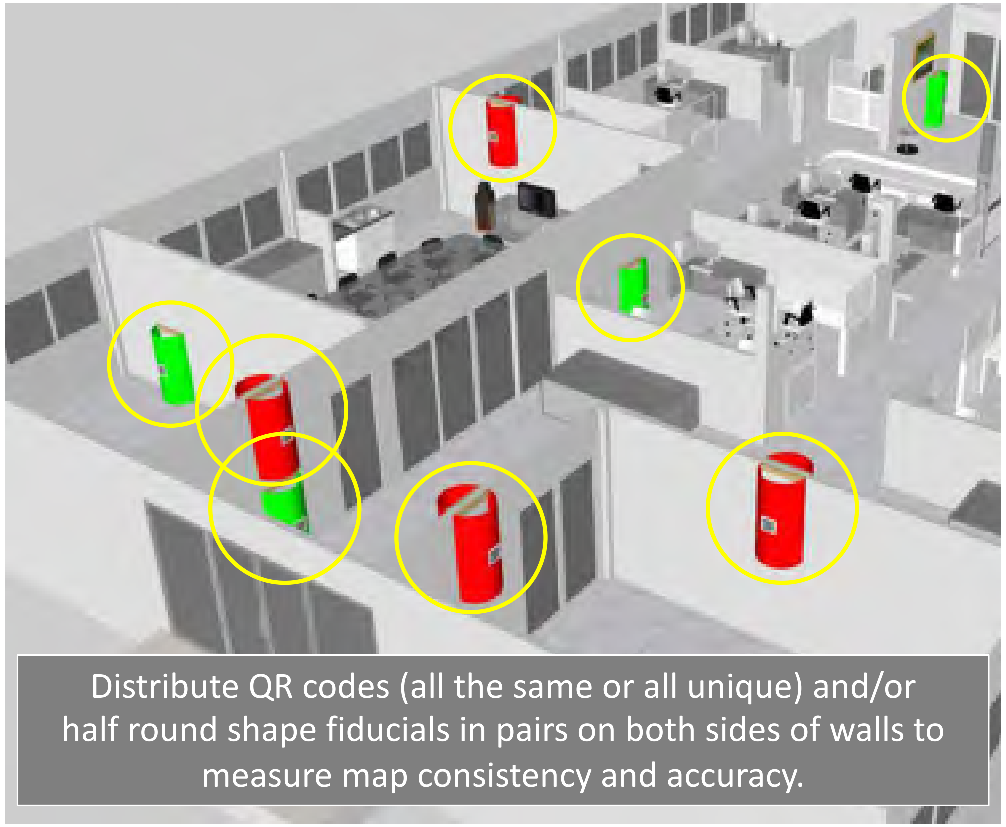


Embedded Mapping Tasks

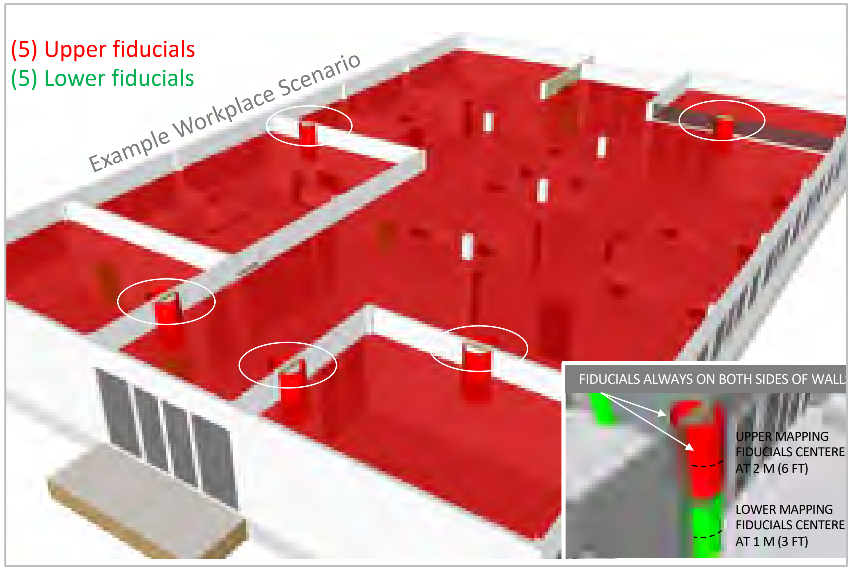
Version: 2024B

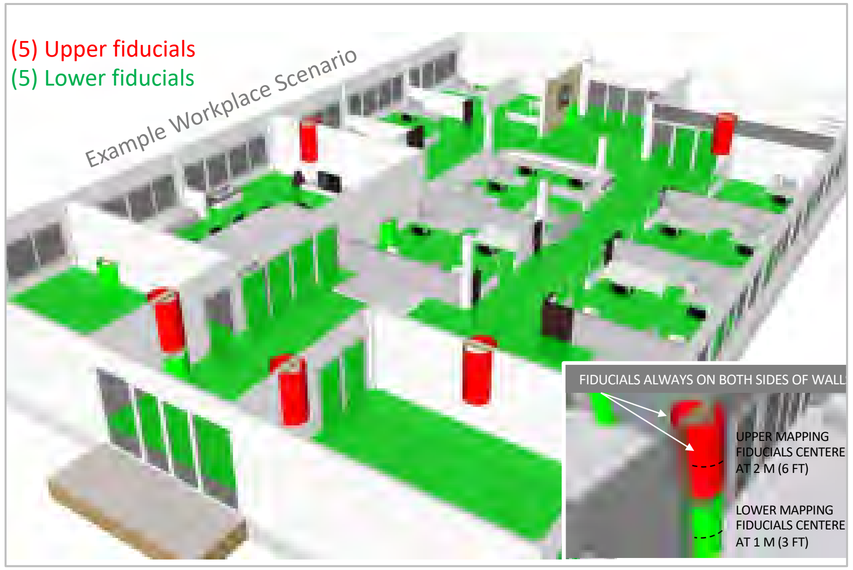
Generate 2-D Maps at 1m (3ft) and 2m (6ft) to be Evaluated

Find and Identify the QR codes and other objects of interest and mark their location on the map.



Distribute QR codes (all the same or all unique) and/or half round shape fiducials in pairs on both sides of walls to measure map consistency and accuracy.



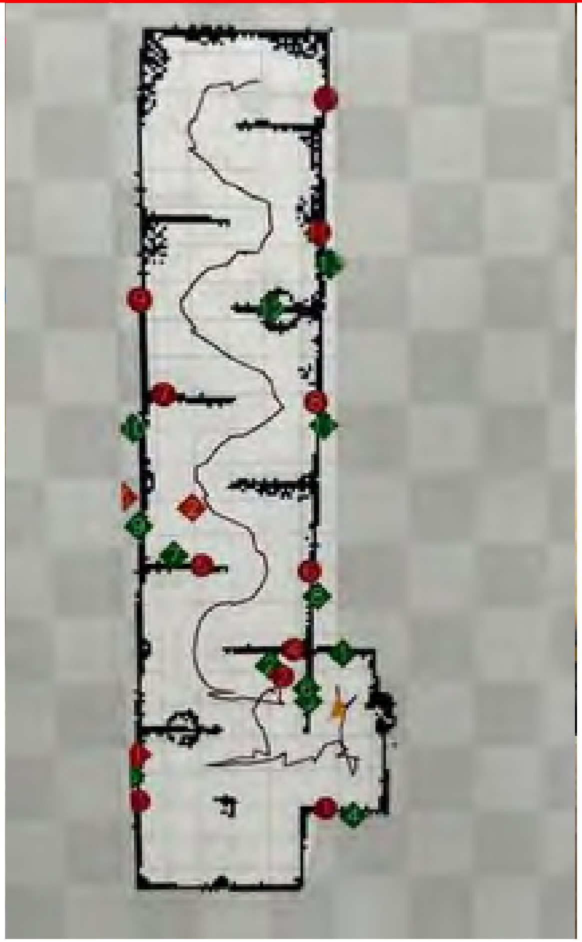


Embedded Mapping Tasks

Version: 2024B

Generate 2-D Maps at 1m (3ft) and 2m (6ft) to be Evaluated

Exploration and Mapping (Remote Operator) **Labyrinth**



Exploration and Mapping tasks can be conducted autonomously or by a remote operator. We use an enclosed Labyrinth with variable terrains and a tarp cover to dim the lighting. The robot needs to get through it to identify all the embedded features and place them correctly on an accurate map.

Scoring Mapping (During 0-10 Minutes)

Proctors Circle the Scored Points as They Happen

Version: 2024B

- Exploration/Mapping tasks are scored based on the accuracy and quality of the maps produced within a single lane or sequence of lanes.
- If using 3D scanners, produce two maps at two different elevations:
  - low is 1m (3ft) and
  - high is 2m (6ft).
- The scored features are split between both map elevations. They include half-round mapping fiducials, QR codes as search gaze tasks, and other objects of interest to identify from a known set.

MAPPING: Display 3-D scanned walls and features on TWO DIFFERENT 2-D MAPS at elevations of 1m (3ft) and 2m (6ft).

QUALITY AND ACCURACY	MAP SET 1	MAP SET 2	MAP SET 3	MAP SET 4
FIDUCIALS (COVERAGE)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
QR CODES (SEARCH GAZE)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
OBJECTS (LEXICON)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

MAPPING

TOTAL POINTS

Scoring Single or Multi-Lane Missions

Scoring Single or Multi-Lane Missions

Proctors Fill In the Header and Circle Scored Points as They Happen

Version: 2024B

ROUND	DATE	COUNTRY	TEAM / ROBOT	PROCTOR: FULL NAME (COUNTRY)

CIRCLE SUCCESSFUL TASKS AND STRIKE THROUGH UNFINISHED OR PENALIZED TASKS. USE A NEW FORM FOR ROBOT RESETS.

TERRAINS (TER)		OBSTACLES (OBS)		EXPLORATION (EXP)
❑ Continuous COMMS NEGOTIATE	❑ K-Rails NEGOTIATE	❑ Traverse/Center COMMS	❑ Stairs	❑ Avoid Holes (Auto)
❑ Crossing Ramps	❑ Sand/Gravel NEGOTIATE	❑ Hurdles with Pipes	❑ Doors	❑ Labyrinth (Mapping)

Single Lane or Multi Lane Mission Form

ion: 2023D

ROUND	DATE	COUNTRY	TEAM / ROBOT	PROCTOR: FULL NAME (COUNTRY)

CIRCLE SUCCESSFUL TASKS AND STRIKE THROUGH UNFINISHED OR PENALIZED TASKS. USE A NEW FORM FOR ROBOT RESETS.

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❑ Crossing Ramps	❑ Sand/Gravel NEGOTIATE	❑ Hurdles with Pipes	❑ Doors	❑ Labyrinth (Mapping)

MOBILITY: Drive TELEOPERATIVELY or AUTONOMOUSLY (no hands on interface) end-to-end in the lane.

	CIRCLE A SINGLE LANE IN THE LIST ABOVE OR WRITE SEQUENCE OF LANES IN ORDER	TELEOP	COMMS x2	AUTO x4	NEGOTIATE 1	2	3	4
1		1	2	4	N	N	N	N
2	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
3		1	2	4	N	N	N	N
4	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
5		1	2	4	N	N	N	N
6	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
7		1	2	4	N	N	N	N
8	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
9		1	2	4	N	N	N	N
10	RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N

MOBILITY — TOTAL POINTS

ELAPSED TIME — MM : SS

NEGOTIATE — TOTAL Ns

DEXTERITY: Perform the available SETS OF TASKS starting anywhere and in any order. No repeated tasks.

SENSOR TASKS	VISUAL	PROXIMITY	MOTION	HAZMAT	THERMAL
VICTIM CRATE (ALWAYS)	1	2	3	4	5

LINEAR TASKS	L 90°	L 45°	CENTER	R 45°	R 90°
INSPECT (ALWAYS)	1	1	1	1	1
TOUCH (PRELIMS)	2	2	2	2	2
INSERT (SEMIS, FINALS)	3	3	3	3	3

OMNI TASKS	L BOT	L TOP	CENTER	R TOP	R BOT
INSPECT (ALWAYS)	2	2	2	2	2
TOUCH (PRELIMS)	4	4	4	4	4
INSERT (SEMIS, FINALS)	6	6	6	6	6
PUSH E-STOPS (FINALS)	10	10	10	10	10
CLOSE VALVES (FINALS)	10	10	10	10	10
INSERT KEYS (FINALS)	10	10	10	10	10

DEXTERITY — TOTAL POINTS

ELAPSED TIME — MM : SS

MAPPING: Display 3-D scanned walls and features on TWO DIFFERENT 2-D MAPS at elevations of 1m (3ft) and 2m (6ft).

QUALITY AND ACCURACY	MAP SET 1	MAP SET 2	MAP SET 3	MAP SET 4
FIDUCIALS (COVERAGE)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
QR CODES (SEARCH GAZE)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
OBJECTS (LEXICON)	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

MAPPING — TOTAL POINTS

Scoring Single Lane Missions

Proctors Fill In the Header and Circle Scored Points as They Happen

Version: 2024B

Single Lane Missions

Prelims (30 minute rotations, 20 minute trials)

- There are 10 concurrent lanes with operator stations.
- Each test lane is conducted individually to capture up to 10 repetitions from end-to-end to refine their systems and tactics for the challenges in each test lane.
- Teams schedule their own test plan each day to balance their objectives with related risks (or the organizers make a schedule).
- Teams must try every lane in the Preliminaries but several scores can be dropped from the totals.
- Each team provides a "Proctor" to score and attest to the results of other team trials. This ensures all teams go home with experience conducting objective evaluations for their ongoing development.

Single Lane or Multi Lane Mission Form

ion: 2023D

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MOBILITY: Drive TELEOPERATIVELY or AUTONOMOUSLY (no hands on interface) end-to-end in the lane.

CIRCLE A SINGLE LANE IN THE LIST ABOVE OR WRITE SEQUENCE OF LANES IN ORDER	TELEOP	COMMS x2	AUTO x4	NEGOTIATE 1	2	3	4
1	1	2	4	N	N	N	N
2 RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
3	1	2	4	N	N	N	N
4 RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
5	1	2	4	N	N	N	N
6 RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
7	1	2	4	N	N	N	N
8 RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N
9	1	2	4	N	N	N	N
10 RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N

MOBILITY — TOTAL POINTS

ELAPSED TIME — MM : SS

NEGOTIATE — TOTAL Ns

DEXTERITY: Perform the available SETS OF TASKS starting anywhere and in any order. No repeated tasks.

SENSOR TASKS	VISUAL	PROXIMITY	MOTION	HAZMAT	THERMAL
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LINEAR TASKS	L 90°	L 45°	CENTER	R 45°	R 90°
INSPECT (ALWAYS)	1	1	1	1	1
TOUCH (PRELIMS)	2	2	2	2	2
INSERT (SEMIS, FINALS)	3	3	3	3	3

OMNI TASKS	L BOT	L TOP	CENTER	R TOP	R BOT
INSPECT (ALWAYS)	2	2	2	2	2
TOUCH (PRELIMS)	4	4	4	4	4
INSERT (SEMIS, FINALS)	6	6	6	6	6
PUSH E-STOPS (FINALS)	10	10	10	10	10
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MAPPING — TOTAL POINTS

Scoring Multiple Lane Missions

Proctors Fill In the Header and Circle Scored Points as They Happen

Version: 2024B

Multiple Lane Missions

Semis (30 minute rotations, 20 minute trials)

- These sequences challenge teams to optimize their systems across different capabilities.
- There are 3 concurrent lane sequences with different operational objectives.
- The lanes are conducted in any order but no repeats are allowed until all lanes are completed.

Combined Scenario Missions

Finals Challenge the Best Robots to Their Limits

- Challenge teams like an operational deployment with various phases.
- The best few teams traverse ALL the available test lanes. Teams may choose their own order to minimize risks.
- The time limit should be set to enable the best teams to finish the set of lanes, perform one dexterity task within each, and map their path for a total score.

Single Lane or Multi Lane Mission Form

ion: 2023D

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7	1	2	4	N	N	N	N
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9	1	2	4	N	N	N	N
10 RETURN UP RANGE TO START POINT	1	2	4	N	N	N	N

MOBILITY — TOTAL POINTS

ELAPSED TIME — MM : SS

NEGOTIATE — TOTAL Ns

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OMNI TASKS	L BOT	L TOP	CENTER	R TOP	R BOT
INSPECT (ALWAYS)	2	2	2	2	2
TOUCH (PRELIMS)	4	4	4	4	4
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PUSH E-STOPS (FINALS)	10	10	10	10	10
CLOSE VALVES (FINALS)	10	10	10	10	10
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DEXTERITY — TOTAL POINTS

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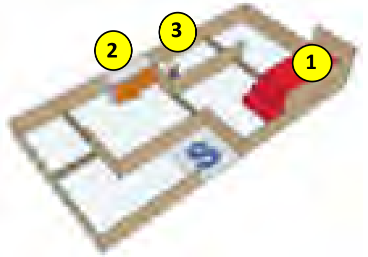
MAPPING — TOTAL POINTS

New Tech Challenge

Tech Challenge

024B



Motivation

The new Technology Challenge provides teams with an opportunity to showcase advanced capabilities in RoboCup Rescue. It encompasses a range of tasks that require supervised autonomy under conditions of severe radio degradation.

In addition to the predefined tasks, the challenge offers an open field where research teams can demonstrate new capabilities relevant to rescue robotics within their respective fields of study. Examples include alleviating operators' stress in repetitive tasks or introducing assistive functions.

The team that performs the best in this challenge will be awarded the Technology Challenge Certificate. The score obtained in this challenge does not contribute to the overall championship or other "best in class" certificates.

Scenario

The objective is to deploy a smart robot into an apartment and enable it to autonomously search for victims with supervision from the operator.

Four Challenging Tasks

- Traverse stairs, open a cabinet door, find and map a victim.
- Open Stage: Teams are encouraged to showcase their own capabilities and demonstrate new technologies relevant to the field.

MOBILITY: Stair Traversal (25 pts) 1

Go up and down a set of stairs
- Align with the stairs (5 pts)
- Go up the stairs and reach the top area (5 pts)
- Rotate robot more than 90°, then align again with stairs (5 pts)
- Go down the stairs and reach the bottom area (10 pts)

DEXTERITY: Cabinet Door (25 pts) 2

Open a cabinet door, look inside and read the QR code
- Drive into area in front of cabinet door (5 pts)
- Detect handle (5 pts)
- Open door at least 90° (10 pts)
- Read QR code which is located inside the cabinet automatically (5 pts)

EXPLORATION: Victim Mapping (25 pts) 3

Detect and localize one victim based on heat (automatic)
- Automatic victim identification (10 pts)
- Location in a 2D map (10 pts)
- Location in a 3D map (5 pts)

OPEN STAGE (25 pts)

Demonstrate new technologies and research
- Usefulness (0 - 10 pts)
- Novelty (0 - 10 pts)
- Technical maturity (0 - 5 pts)

Tech Challenge

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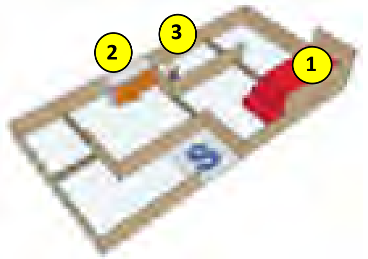
Environment, Setup and Scoring

- The robot must traverse uneven terrain, with 10 cm x 10 cm beams on the ground.
- All tasks must be performed with high radio degradation (bandwidth < 1 Mb/s), but full connectivity is ensured within the 1.2 m x 1.2 m start zone.
- Tasks can be performed with human-in-the-loop supervision, emphasizing supervised autonomy.
- All 4 tasks must be performed in a single 30 minutes mission: 5 minutes to set up, **20 minutes of operation,** 5 minutes to exit.
- The maximum score for the challenge is 100 points, with each task worth 25 points.
- Each task can be skipped. The order of the task execution can be determined by the operator.
- Detailed scoring sheets will be used to evaluate the fixed tasks, while technical experts will assign points for the Open Stage demonstration.



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- Novelty (0 - 10 pts)
- Technical maturity (0 - 5 pts)

Awards Recognize Important Contributions

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Every team get to comprehensively evaluate their robot. Teams seeking to accumulate scores can win awards to recognize their accomplishments.

Scores are normalized relative to the best score in each lane or sequence so the results can be compared with other lanes that are easier/harder for teams in general.

- ***Best-In-Class Awards*** are given for teams that demonstrate the most capable and reliable robots within a class of tests: Mobility, Dexterity, and Exploration/Mapping. The trials are captured during the Preliminaries when all teams are involved.

- ***1st, 2nd, and 3rd Place Awards*** are given to teams that combine all three categories of capabilities to demonstrate the best performance across the entire arena. These teams perform the most challenging mission sequences on the final day.

- ***Certificate Awards*** recognize important contributions across the league such as the most intuitive operator interface or particularly effective design functionalities and the Tech Challenge.